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"*Notes on Laparoscopic Gastrointestinal Surgery (Chinese version, 1e)*" was well received and has become one of the best-selling book since its being published in 2015, and gained support from many colleagues in China for its rich content, concise text, and clinical practicability in operation with helpful tips and notes; All "Iron warriors", as what we called ourselves, are very proud and pleased to receive positive feedbacks as well as precious advices from peers. The book condensed efforts of more than 40 "iron warriors" all over China sharing our technical experience and clinical thinking with national colleagues. To share and exchange information and skills is our primary goal of writing the book.

Laparoscopic gastrointestinal surgery has developed rapidly, since the publication of the first edition *Notes on Laparoscopic Gastrointestinal Surgery* being, our technique of laparoscopic gastrointestinal surgery has updated, especially in the improvement of skills, the recognition of surgical spaces, the concept of lymphadenectomy, the breakthroughs of digestive reconstruction and the modification of the reconstruction equipment. With the trend of medicine progressing, surgeons should keep on learning and improving the technique and skills. We also have an obligation to share the updates to younger ones.

In 2015, an association named "*Chinese-Japanese-Korean Alliance of Young Surgeons*" was founded and a series of meetings between young surgeons from the above countries followed. As it is known to us, both basic research and clinical treatment of gastrointestinal cancer in Japan and Republic of Korea ranged top level worldwide, and some well identified standards and regulation of treatment related were made. Japan and Republic of Korea's young experts is the backbone of Japanese and Korean medical world. They inherited the diligence, rigorousness, studiousness and innovative spirit of pioneers, constantly opening up new technologies, advocating new ideas and greatly advancing the gastrointestinal field of medical development and progress. What I see since the foundation of the "*Chinese-Japanese-Korean Alliance of Young Surgeons*" is the relationship between young surgeons focusing on gastroenterology becoming closer. It is right during those meetings when I came up with the idea of inviting young and excellent surgeons from Japan and Republic of Korea together with promising young gastrointestinal surgeons in China to work on a new edition of "*Notes on Laparoscopic Gastrointestinal Surgery, 2nd Edition*" in English version.

After the first successful attempt of the first edition of the *Notes on Laparoscopic Gastrointestinal Surgery*, we are confident in the second edition with support of our colleagues and their passion as well as significant contribution. We adopted most manuscripts with surgical techniques and ideas updated, while adhering to the originality, popularity, practicality, intuitiveness and most important speciality.

For the completion of this book, I am sincerely grateful to the domestic gastrointestinal leading authority who supports our work, as well as supports from surgeons internationally especially from Japan, and Korean. Without their contribution, this accomplishment would be impossible. We will continue dedicating to the development of laparoscopic technology, and we sincerely hope that the Chinese surgeons dedicating in gastrointestinal diseases can embark on the world's stage.

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Preface

Surgery is a subject synthesizing science, technology and art, where surgeons are required to be science thinking, skillful and precise in operating, and beyond that, with exquisite craftsmanship like a sculptor sculpting a delicate art. A good surgery is a result of brain co-working with hands in the most perfect way after countless practice with instruction and encouragement given by more experienced and senior surgeons.

The current book *Notes on Laparoscopic Gastrointestinal Surgery* is an output of more than 40 talented and young surgeons, mostly from China, Japan, and Republic of Korea and some other countries, focusing in laparoscopic surgery as editors and authors sharing their experiences, skills and creativities.

I would like to congratulate the Editors and authors for making this book come true. The book series itself and the contributors of the books can be a model for all gastrointestinal surgery colleagues. As the second edition with language of English, it is a big step moving forward from the previous edition considering readers internationally be benefit. It is also encouraged to update the work once several years to stay up-to-date.

My suggestions to young surgeons as it is asked would be as followed.

First, treasure your time and be even more hardworking. For medical career, a whole lifetime is even not enough. Lifetime achievements of medical achievement depends on one's talent and hardworking. Talent is one's capability of understanding and practicing the medical concept while being hardworking maximizes the results. After all, there is no end to the career.

Second, solid basic knowledge is essential before digging deep into one specific field. I as always, strongly recommend the rotation system for young doctors newly graduates. Human body is not separated but closely related and a certain disease might be a signal given by the whole-body system. The solid basic knowledge would give a higher level of perspective to surgeons to avoid from parochialing oneself. Thus for young doctors before taking a specialty, take your time to store solid basic theory and knowledge as well as the skill practice.

Third, be critical thinking and explorative. It is a challenge for us to be explorative since it is precision and accuracy that is strictly and firstly required during our daily practice and only after the above two requirements are fulfilled, shall we begin the journey of exploration, accompanying progress and creation.

Last but not least, scientific research ethics shall be followed. Considerable development and progress has been made in the field of medicine. At the same time a side effect of the blossoming is the rising of fickle utilitarianism heading to harm. It is urgently expected that young doctors and researchers shall shape their correct scientific ethics.

I am very glad to share my ideas towards to the book *Notes on Laparoscopic Gastrointestinal Surgery* and my suggestions to the younger generations. I am sincerely hoping the young generation doctors would treasure your time, work hard to get knowledge and skills, think deep and explore more to become good surgeons, excellent doctors, outstanding scientists.

Jiafu Ji, MD, FACS
Peking University of School of Oncology & Beijing Cancer Hospital, *Beijing*, *China*

Congratulations on the upcoming publication of the book *Notes on Laparoscopic Gastrointestinal Surgery*, collecting a group of talented young surgeons focusing in laparoscopic gastrointestinal surgery. I am pleased to write a preface for their work recording their progress.

Mixed feelings emerged noticing that 30 years has already passed since the beginning of my medical career. Looking back in 1986, I know I studied in France during the best years as the cradle land of laparoscopic surgery. I had the chance to witness and experience the start and historical progress of laparoscopic surgery technology. My mentor offered me plenty of opportunities in the operating room for I had facile hands well-trained by chopsticks that it was in 1989 when I first did the laparoscopic cholecystectomy. It was in my 30s when I came back to China and operated the first radical resection for sigmoid colon cancer in China in 1993. I remember so well because it was the tough years back there in China. With more than 20 years' development, laparoscopic surgery in China has developed tremendously. It is this 20 years the golden times for laparoscopic surgery and the most energetic times for gastrointestinal surgery. For now, concepts of laparoscopy including precise anatomy, medial approach, membrane anatomy, laparoscopic anatomical marks and levels are all borrowed to open surgery; and endoscopic equipments like ultrasonic scalpel and cutter staple are widely applied in traditional surgery. Laparoscopic surgery's supporting back to traditional surgery makes it even more attractive for gastrointestinal surgeons to learn the techniques and consistently promoting the progress of laparoscopic gastrointestinal surgery.

The book *Notes on Laparoscopic Gastrointestinal Surgery* comes out at the right time when the laparoscopic surgery are widely done and done skillfully. The authors share their personal experience and inspiration in a specific surgery procedures in forms of video demonstration, figure illustration and verbal description.

I am glad to see the contributions made by this group of young talented laparoscopic surgeons and hope this book would benefit more gastrointestinal surgeons, other doctors and medicos interested in the technique.

Minhua Zheng, MD

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More than 30 years have passed since the inauguration of laparoscopic surgery. Since, this technique has evolved as a less traumatic option for a fistful of un-complex interventions. Over the past decades laparoscopic surgery has left its niche existence and has become a central tool in gastrointestinal surgery and even in oncologic surgery. Nowadays it is routinely applied in almost the entire field of gastrointestinal surgery and is continuously replacing open surgery to minimize the abdominal wall trauma of the patients, thereby reducing hospital stay.

With the present book *Notes on Laparoscopic Gastrointestinal Surgery, 2nd Edition* some highly experienced surgeons share their experience and knowledge in laparoscopic tumor surgery with a strong emphasis on gastric and colorectal surgery and comment in detail upon specific problems and technical recommendations on these topics. Herein, the book perfectly pics up the current spirit in surgery and with certainty represents only a first starter in the rapidly widening field of oncologic laparoscopic surgery. It has to be assumed, that with the increasing application of robotic surgery and the advent of other supportive technologies, e.g. image guided surgery in combination with multimodal tumor therapy, laparoscopic surgery will also conquer other fields in oncologic surgery, that at present still are a main domain of conventional surgery. In this context, hepatobiliary and esophageal surgery are perfect candidates, and it could already be shown, that laparoscopic surgery is amenable for these applications as well and with remarkable results.

Thus, one can expect *Notes on Laparoscopic Gastrointestinal Surgery, 2nd Edition* to be continuously extended and complemented in other fields of oncologic surgery, which could only be touched in this current issue.

We warmly recommend this excellent book to any gastrointestinal surgeon who is interested in offering modern therapy to his patient and who is open minded to new techniques and the advancement of surgery. Once unmated oncologic surgery at current has to compete with other upcoming treatment options, such as interventional radiology, biologicals and specific therapies that, although being less responsive to date, depict some attractiveness to patients as they are less invasive and painful. To maintain is importance, surgery is well-advised to adapt to this development, however without losing its superiority, radicalness and effectiveness. Laparoscopic surgery to date is the best tool we have to compete with these developments and therefore should be liberally applied when indicated.

It is my strongest wish to encourage every surgeon to further evolve our surgical armamentarium with new and gentle modalities and to advance surgery to the next level. However, we should never abandon to critically assess any new technique and its application in the treatment of our patients as cure and longtime survival in combination with a high life quality represent the highest goals in oncologic surgery. Accordingly, the topics of this book were chosen wisely and focus on the fields only, where laparoscopic surgery has been proven to be at least equally effective as conventional surgery.

We would like to congratulate the publisher and all authors, who have composed an excellent and elaborated scientific work on laparoscopic gastrointestinal oncologic surgery and who by this have contributed to the welfare of our patients.

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Educational system of laparoscopic gastrectomy for trainee—how to teach, how to learn

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Contributions: (I) Conception and design: All authors; (II) Administrative support: All authors; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: A Kaito; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: The feasibility of laparoscopic gastrectomy (LG) has been gradually proven by several scientific works, however, proper training method for this kind of surgery are still under investigation and debate. Here we report our educational system of LG to enhance the skill of young surgeons in our hospital. Our training program for trainee consists of 3 years of junior residency and 2 years of senior residency programs, requiring 5 years in total. In order to master LG, three following factors seem to be essential: learning, practice and experience. Learning means that trainee study techniques and concepts by educational materials, such as operative videos, lectures, or textbook. Practice means animal laboratory training or dry box training to acquire hand-eye coordination or bi-hand coordination, leading to precise movement of surgical devices. Experience means actual on-site training, participating in clinical LG as scopist, assistant or operator. In the actual surgery, we have some common principles for scopist, assistant and operator, respectively, and these principles are shared by entire surgical team. These principles are transmitted from trainer to trainee using simple keywords repeatedly. In conclusion, combination and balance of the three factors, learning, practice and experience are necessary to efficiently advance education of LG for trainee and may leads to benefits for gastric cancer patients.

Keywords: Laparoscopic gastrectomy (LG); education system; trainee

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Introduction

Laparoscopic gastrectomy (LG) are firstly reported by Kitano *et al.* in 1994 (1) and now widely spread to East Asian countries. Japan Society for Endoscopic Surgery (JSES) reported 34.0% of the gastrectomy for gastric cancer is performed under laparoscopy in Japan, in 2013. Laparoscopic distal gastrectomy (LDG) for early gastric cancer has been accepted as a standard procedure for experienced laparoscopic surgeons following the results of feasibility studies conducted in Japan and Korea (2,3). Although low complication rate was shown in these trials, the surgeons who performed surgery included in these studies were so-called "expert" surgeons because the criteria as for operator in these trials was restricted to surgeons with experiences of at least 30–80 laparoscopic gastrectomies. Feasibility of laparoscopic surgery performed by trainee is still debatable and only a few studies had been existed so far describing its educational system. It is reported that less than 50% of educational institution of LG in Japan and Korea adopt their own educational program for trainee (4). Here we report our own educational system for LG for trainee in our hospital.

Early period after introduction of LG in our institution

We introduced LG for gastric cancer in 2010, and recently our hospital became one of the high-volume centers

Table 1 Factors associating mastering LG

Factors	Materials
Learning	Operative videos with explanation
	Presentation/lecture
	Textbook
Practice	Task in the dry box (suturing, handling surgical forceps etc.)
	Animal laboratory training
Experience	Participation of actual LG

LG, laparoscopic gastrectomy.

Figure 1 Typical educational video. This video shows the typical exposure of operative field of supra pancreatic lymph node dissection in LDG for early gastric cancer. Trainee can learn typical exposure named "the first, second and third point of view" as shown in this video with marks and titles (6). LDG, laparoscopic distal gastrectomy.
Available online: http://www.asvide.com/articles/1332

regarding LG in Japan. Standardized procedure was introduced by an expert surgeon. Standardized surgical procedure and environment are described in "laparoscopic manuals" edited in our institution, which could be shared not only with surgeons but with surgical co-medicals, such as nurses or medical engineer, finally established a "laparoscopic team". As surgical procedures or used devices were improved and changed, these contents were reflected to our manual. The significance of team participation training system was reported previously by us (5).

Characteristics of our residency program

Around 300 cases of gastrectomy for gastric cancer are performed annually and currently 70–80% of the cases are operated laparoscopically. Trainee who wants to work in our division usually apply for our residency program at 5–8 post-graduation years after they have acquired the board certification from Japan Surgical Society. Our residency program consists of 3 years program as junior resident and 2 years program as senior resident. In the first 2 years of the junior residency program, actually they work at gastric surgery division only for 6 months, and for the rest period rotate in other surgical divisions (esophageal, hepato-biliary pancreatic and colorectal surgery), pathological division and medical oncological division to learn widely oncology and basic skills of gastroenterological surgery.

The last year of junior resident are specialized in the training program of gastric surgery division. Senior residency program are aiming to more deepen their knowledge and skills as gastric surgeons.

Three factors for mastering laparoscopic surgery

Learning, practice and experience are the three indispensable factors for mastering LG as shown in *Table 1*.

"Learning": learn the standardized procedure

Trainees learn the standardized reproducible procedure thorough the non-edited operative video performed by trainer repeatedly as well as textbook to learn ideal exposure of operative field. The typical exposure of operative field for supra pancreatic lymph node dissection are demonstrated in *Figure 1*.

"Practice": practice using the dry box

Trainee should practice laparoscopic suturing techniques or handling of surgical devices through the training using the dry box. Hand-eye coordination and peculiar movement of laparoscopic surgery could be acquired by effective creative tasks in the dry box before participating in actual surgery as shown in *Figure 2*.

"Experience": participate in actual laparoscopic surgery

In our division, junior resident participate in laparoscopic surgery basically as a scopist in their first year. After they experienced five to ten cases as a scopist and understood the standardized procedure, they can promote to an assistant of LDG or an operator of easier laparoscopic surgery, such as staging laparoscopy or laparoscopic gastrojejunostomy. At the same time, they can also experience open gastrectomy as well. Trainee performs their first LDG as an operator after ten to twenty experiences as assistant. At the third year of junior resident or the first year of senior resident, they can take the examination to obtain certification of endoscopic surgical skill qualification system of JSES (8). Training program of our residency system was summarized in *Figure 3*.

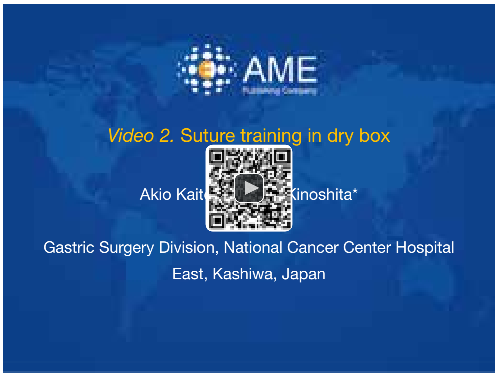

Figure 2 Suture training in dry box. This video shows the example of training tasks in the dry box (7).
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The principles for our surgical team to play each role in laparoscopic surgery

We have following common principles and concepts as described below.

The principles for scopist

Show the typical view

A 10 mm flexible scope is routinely used in our institution. The operator and the assistant have to make the standardized operative field, and the scopist have to show these reproducible operative fields. Discrepancy of the typical view shown by scopist could lead to misunderstanding of surgical anatomy, which may be associated with unexpected injury of other organs.

Avoid collision between scope and other surgical devices

Scopist should recognize intraabdominal positional relationship of each surgical device, and control scope position not to conflict with other devices. This principle must be recognized by operator and assistant as well, always considering provision of space for scope.

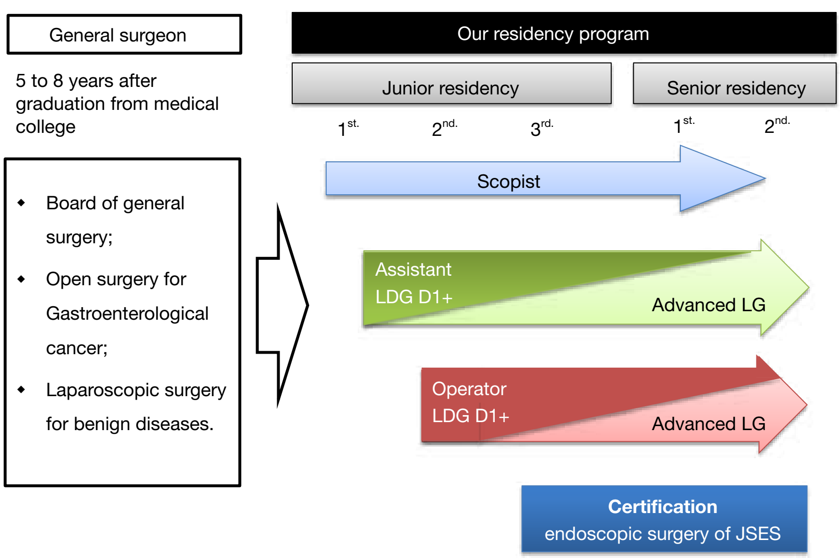

Figure 3 Our residency program. Trainees of our residency program are surgeons in fifth to eighth post graduate years. They experience laparoscopic gastrectomy as a scopist, an assistant and an operator as shown in this figure. They also take examination of the certification examination of certification of endoscopic surgical skill qualification system of JSES. LG, laparoscopic gastrectomy; LDG, laparoscopic distal gastrectomy; JSES, Japan Society for Endoscopic Surgery.

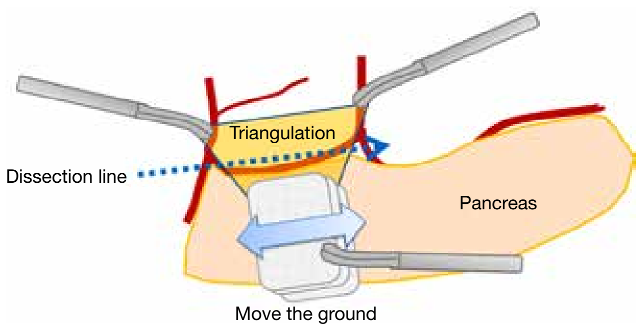

Figure 4 The concept of "triangulation" and "move the ground". The operator and assistant expose the operative field as triangle shape. The axis of surgical devices treated by operator are usually fixed, thus dissection line should be adjusted by move the ground method.

Figure 5 The concept of "triangulation" and "move the ground" in dry box. This video shows the concept of ''triangulation" and ''move the ground". Trainee can practice exposure of operative field using dry box training as shown in this video (9).
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Show surgical devices not blindly

Any energy devices have possibility to give thermal injury to other organs, such as pancreas or major vessels due to blind activation and cavitation. Scopist should pay maximum attention to show the active blade of energy devices as possible to avoid blind procedures. For this, articulating function of the flexible scope is very useful.

The principles for assistant

Basic step of assistant begins with exposure of typical operative field in LDG for early gastric cancer. More advanced procedures, such as total gastrectomy with splenic hilar dissection for advanced gastric cancer, require more complicated exposure of surgical field, thus assistant should understand surgical anatomy and operative procedure very well. The principles for assistant which are decided in our institution to expose the good operative field are as follows.

Triangulation and move the ground

Triangle formation to expose the operative field with proper tension can be made using two forceps handled by assistant and left hand forceps of operator (triangulation). In laparoscopic surgery, the axis of surgical device is fundamentally fixed by the trocar. Thus, operator and assistant should adjust the dissection line to the axis of surgical energy devices driven by operator's right hand by moving organs (move the ground) as shown in *Figures 4,5*. Delicate organs, such as pancreas, should be handled gently using gauze grasped by assistant to prevent related complications, such as pancreatic leak or pancreatitis.

The principles for operator

Needless to say, basic skills, such as stable movement of forceps/energy devices, vessel ligation or hemostatic techniques, should be mastered. Moreover, advanced surgical knowledge regarding lymph node dissection (proper dissection layer, anatomical landmark) or reconstruction (intracorporeal stapling techniques) should be fully understood.

How to teach and how to learn the laparoscopic surgery efficiently?

Because of the complexity of the relevant anatomy, LG had been thought to be difficult to be learned or performed by young surgeons. Detailed standardization of the procedure not only for surgeons but also for co-medical staffs seems to play a pivotal role for it. Although in several situations in actual clinical surgery standardized procedure will not fit due to tumor progression or patient's specific condition, such as obesity, fragility of tissue and adhesion. However, if the principle for surgical performance is decided and shared by surgical team, we can overcome tough situation. Trainer should make effort to teach these methods to trainee using understandable key words such as "triangulation", "move the ground", "no conflict" repeatedly. Trainees should fully understand meanings of these words and practice task in the dry box with purposes, and discuss with trainer or other surgical team members.

In conclusion, we believe, combination of the three factors "learning", "practice" and "experience" are the key words for mastering LG. Trainer should transmit standardized reproducible procedures to trainee using understandable words repeatedly, and trainee should trace trainer's manner repeatedly.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Experience Sharing

I am your eyes—the reflection of being a camera-holder in laparoscopic gastrointestinal surgery

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Abstract: There are two kinds of laparoscopy. It is hard to be a good camera-holder in gastrointestinal surgery. This article aims to introduce the basic structure of laparoscopy and share the experience how to be a good camera-holder, including stable, clear, expose and cooperation.

Keywords: Camera-holder; stable; clear; expose; cooperation

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Introduction

There are two kinds of laparoscopy regarding the direction of view: 0° and 30°. The 30° laparoscopy can provide a wide-field view of operative field in multiple angles by rotating the fiber optics (*Figure 1*), which it is good for showing the frames of surgery and increasing the safety of surgery. As a result, it is adopted by lots of hospital.

Owing to lack of touch, a high quality of visualization is required in laparoscopic surgery. It is necessary for a camera-holder to provide an optimum visualization of operative view which is stable and clear. Also, the camera-holder should have a good teamwork with other operators. A qualified camera-holder should have the ability to learn and summarize from experiences.

Stable

During laparoscopic surgery, the view of operative field should be stable, and the target dissection should be in the center of the screen (*Figure 2*). The camera-holder needs to avoid the fast-movements and frequent rotations which might cause visual fatigue. This requires the camera-holder to have a clear understanding of the surgical procedures, which helps to cooperate by the operating surgeon with each step in a real-time basis. Generally, the camera follows the operating ongoing direction, and move slowly and exactly, so that the surgeon feel comfortable during surgery.

Clear

Before the surgery, we should test the laparoscopy, including white balance, focus, adjusting the brightness, aperture, wiping lens and so on. Fogging and polluting of the lens is the main reasons to the blurry view in surgeries.

The reason of lens fogging is that the temperature of the lens is lower than that of the enterocoelia. Fogging liquidates the lens, and it leads to dim images. Currently, most hospitals use gauze with iodine to scrub the lens. It can clean the feculence on the lens. Moreover, the iodine can create a protective layer to reduce the surface tension and weaken the ability the fog formation. However, when the lens is close to the harmonic scalpel and the electrotome, the lens would still turn foggy because of the significant temperature difference. In order to minimize the temperature difference and prevent fogging, some surgeons soak the lens in warm saline. In general, the temperature of the saline is between 60–70 ℃. Before operation, the lens should be soaked in the saline for 60 seconds. During the operation, this process can be shortened to several seconds. Surgeons use the dry gauze to scrub the lens after taking the lens out from the saline and putting it into the abdomen as soon possible. When fogging or polluting takes place in some emergency situations, and the operation cannot be stopped, camera-holders can wipe the lens on the viscera or the omentum. By this way, it requires that the lens should contact with the viscera completely, briefly, and gently. Once the emergency situation is settled, the lens can be taken to clean. However, sometimes it can be blurrier by doing this, so operators should be cautious to adopt this method. If there is at least one-quarter of the screen being clear, operators should put the operation view at the center of the clear screen. It could save time and the surgery would not be interrupted if camera-holders wipe and soak the lens at the same time when other operators change the appliance.

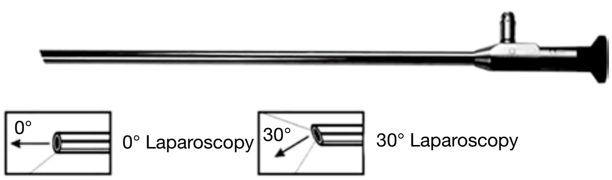

Figure 1 Different endoscopes.

Most lens pollutions are due to narrow space (presacral space, lateral wall of rectum) or getting too close to the surgical site. Especially when the tissue is edematous, bleeding, or adipose, the mist generated by ultrasonic knife, the fragment of tissue, and blood could make the lens dirty. When the ultrasonic knife is working, the lens should be moved backwards to protect the lens, and the lens could be moved forwards after the ultrasonic knife procedure is finished. Meanwhile, the operative field should always be kept in the center of the view. In addition, lens entering trocar is another way to get lens polluted. Because of the pressure difference between enterocoelia and the atmosphere, it pushes out the liquid drop and the tissue from the trocar that causing the lens polluted. Also, the polluted valve can contaminate the lens easily (*Figure 3*). Therefore, cleaning the trocar before the lens entering the trocar is recommended.

Expose

In general, the camera-holder could use the 30° laparoscopy to display a nice image of surgery for the other operators.

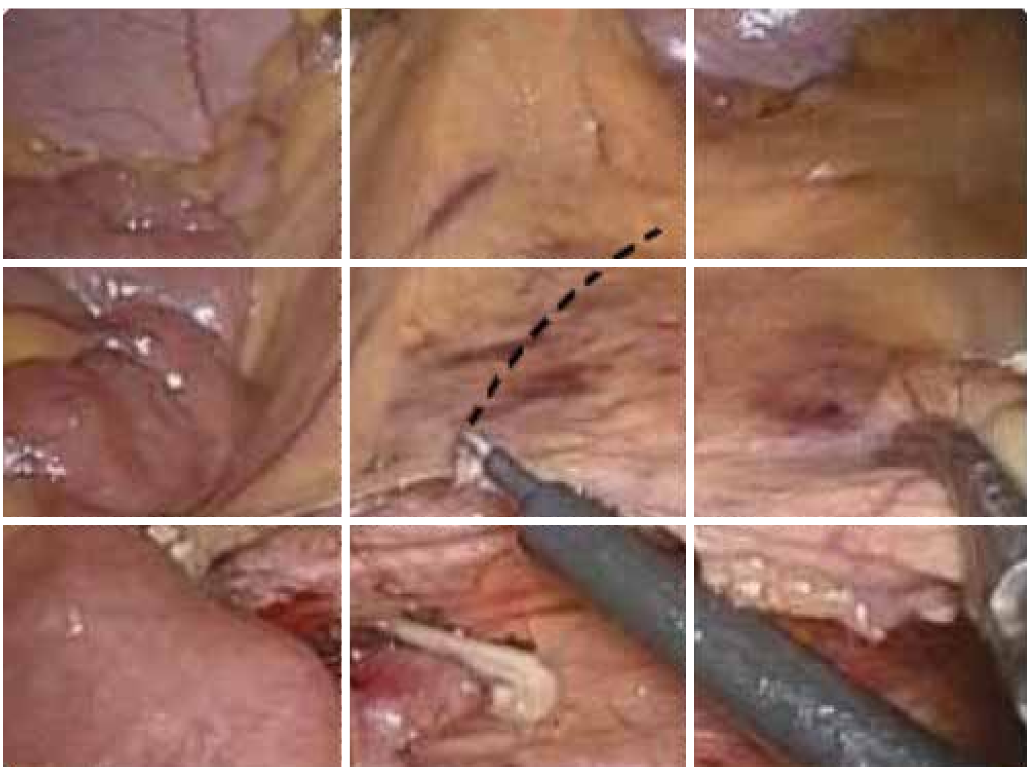

Figure 2 The main battlefield is in the center of the screen.

Figure 3 Trocar pollution.

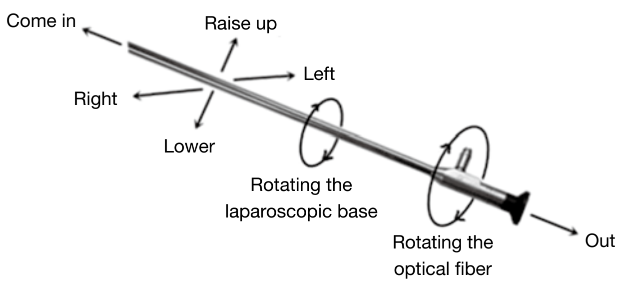

Figure 4 4 planes and 1 deepness.

The camera-holder should show the operative field sufficiently, but avoid arm collision.

Fully understanding of the construction of the 30° laparoscopy is the basis of effectively using it. It consists of the laparoscopic base and fiber-optics. It has four planes and one deepness (*Figure 4*), i.e., rotating the optical fiber in 360°, rotating the laparoscopic base in 90°, the laparoscopic base wiggles to left or right in 360°, raise up or lower the laparoscopic base in 90°, and the laparoscopy comes in and out.

The laparoscopic base is similar to a human body (*Figure 5*). When operating, the operator should put it in a flat plane to provide the same angle of view as the open operation. No matter how to change the position during operation, the viscera should be in a horizontal position and the base should be parallel to the operative field, or the vertical axis lens barrel and base should be vertical to the operative field. When the patient is at the left lateral position, the base should rotate to left to maintain the angle, and so as to the right lateral position. During operation, operators can make reference to the viscera. For

Figure 5 Parallel to the operative field.

example, when having an operation at upper abdomen, operators should keep the liver and pancreas horizontal (*Figure 6*); when having an operation at lower abdomen, operators should keep the uterus and the urinary bladder at 12 o'clock position (*Figure 7*); when dissociating the inferior mesenteric vessels, operators should keep the abdominal aorta horizontal (*Figure 8*); when dissociating the right colon vascular, operators should keep the superior mesenteric vein (SMV) vertical (*Figure 9*). In brief, operators should rotate the base on the basis of the different operating plane.

The laparoscopy could go forward and backward to achieve the best view. When it goes forward, the view becomes smaller and displays more details of the target dissection; when it goes backward, the view becomes bigger and the image of target dissection is shrunken. In most

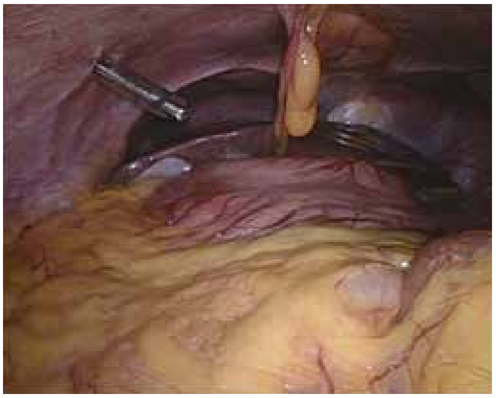

Figure 6 Liver horizontal.

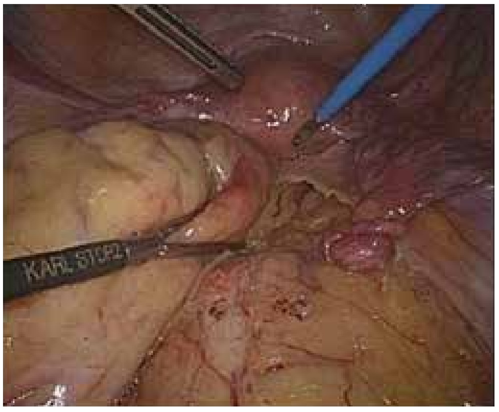

Figure 7 Uterus at 12 o'clock.

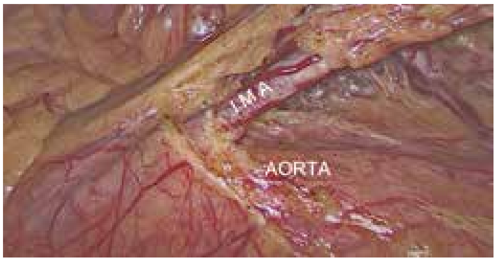

Figure 8 Abdominal aorta horizontal.

cases, operators would choose a perfect visual to have a better knowledge of the overall structure including the target and the surrounding dissection. When having a micro or dangerous operation, operators should use close-up viewing. When trying to recognize the anatomical position or searching, a distanced viewing would be more effective. In addition, camera-holders should timely adjust

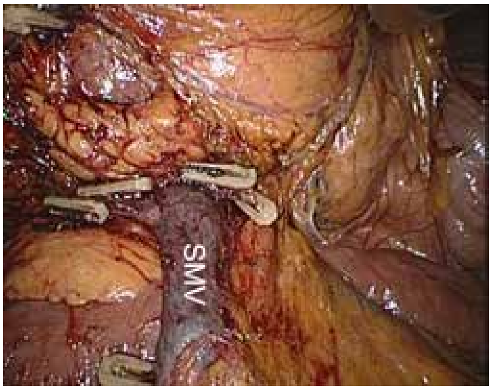

Figure 9 SMV vertical. SMV, superior mesenteric vein.

the laparoscopy (i.e., wiggle to left or right, raise and lower the laparoscopy) to coordinate with rotated fiber optics and keep the operating dissection at the middle of screen.

Rotating the fiber optics can provide another plane for 30° laparoscopy. To rotate the fiber optics' mirror surface is similar to rotate human head with long braid, and the fiber optics moves in opposite direction as the surface goes. The displayed image would not be bottom up. For example, when the fiber-optic is rotated to the left, it will show the right. When it is rotated by 180°, it will show the top, which is called "looking at the ceiling". This is an important method in radical proctectomy for rectal cancer when dissecting the anterior sacral ligament.

It is important to understand when to rotate the 30° laparoscopy camera. First of all, the aim of rotating the 30° laparoscopy is to provide an optimum view that we can observe the target dissection and operating apparatus. During an operation, there are many situations that may cause poor viewing (not showing the overall structure or only showing the end of the operating apparatus), such as limited operating space, inappropriate angle, or the unsatisfied trocar location. If operators force to operate, other tissue may be injured. Especially when denudating the vessel, it leads to bleed easily. Therefore, we rotate the fibers to adjust the angle of view to avoid unnecessary injury. Second, rotating the 30° laparoscopy can provide an excellent angle of view for other operators. Some camera-holders may keep the operative field at the middle of screen, but they are unable to show a clear image of the tissue around or behind because of an inappropriate angle. By adjusting the angle of the optic fiber, coordinating with the wiggling laparoscopy, and maintaining vertical angle to operating position, so that operators can obtain the better view and recognize the anatomy, and avoid injury. At last, to rotate 30° laparoscopy can reduce the problem causing by wide-angle wiggling laparoscopy. Wide-angle of wiggling may disturb the operator. Rotating 30° laparoscopy can decrease the angle of wiggling. Since the body of laparoscopy and fiber optics are not independent sections, rotating the fiber optics should coordinate with the body of laparoscopy.

Cooperation

A successful surgery requires that the operator, camera-holder and nurse should cooperate with each other. As a camera-holder, one should not only understand the basic principle of control the camera, but also try to understand every operation, every step of the operation, and the habit of every operator, so that the camera-holder can better predict the operator's intention in advance, and provide the best view for the operator. Holding the laparoscopy is not only a physical work, but also a technical work. Only when we practice and make summarization constantly, can we master the skill of holding the laparoscopy and make the operation fluent.

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Footnote

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Small gauze, big skills—the application of gauze in laparoscopic gastrointestinal surgery

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Abstract: This article aims to introduce the application of gauze in laparoscopic gastrointestinal surgery. When we perform a gastrointestinal surgery, we usually use the instruments which were sharp and hard to help us to finish the surgery better, however, it also causes the extra damage. So the application of gauze is important. But what is the most suitable gauze and how to use it properly? This article is to solve this problem. We consider that a perfect gauze should have strong absorbing capability, has the proper size, with the clear mark, and can be positioned with X-ray. And we introduce the function of the gauze like compression, blockage, cushion, indication, prevention, blunt dissection, insulation. Of course, there are shortcomings of gauze, if you use the gauze improperly, it will be a nightmare.

Keywords: Gauze; laparoscopic surgery; gastrointestinal; compression; blockage; cushion; indication; prevention; blunt dissection; insulation

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In the process of learning laparoscopic gastrointestinal surgery, young surgeons always pay attention to the dissection and digestive tract reconstruction. Learning how to expose the operative field and cooperate harmoniously with the operators are very important for the assistants. However we rarely pay attention to the way the operator using his left hand to assist with the surgery.

I usually analog laparoscopic surgery to a duel which needs capable of both attack and defense. Harmonic scalpel and electrome are our swords for the tissue dissection. The instruments of laparoscopic surgery are mostly sharp and hard, it is sophisticated but also easy to damage the normal tissues and organs. We recommend soft gauze as shield during the laparoscopic surgery. It can make up for the shortcoming of the laparoscopic instruments, help us complete a preferable laparoscopic gastrointestinal surgery, reducing vice injury.

We use gauze on daily basis, but seldom considering much about how to choose it. A piece of perfect gauze should meet the following criteria:

(I) Strong absorbing capability, can absorb the blood, and make a clear view of the operation.
(II) Proper size, suitable for the operation of laparoscopic, and could access 12 mm trocar freely. We choose 20 cm × 4 cm gauze as a dedicated laparoscopic gauze, accord with most of the reports in literature abroad.
(III) Clear mark, can be identified easily during the operation.
(IV) X-ray developable mark line, it can be identified and positioned with X-ray.
(V) Based on my personal experiences, several methods are summarized here regarding how to use gauze in laparoscopic gastrointestinal surgery, and hope could be useful for surgical professionals.

Compression

Compression is the most commonly used function of gauze in surgery, and also it is one of the most important functions of gauze. When faced with small ooze blood in laparoscopic surgery, it's easy to damage the surrounding tissue if we

Figure 1 Superior spleen bleeding.

Figure 2 Gauze compression.

Figure 3 Use gauze to fend off the small intestine.

Figure 4 Operative field without interference.

using harmonic scalpel and electrome blindly, such as normal intestinal wall, ureter, presacral tissue, spleen, etc. (*Figures 1,2*). If conditions allows, it is more effective to use hemostatic gauze.

Blockage

Exposure is important in laparoscopic gastrointestinal surgery. But there are times we unable to make the small intestine away from our operative field by position changes. We use a gauze to fend off the small intestine as the terminal ileum always interfere in the operative field when we dissected the left Toldt's space (*Figures 3,4*). At the same time, as the gauze is just around the operative field, it is ready at hand when we encounter a small bleeding.

Cushion

The laparoscopic instruments are sharp and hard, it is easy to damage the normal tissue during the surgery, especially by the time we meet the pancreas, liver and other organizations (*Figures 5-7*). We can use gauze to increase the contact area and reduce the damage to the organization, increase the exposed area and expand the space of operation at the same time.

Indication

Different from traditional open abdomen operation, laparoscopic gastrointestinal surgery separates space first and then removes the upper tissue. Due to the limitations of laparoscopic vision, we could only judge the anatomical level through observation. There is a certain difficulty in the confluence of two levels and it is easy to damage the lower normal tissue. We usually placed gauzes to indicate the level of the clearance. For instance, we put a gauze in the dissected Toldt's space during the sigmoidectomy to avoid injury of ureter (*Figures 8,9*). Gauzes covered on pancreatic head and duodenum during the dissection of hepatocolic ligament (*Figures 10,11*).

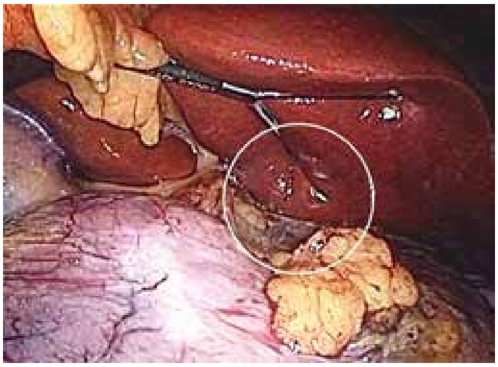

Figure 5 Liver injury.

Figure 6 Liver injury reduced after using gauze.

Figure 7 Protect the pancreas.

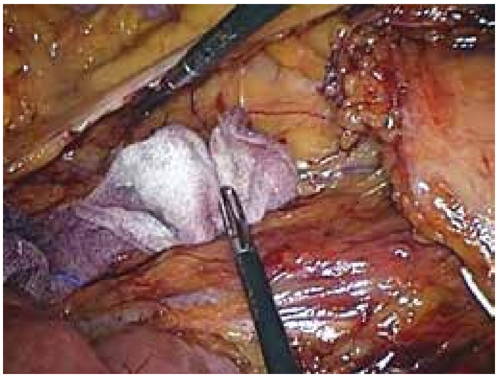

Figure 8 Put gauze into the left Toldt's space.

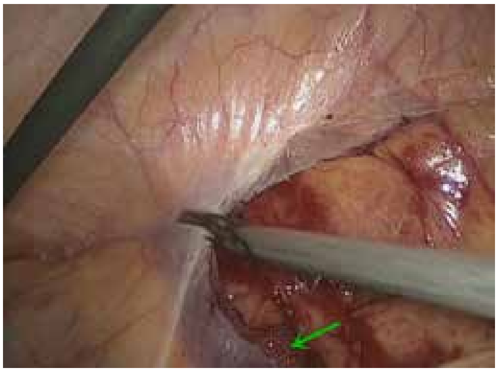

Figure 9 Separate the left paracolic sulci.

Figure 10 The right hemicolectomy, gauzes instruct the right Toldt's space.

Prevention

Subsidiary-injury is the biggest issue that confronts the beginners. Besides the influence of human factor, we could use some little tips to protect surrounding tissues from being injured. Method which was often used is utilizing gauze to fend off surrounding tissues. For example, in addition to indicating the Toldt's clearance, gauzes we put at the juncture of the left Toldt's clearance and the left ureter during the operation sigmoid could also protect the left ureter from being injured when we separate the left

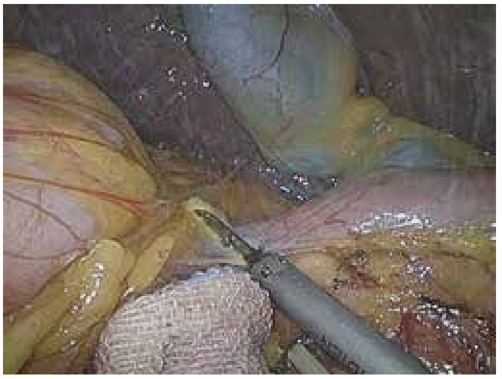

Figure 11 The right hemicolectomy, see the gauzes placed in the right Toldt's space.

Figure 12 Cover on the head of pancreas.

Figure 13 "Peanut".

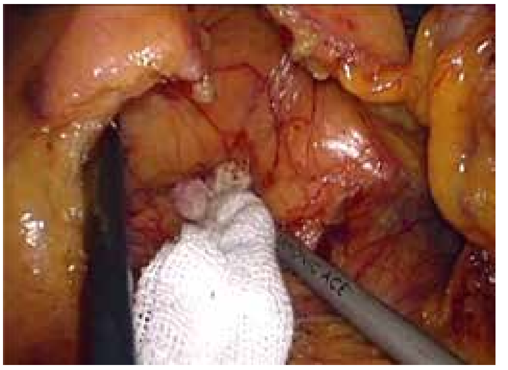

Figure 14 Expanding Toldt's space.

paracolic sulci (*Figure 12*). In the same way, the small gauzes could not only support the Toldt's clearance, but also keep the duodenum and the head of pancreas unharmed during the right hemicolectomy.

Blunt dissection

The laparoscopic instrument "Peanut" (*Figure 13*) used to perform blunt dissection in surgical space. In our institute, for a lot of reasons, "Peanut" is unavailable. We use the ultracision clamping a gauze to accomplish blunt dissection. Gauze has a large contact area which is an advantage comparing to the "Peanut" in expanding Toldt's space (*Figure 14*). Furthermore, you can manage the hemorrhage immediately by using the ultracision during the blunt dissection.

Insulation

After the surgery, normal saline (NS) is usually utilized to irrigate the operating field. When we use a suction, it usually plugged, in this moment, a small gauze placed on the area for suction is significant. This application would not only protect the surrounding tissue but also make the use of siphoning of the gauze (*Figure 15*).

Gauze is a good helper, but it can be a tragedy if it is not used properly.

Remnant of gauze is the nightmare to patience and surgeons! To avoid that, my suggestion is: (I) when using gauzes, they should be placed at a place without the intestine and omentum interference, such as hepatorenal

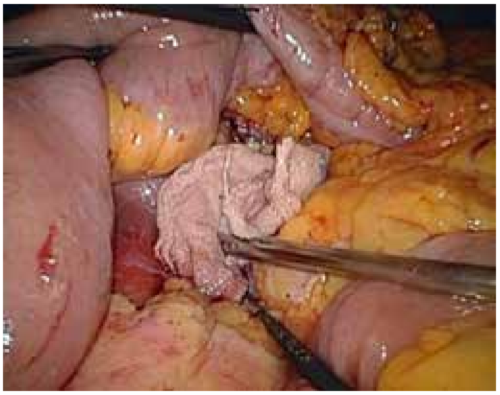

Figure 15 Gauze can enhance the aspirator efficiency.

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recess, presacral space, spleen fossa and the place easy for searching; (II) if it is allowed, it would be optimal to follow the "one by one" principle, which means to remove the gauze after using it. It will reduce the chance of mistakes.

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Footnote

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Gastric Surgery

Laparoscopic radical gastrectomy for gastric cancer: traps and strategies

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Introduction

Surgeries remain the mainstream treatment for gastric cancer. Early in 1991, Kitano *et al.* conducted the first laparoscopy-assisted distal gastrectomy for treating early gastric cancer. In the past two decades, the surgical techniques have become more mature, along with increased surgical indications and lower incidences of surgery-related complications. However, due to the rich blood supply, multiple anatomic levels, complex lymph node dissection, and special requirements of the laparoscopy itself, this surgery is quite difficult and has high technical requirements. During the laparoscopic radical gastrectomy, it is equally important to achieve the complete resection of the tumor and to ensure the surgical safety. As the laparoscopic radical gastrectomy has increasingly been applied, it has become a priority to pay special attention to the safety of this surgical technique, so as to avoid the occurence of severe complications. Based on literature review and clinical experiences, we elucidate the challenges and strategies of laparoscopic radical gastrectomy for gastric cancer.

Complications of laparoscopic radical gastrectomy for gastric cancer

East Asia has the highest gastric cancer rates in the world. Also, the frequencies and types of the complications of the laparoscopic radical gastrectomy for gastric cancer were also similar among China, Japan, and Korea. According to a national survey conducted by the Japan Society of Endoscopic Surgery (JSES), 10,951 patients underwent laparoscopic radical gastrectomy for distal gastric cancer in 2010 and 2011, among whom the incidences of intra- and post-operative complications were 1.3% and 9.1%, respectively; 2,278 patients underwent laparoscopic total gastrectomy, among whom the incidences of intra- and post-operative complications were 2.5% and 19.4%, respectively; 666 patients underwent laparoscopic radical gastrectomy for proximal gastric cancer, among whom the incidences of intra- and post-operative complications were 1.7% and 18.0%, respectively (*Figure 1*). In a Korean retrospective study enrolling, 1,485 patients who had received laparoscopic radical gastrectomy for gastric cancer in 10 centers showed that the incidence of the surgery-related complications was 14.0%. The Chinese Laparoscopic Gastrointestinal Surgery Study (CLASS) group retrospectively analyzed 1,331 patients who had undergone laparoscopic radical gastrectomy in multiple centers and found the incidence of the surgery-related complications was 11.3%. Shanghai Ruijin Hospital also retrospectively analyzed 312 patients who had undergone laparoscopic radical gastrectomy and found the incidence of the surgery-related complications was 11.2%. Many retrospective studies and a few prospective studies with small sample sizes have demonstrated that the incidences of the laparoscopic radical gastrectomy-related complications are equal to those of open surgeries. Also, its pattern is also similar to that of open surgery. For example, the incidences of complications are higher after laparoscopic total gastrectomy than after radical distal gastrectomy, and are higher in patients with advanced gastric cancer than those with early gastric cancer. Thus, although the laparoscopic radical gastrectomy has been applied for treating gastric

Nationwide surveys conducted by JSES	7th(2002-2003)	8th(2004-2005)	9th(2006-2007)	10th(2008-2009)	11th(2010-2011)
Intra-operative complications					
LADG	3.5%(94/2671)	1.9%(71/3729)	1.7%(112/6615)	1.1%(11/10355)	1.3%(71/10951)
LATG	0.8%(1/128)	5.1%(16/312)	2.1%(22/1023)	2.6%(50/1909)	2.5%(16/2278)
LAPG	8.3%(10/120)	2.7%(6/223)	1.3%(11/811)	1.2%(7/583)	1.7%(6/666)
Post-operative complications					
LADG	14.3%(383/2671)	9.0%(341/3729)	8.2%(543/6615)	7.5%(777/10355)	9.1%(341/10951)
LATG	28.9%(37/128)	7.1%(22/312)	14.1%(144/1023)	21.8%(416/1909)	19.4%(22/2278)
LAPG	33.3%(40/120)	14.3%(32/223)	9.1%(74/811)	16.2%(94/583)	18.0%(32/666)

Figure 1 Nationwide surveys on the complications of laparoscopic surgeries for gastric cancer by the Japan Society of Endoscopic Surgery (JSES).

cancer for over 20 years, there are still some challenges to be addressed.

Lymph node dissection during laparoscopic radical gastrectomy for gastric cancer: challenges and strategies

Like the open surgery, the extent of lymph node dissection during the laparoscopic radical gastrectomy for gastric cancer must also follow certain rules. The Japanese gastric cancer treatment guideline (3rd edition) released by Japan in 2010 have been widely recognized as the most instructive documents in this field. In the document, the extent of lymph node dissection was dramatically changed. For the distal gastric cancer, the D1 was modified from the dissection of No. 3, 4d, 5, and 6 to the dissection of No. 1, 3, 4sb, 4d, 5, 6, and 7 (+ No. 1, 4sb and 7); for D2, the resected lymph nodes were changed from D1 + No.1, 7, 8a, 9, 11p, 12a, 14v to D1 + No. 8a, 9, 11p, and 12a (– No. 14v). The most common complication of the laparoscopic D2 lymphadenectomy for gastric cancer is intraoperative intraperitoneal hemorrhage. The following hemorrhage-prone sites are also the largest challenges during the surgery:

(I) Hemorrhage when dissociating the right gastroepiploic vein (RGEV): often due to the damage of the branches of the anterior superior pancreaticoduodenal vein (ASPDV) and subpyloric vein or the head of the pancreas. When handling RGEV from its root, dissection of No. 6 can easily damage the ASPDV and thus cause bleeding. ASPDV is typically small and prostrate at the pancreatic head and can retract back once being damaged, making the hemostasis particularly difficult. Improper hemostasis can hurt the head of the pancreas and even the right colic vein or Henle's trunk, causing more severe bleeding. Thus, during the handling of RGEV, the fusion fascia between the descending part of duodenum and the mesentery of transverse colon should be dissociated firstly. Then, the middle colic artery can be used as a marker. It is always located at the middle-right of the mesentery of transverse colon, with obvious beating activity. With the middle colic artery as the marker, the anterior lobe of the mesentery of transverse colon was dissected upwards till the lower edge of the neck of pancreas, and then the Henle's trunk can be visible. The Henle's trunk usually is joined by RGEV, ASPDV, and accessory right colic vein. RGEV can be tracked along the Henle's truck. Excessive skeletonization of this vein is unnecessary; instead, divide it after clamping with absorbable clips. Furthermore, after the division of RGEV, the lymphadenectomy along the surface of the head of the pancreas is somehow like an action of "climbing a hill". RGEV is not closely accompanied by the right gastroepiploic artery (RGEA): the root of RGEV is often located at the lower edge of the head of the pancreas, and the root of RGEA is often close to the upper edge of the head of the pancreas. Thus, they need to be handled separately (*Figure 2*).

(II) Hemorrhage when dissociating the right gastric artery: the hemorrhage often occurs at the superior pancreaticoduodenal artery. Since the laparoscope can provide views from multiple angles, the operator can search for the root of the right gastric artery along the gastroduodenal artery and the proper hepatic artery and dissect the No. 5 lymph nodes, during which the superior pancreaticoduodenal artery between the duodenal bulb and the right gastric artery may be damaged. The superior pancreaticoduodenal artery often has two or three branches, and can not be clearly exposed even after the gastric antrum and duodenum are pulled upward. When it is particularly difficult to dissociate the right gastric artery backward, a frontwards approach may be adopted, which allows a more convenient and safer maneuver. In addition, during the backward division of the right gastric artery, the proper

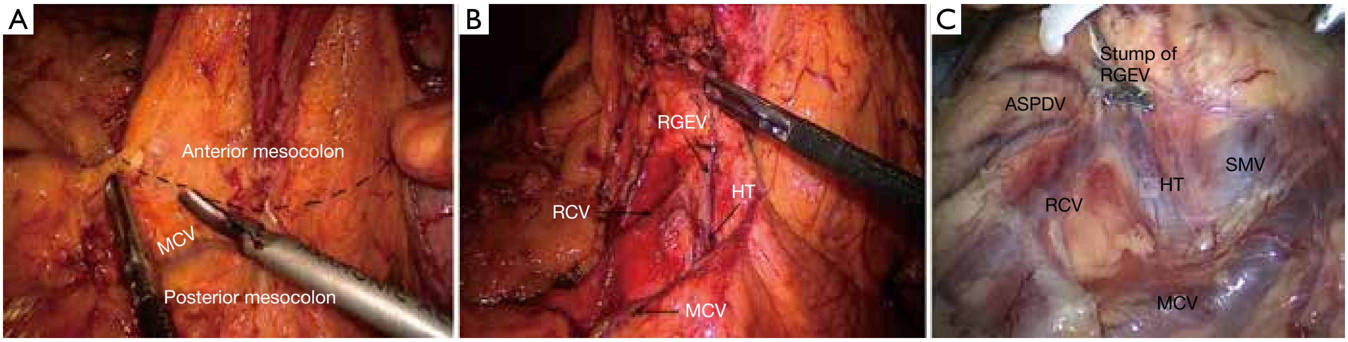

Figure 2 Handling of the right gastroepiploic vein.

hepatic artery must be exposed firstly, so as to avoid the division of the circuitous proper hepatic artery as the right gastric artery by mistake.

(III) Hemorrhage after the spleen damage: hemorrhage is often occurs at the early stage of surgery and can be difficult to stop. It is often due to the rupture of the capsule of the spleen after the assistant pulls the greater omentum in an improper manner. Anatomically, the greater omentum often has membraneous fusions with the middle or lower capsules of the spleen. During the dissection of the No. 4sb lymph node, the assistant may excessively pull the greater omentum with an attempt to expose the dissection field more clearly; as a result, the tension at the fusion area becomes too large and thus the spleen capsule is torn. To prevent this situation from happening, the adhesions between the greater omentum with the left diaphragm/spleen capsule may be loosened before the dissection of No. 4sb lymph node, so that the dissection field can be easily and clearly exposed and meanwhile the risk of bleeding can be avoid. Another situation is: the last branch of the short gastric arteries may be extremely short in some patients. It may directly drain into the superior polar artery of the spleen. The stomach fundus is closely attached to the the upper pole of the spleen, resulting in the loss of the gap between stomach and spleen. Forceful traction by the assistant will cause the rupture of the vessel; once torn, the broken end is extremely difficult to manage, and any careless handling may lead to even heavier bleeding due to the injury of the upper pole of the spleen. If such condition occurs, it is more feasible to handle the posterior gastric artery firstly, then handle this condition after lifting the stomach fundus from the back side of the stomach; alternatively, open the the lining of the lower part of the esophagus and handle the condition after pulling the stomach fundus from the front to the lower right side.

(IV) Hemorrhage at the left gastric vein: left gastric vein, with some variations, can drain into the portal or splenic vein via the front/back side of the common hepatic artery or splenic artery. During the dissection of the lymph nodes on the upper edge of the pancreas, neglecting the anatomical variation of this vein may cause injury, resulting in massive bi-directional bleeding, which can affect the effective dissection of the lymph nodes on the upper edge of the pancreas. If the broken end retracts back after the injury, the handling will be even more difficult. Therefore, the operator must be familiar with the variations in the left gastric vein. During the exposure, the assistant need to maintain certain tension of the gastropancreatic fold but must avoid excessive traction. When an ultrasonic scalpel is used to dissect lymph nodes on the upper margin of the pancreas, tissue atomization and a small amount of capillary hemorrhage from the penetrating branches of the vein inside the lymph nodes may affect the visual field and operations of the operator. By using a small-flow intermittent suctioning technique, the assistant can clearly expose the surgical field and effectively avoid such injuries.

(V) Splenic hilar vascular hemorrhage: the No. 10 lymph node needs to be dissected during the radical total gastrectomy with D2 dissection (TG + D2). Laparoscopic spleen-conserving splenic hilar lymph node dissection is similar to the in situ splenic hilar lymph node dissection under open laparotomy in terms of surgical procedures. Nevertheless, the laparoscopy brings clearer and larger surgical field, the ultrasonic scalpel has better hemostatic effectiveness, and the surgical instruments can operate in deeper sites. All these features make the in situ splenic hilar lymph node dissection become possible under laparoscope. However, the splenic hilar area has complex vessels, deep location, and narrow space, which brings high risks of vascular injury and bleeding at the splenic pole and splenic lobes. Computed tomography angiography (CTA) should be performed before surgery to find out the course of the splenic artery and its relationship with the body and tail of the pancreas, learn the type of the terminal branches of the splenic artery, and identify the types of vessels in the splenic lobes. During the surgery, dissection of the pancreatic tissue by mistake will lead to postoperative pancreatic fistula. Also, injury of the terminal branches of the splenic artery will cause uncontrolable bleeding or splenic lobe ischemia. If hemorrhage occurs, the assistant shall assist the exposure with one hand; meanwhile, he/she shall perform small-flow intermittent suctioning with another hand, so as to expose the bleeding site. The operator should quickly and gently clamp the bleeding site with noninvasive grasping forceps to control bleeding; meanwhile, titanium clips should be applied to stop bleeding. In addition, the proper positioning of the operator is also very important. During the splenic hilar lymph node dissection, the operator can stand between patient's legs, so as to facilitate the stable operations with the right hand. Also, this procedure should be performed by a fixed group with rich experiences in D2 laparoscopic radical resection for gastric cancer.

Digestive tract reconstruction during laparoscopic radical gastrectomy for gastric cancer: challenges and strategies

Digestive tract reconstruction is key to the success of laparoscopic radical gastrectomy for gastric cancer. Anastomotic leakage, haemorrhage, and stricture are the most common complications after the laparoscopic radical gastrectomy for gastric cancer. These three complications have common causes and are ofter correlated with each other. Digestive tract reconstruction after laparoscopic radical gastrectomy for gastric cancer is often performed using small incisions, whereas its procedures often refer to those used in conventional open surgery. However, these small incisions limit the visual field and may lead to excessive traction, thus resulting in anastomosis-related complications. It remains particularly problematic during the reconstruction after laparoscopic total gastrectomy.

(I) Digestive tract reconstruction after laparoscopic distal gastrectomy: small incision-assisted approaches are often used, with the most common surgical procedures including Billroth-I, Billroth-II, and Roux-en-Y reconstruction.

(i) Billroth-I reconstruction is recommended for tension-free anastomosis. It is easy to perform and physiologically most feasible. The incidences of postoperative complications such as reflux gastritis, dumping syndrome, malnutrition, and gall stones significantly reduced after the Billroth-I reconstruction. However, the blood supply of the anastomosis must be ensured. It can be affected by both the preservation (or not) of the short gastric vessels and posterior gastric vessels and the distance between the anastomosis and the gastric cutting line. If the Billroth-I reconstruction is applied for the anastomosis between the duodenal stump and the posterior wall of the remnant stomach, a 3-cm gap should be kept between the anastomosis and the gastric stump, so as to avoid anastomotic ischemia.

(ii) However, Billroth-I reconstruction is not feasible for anastomosis under tension. Billroth-II reconstruction will be applied instead. It is featured by tension-free anastomosis, easier performance, and smaller incisions. However, compared with Billroth-I reconstruction, it has higher incidence of complications. In particular, the leakage of the duodenal stump due to afferent loop obstruction and internal hernia must be repaired by a second surgery. Although the retrocolic anastomosis (or together with Braun anastomosis) can effectively lower the incidences of such severe complications, alkaline reflux gastritis and anastomosis inflammation will be unavoidable.

(iii) If the remnant stomach is relative small, the anastomosis has tension if treated with Billroth-I reconstruction, or the tumor is near the pylorus, we prefer to use the Roux-en-Y reconstruction instread. The Roux-en-Y reconstruction can create tension-free anastomosis and effectively lower the incidences of complications such as bile reflux, residual gastritis, anastomotic leakage, and anastomotic stricture. It may also be helpful in treating type 2 diabetes mellitus. However, the Roux-en-Y reconstruction also has some limitations. In particular, it may lead to Roux stasis syndrome, which is manifested by vomiting of food but not bile, postprandial pain, and nausea. For these patients, indwelling of gastric tube and "wait and see" will help to achieve self healing. Smaller remnant stomach and shorter Roux loop are effective prevention strategies. In our practices, we have shortened the length of the Roux loop from 40 to 30 cm, which effectively lowers the incidence of Roux stasis syndrome.

In 2002, Kanaya *et al.* for the first time discribed the application of Delta-shaped anastomosis in totally laparoscopic D2 radical distal gastrectomy, during which the endoscopic cutter stapler is used to complete the Billroth-I reconstruction. As a rationally designed method, it has larger inner diameter of the anastomosis, shorter reconstruction duration, and lower incidence of anastomotic leakage. As a safe and relatively easy Billroth-I reconstruction for totally laparoscopic surgeries, it is worthy of our reference. For instance, during the stomach-jejunum Roux-en-Y anastomosis, we prefer to employ an iso-peristaltic method, during which the common entry was sutured artificially; however, it is often difficult if performed totally under laparoscopy. In recent years, we begin to apply an anti-peristaltic method instead, during with the common entry is closed using the linear stapler totally under laparoscopy. It is an easy and safe procedure, and can be a useful anastomosis totally under laparoscopy.

(II) Digestive tract reconstruction after laparoscopic proximal gastrectomy: laparoscopic proximal gastrectomy is feasible for treating upper gastric cancer (Ia stage) and early gastric cancer (Ib stage, sized <2 cm). For these conditions, the digestive tract reconstruction is mainly applied for residual stomach-esophagus anastomosis using small incisions. Although the end-to-side anastomosis between the esophagus and the anterior wall of remnant stomach is simple, less time-consuming, and physiologically feasible and has a low incidence of anastomotic leakage, the high incidence of postoperative reflux esophagitis remains a big challenge. Some patients may complain of obvious retrosternal burning sensation, and a second surgery will be needed in severe cases. Therefore, although the laparoscopic proximal gastrectomy may preserve the physiological functions of some remnant stomach and the patients may benefit from quicker body weight gain and better nutrition status, many surgeons still prefer to perform total gastrectomy. In recent years, we have employed the esophagus-tubular stomach anastomosis, which can remarkably lower the incidence of reflux esophagitis. During the tubular gastroplasty, the right gastro-omental artery and vein as well as the distal branch of the right gastric artery are preserved; an anvil was placed after the esophagus was transected; a tubular stomach (15-20 cm in length and 3-4 cm in width) was made from the remnant greater curvature of stomach using the linear stapler. The pyloric canal must be preserved. The end-to-side anastomosis between the esophagus and the anterior wall of the tubular stomach was performed using a circular stapler. Since it has a single anastomosis and the operation is quite simple under the assistance of small incisions, this reconstruction been regarded as an effective method for preventing postoperative reflux esophagitis.

(III) Digestive tract reconstruction after laparoscopic total gastrectomy: during the laparoscopic total gastrectomy, the exposure of the lower esophageal is more complete, and surgical field is clearer, and the dissociation is more convenient. Small incision-assisted Roux-en-Y reconstruction is often preferred. This procedure is highly safe, easy to perform, time-saving, and economically affordable. Therefore, it has become the most commonly used reconstruction method. However, this procedure also has some limitations: it is often limited by the patients' body shape and the tumor condition. In patients with obesity, left hepatic hypertrophy, small costal angle, or high tumor location, the esophagus is expected to be divided at relatively high level. In such cases, the small incision-assisted reconstruction is often more difficult, and the incision often has to be extended to ensure the safety of the procedure. Therefore, in difficult cases, appropriately extending the small incision is particularly important to ensure the anastomosis safety. To avoid this limitation, in recent years we have adopted the completely laparoscopic oesophagus-jejunum anastomosis, which has shown better surgical field, simpler operation, and higher safety. It may the optimal digestive tract reconstruction method after laparoscopic total gastrectomy. The completely laparoscopic oesophagus-jejunum anastomosis can be performed using two different instruments: circular stapler and linear cutter & stapler.

The most challenging tasks during this procedure include the purse-string suture and the placement of an anvil. In previous practices, after the thorough dissociation of the esophagus, part of the esophageal wall shall be dissected; then, after the purse-string suture and the placement of an anvil are peformed under the laparoscope, divide the esophagus after tightening the purse-string. This approach is safer and more effective than the placement of an anvil after the complete transection of the esophagus and then the purse-string suture, thus avoiding the retraction of the esophageal stump. In recent years, we also apply the OrVil™ system (Covidien, USA) for anastomosis. Compared with other products, the OrVil™ system is easier to grasp and enables anastomosis at higher locations; also, it can achieve higher surgical margins (compared with the purse-string suture) and ensure the complete surgical margin, safe digestive tract reconstruction, and short surgical time. This product actually is a modified circular stapler. Compared with the conventional circular stapler, the OrVil™ system allows the placement of the anvil downwards via the esophagus. Some notable points include: (i) the introducer of the OrVil™ system must be thoroughly lubricated; (ii) the placement of the OrVil™ system via mouth should be performed by an anesthesiologist; it should be conducted under the direct vision of the laryngoscopy after the release of the safety airbag of the tracheal tube; (iii) avoid making too large hole at the esophageal stump; and (iv) the introducer should be gently pulled under the laparoscopy; excessively forceful pulling may cause the avulsion of the esophagus. However, the application of the OrVil™ system is limited by its high price. Thus, we have introduced a simple and safe "anti-puncturing" approach for oesophagus-jejunum anastomosis. This approach, initially reported by Omori *et al.*, uses a #25 tubular stapler anvil and allows a 2-0 sewing needle with stitches to penetrate through the hole on its tip; the tail of the stitches is knotted to form a 2-cm woven braid. After the thorough dissociation of the stomach and esophagus, a small incision is made at the anterior wall of the esophagus, via which the device is delivered into the lower part of the esophagus, with its head facing the oral cavity. Then, the needle with stitches is sewed reversely at the anterior wall of the esophagus over the incision. The anvil is introduced and then tightened. The closure of the esophageal stump is completed using a linear stapler under the anvil. Thus, we use the stapler to replace the conventional purse-string suture and simplify the operational steps; thus, it can achieve higher cutting edge and lower surgical cost when compared with the OrVil™ system.

The completely laparoscopic esophagus-jejunum anastomosis using linear stapler was firstly proposed by Uyama *et al.* and then modified by Okabe *et al.* in 2009. Based on Kanaya's delta anastomosis and Okabe's FETE anastomosis, we performed a total of seven cases of completely laparoscopic esophagus-jejunum anastomosis from July 2013 to October 2013. The average operative time was (234±23) min, and the time consumed during the anastomosis was (34±7) min. There was no post-operative complication such as anastomotic fistula, anastomotic stricture, or abdominal infection, and the short-term follow-up outcomes were satisfactory. The completely laparoscopic anastomosis using linear stapler have some advantages: (i) it avoids the two difficult steps (purse-string suture and anvil placement) in the circular stapler-based procedure; (ii) it avoids the difficulty in placing the stapler into esophagus or jejunum with small diameters; (iii) the diameter of the anastomosis is not constrained by the esophagus diameter, which lowers the risk of anastomotic stricture after the surgery; and (iv) the whole anastomosis procedure is competed under the direct vision of laparoscope. However, such procedures also have some limitations: (i) when the anastomosis level is above the esophageal hiatus, the space inside the mediastinum is relatively narrow and often blocked by bilateral diaphragm angles, making the anastomosis under the laparoscopic monitoring particularly difficult; (ii) when the anastomosis level is relatively high, the closure of the common entry after the esophagus-jejunum anastomosis, whether by using a linear stapler or artificially, will be quite difficult; (iii) during the surgery, it needs 5-7 staplers, which is a little expensive. In our opinion, the completely laparoscopic esophagus-jejunum anastomosis is quite convenient and simple, with better anastomotic vision and larger anastomotic diameter; furthermore, it will not increase the anastomotic time. Therefore, it is a relatively safe, simple, and effective anastomotic method. In a recent report, Okabe *et al.* reported that they had performed completely laparoscopic esophagus-jejunum anastomosis using linear stapler in 104 patients, with a median follow-up of 29.6 months and an overall survival rate of 96.5%. Among these patients, the incidence of anastomotic leakage was 2.9%, which is similar to that of conventional open surgery. No anastomotic stricture was found. Obviously, the linear cutter & stapler has its unique advantages and can dramatically improve the patients' quality of life.

Laparoscopic radical gastrectomy for gastric cancer requires the operator to have both the solid anatomic knowledge on gastric cancer and skillful laparoscopic operation capabilities. Any problem encountered during the surgery can be addressed using a progressive strategy. During the patient selection, a less experienced operator shall choose relatively younger and thinner patients with gastric cancers still in the early stages. It is believed that, along with the accumulated knowledge on gastric cancer and the improved skills in laparoscopic operations, the laparoscopic surgical treatment for gastric cancer will be further improved and promoted in China.

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Footnote

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Technical tips of laparoscopic linear-stapled esophagojejunostomy (overlap method)

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Abstract: Laparoscopic esophagojejunostomy is one of the most technically challenging aspects when expanding institutional indication from distal to total gastrectomy. Expected advantages of linear-stapled overlap method are better intraperitoneal visibility, wide applicability to high anastomosis or small-sized intestine, and no concern for postoperative stenosis. In our standardized method, the esophagus is divided after twisted in 90 degree clockwise, so that the esophageal stump results in vertical direction. The jejunum is anastomosed to posterior wall of the esophagus, to make an opening hole face anterior, which enables stress-free suturing for closure. During the anastomotic steps, guidance by a nasogastric tube is very useful. Additionally, preparation of the tension-free jejunal limb is essential for secure anastomosis. In high anastomosis, the diaphragmatic crus should be cut to widen the esophageal hiatus. Articulating function of the linear stapler is useful to adjust the insertion axis to the esophagus. There are several well-known intraoperative pitfalls regarding this procedure, such as involvement of a nasogastric tube or miss-introduction of the stapler tip to the submucosal layer, therefore surgical team should pay maximum attention to prevent these events.

Keywords: Gastric cancer; laparoscopic total gastrectomy; esophagojejunostomy

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Introduction

Laparoscopic esophagojejunostomy is one of the most technically difficult aspects when expanding institutional indication from distal to total gastrectomy. Presently, either circular stapler or linear stapler is utilized for this anastomosis according to surgeons' choice or situation. Both devices have their pros and cons, thus above all surgeons should fully understand their characteristics in clinical use. Laparoscopic side-to-side esophagojejunostomy, called as overlap method, was first developed by Prof. Inaba in Japan (1). In this chapter, a standardized procedure in our institution to perform overlap method is described (*Figure 1*).

Expected advantages of linear-stapled overlap method

Generally, operative field around the esophageal hiatus for esophagojejunostomy is deep and allows only small space. When performing laparoscopic esophagojejunostomy, assurance of nice visibility is an indispensable factor. One crucial issue is size of devices. The diameter of linear stapler's shaft is 12 mm designed to pass through the common trocar, which is much smaller than that of circular stapler. As a result, better view can be obtained during handling the device in the peritoneal cavity. This advantage will be more enhanced when attempting to perform esophagojejunostomy in the lower mediastinal space after high level resection of the esophagus. Apart from this point, linear stapler can be applicable regardless of diameter of the esophagus or the jejunum. In circular stapler, sometimes insertion of anvil head or main body is difficult when operating small-sized patients. In terms of postoperative outcomes, it is generally pointed out that incidence of anastomotic stricture is quite rare (1,2).

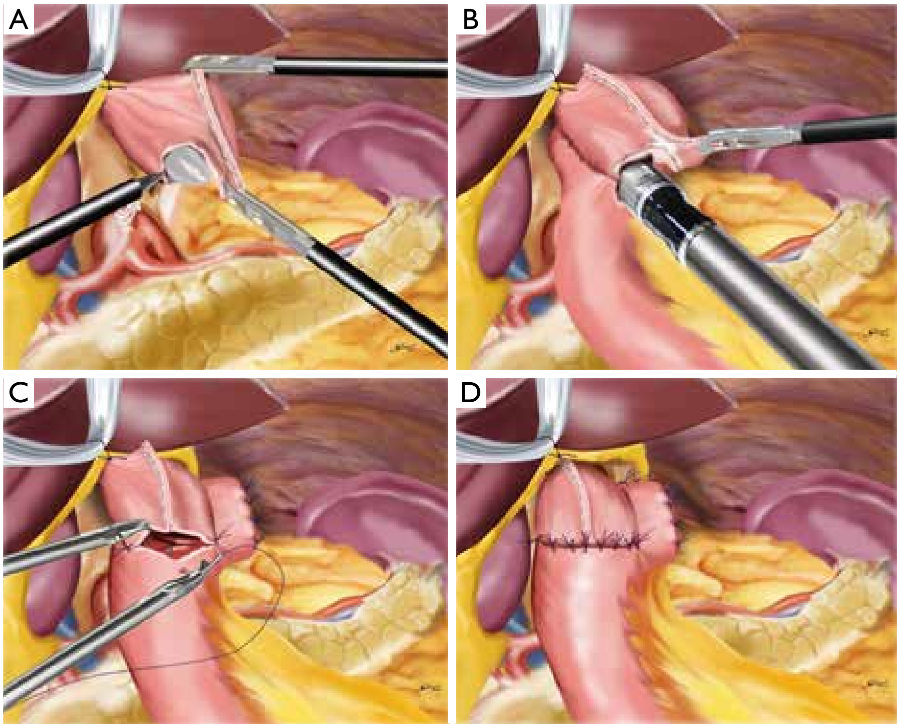

Figure 1 Schematic illustration of laparoscopic esophagojejunostomy by overlap method.

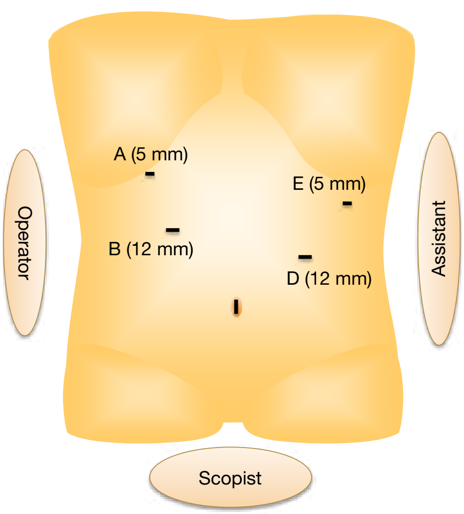

Figure 2 Port placement for laparoscopic total/proximal gastrectomy with laparoscopic esophagojejunostomy.

Position of the port placement

Patient is placed in supine position with legs apart and head-up tilted. Standard port setting for total gastrectomy or proximal gastrectomy (followed by double-tract reconstruction) is shown in *Figure 2*. First operator stands at the right side of the patient. A flexible laparoscope (2- or 3-dimentional) with high imaging resolution is used. Lateral segment of the liver is retracted using 11 cm-long Penrose drain. Center of the drain is fixed to the anterior part of the esophageal hiatus, and each end is retracted to the abdominal wall by attached threads.

Division of the esophagus (*Figure 3*)

After all of the steps for lymph node dissection and mobilization, the abdominal esophagus is exposed. It is quite important not to cause either direct or thermal injury to the esophageal wall, aiming secure subsequent anastomosis. If the esophageal invasion from the tumor is recognized, retraction with a use of a cotton tape encircling the esophagus is effective. Usually, the esophagus is divided at the level just above the esophagogastric junction, however if esophageal invasion exists, intraoperative peroral gastroendoscopy is carried out to determine a proper resection line. Finally, the abdominal esophagus is twisted in 90 degree clockwise, and division is completed with a 60 mm linear stapler (*Figure 4A*), which is introduced from port

B (shown in *Figure 2*). With this, stapling line of the esophageal stump resulted in vertical direction (anterior-posterior direction) (*Figure 4B*).

Preparation of the jejunal limb

In linear-stapled esophagojejunostomy, tension-free jejunal limb is essential to avoid embarrassing complications, such as injury of the intestinal wall. Creation of the jejunal limb is basically performed through mini-laparotomy, which is made by expansion of the umbilical port wound. Before making the mini-laparotomy, the jejunum, 20 cm distal from the Treitz ligament, is grasped by forceps by assistant surgeon under laparoscopic view to be kept with confirmation of the peristaltic direction. After making mini-laparotomy and placing a wound retractor, the grasped jejunum is extracted outside through it. After verifying vessels' structure in the mesentery, the jejunum is divided using a linear stapler, usually approximately 20 cm distal from the Treitz ligament. The marginal vessel is basically divided, and if there is still strong tension so far, a branch of jejunal artery and vein is divided after clamping test using a temporary vessel clamper. The length of jejunal limb is designed as 40 cm. Jejunojejunostomy is done by side to side fashion using a 60 mm linear stapler, and the entry hole is closed by manual suturing in full-thickness layer. Mesentery gap resulted from jejunojejunostomy is also closed by hand suturing. Lastly, a small entry hole for stapler insertion for subsequent esophagojejunostomy is made at the end of the jejunal limb. Because decision of this position under laparoscopy is sometimes difficult, it is routinely done under direct vision with measuring the accurate distance and stretching the intestine.

Figure 3 Typical case of laparoscopic esophagojejunostomy using overlap method (3).
Available online: http://www.asvide.com/articles/1267

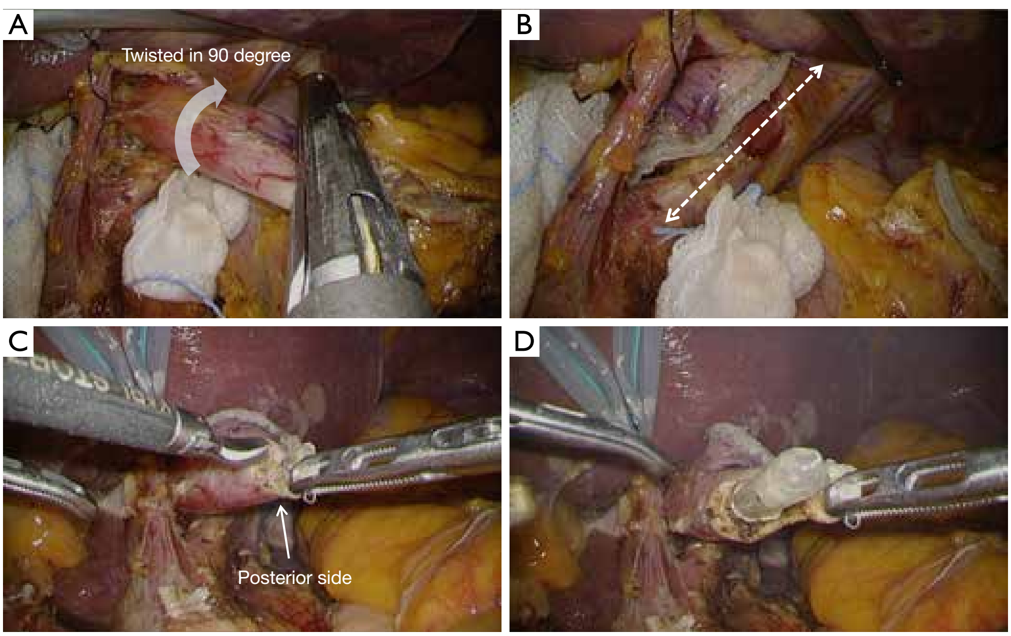

Figure 4 Division of the esophagus.

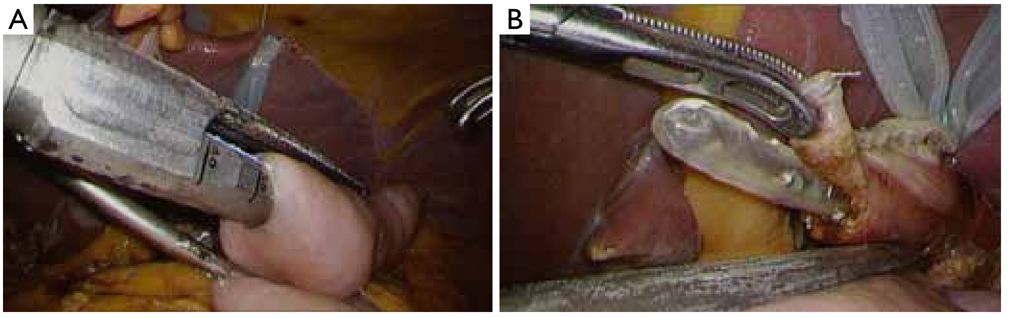

Figure 5 Insertion of the stapler to the jejunal limb.

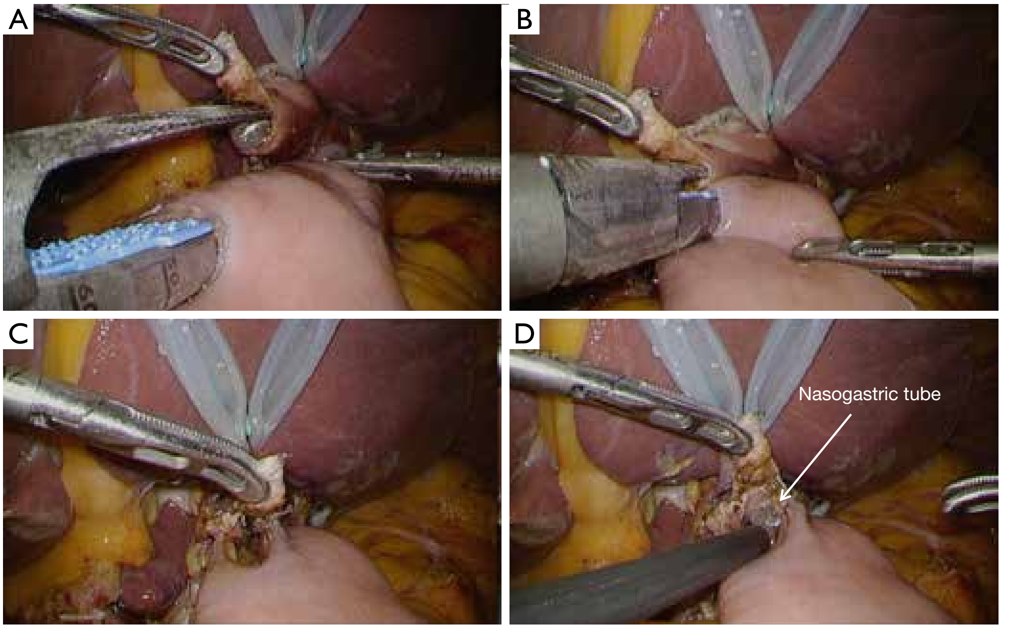

Figure 6 Esophagojejunal stapling.

Esophagojejunal stapling (*Figure 3*)

After re-establishment of the pneumoperitoneum, a small hole is made at the posterior edge of the esophageal stump using high-frequency electrocautery with a guidance of nasogastric tube (*Figure 4C,D*). This hole should be ideally as small as possible, just allowing passage of the tube. The semi-separated staple line should be left as attached to the esophagus, because this part can be useful for retracting the esophagus during the anastomosis. Next, mobilization of the esophageal stump is examined. At least 45 mm length of the free wall should be ensured at the posterior site for subsequent stapling. The created jejunal limb is brought up to the upper abdomen basically via ante-colic route. If the tension seems tight because of a large amount of visceral adipose tissue, retro-colic route is chosen. The linear stapler is introduced from port B (as shown in *Figure 2*), and the cartridge site is inserted to the jejunal limb (*Figure 5A*). Then, the stapler is moved to an expected position for anastomosis as a simulation (*Figure 5B*). The operator grasps the semi-separated staple line of the esophageal stump to pull towards caudal. The stapler is moved to the posterior site of the esophagus, to insert the anvil folk into the esophageal lumen with a guidance of the nasogastric tube (*Figure 6A*). The stapler is clamped at the posterior wall of the esophagus. This clamping should be done several times, to make sure no step between the esophagus and the

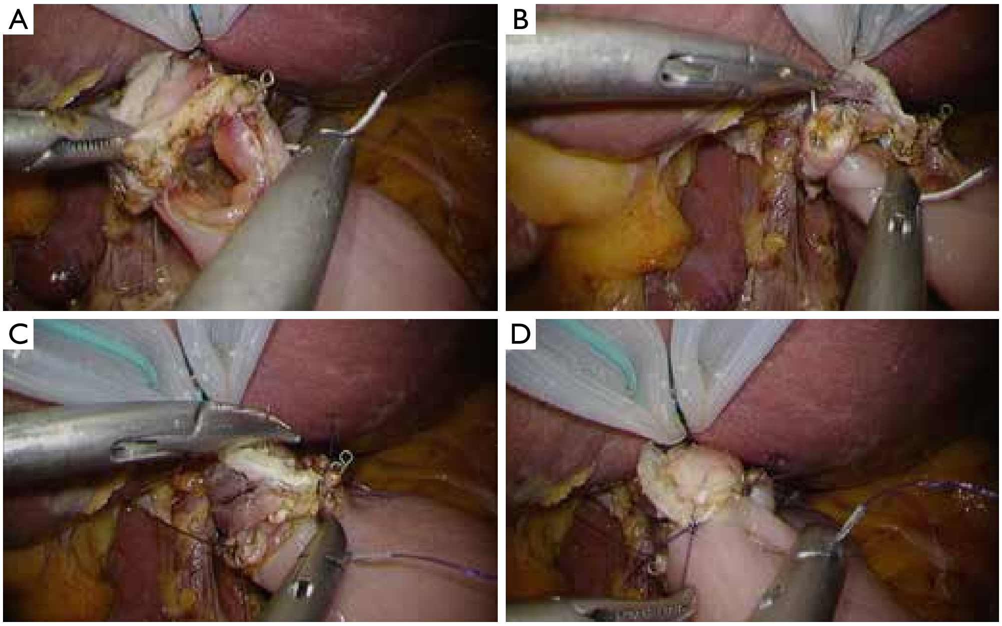

Figure 7 Closure of the entry hole.

Figure 8 Completion image of anastomosis.

jejunum at the lateral side (*Figure 6B*). Firing of the stapler is usually employed by motor-driven systems to more accurately stabilize the stapler during handling. After firing, the stapler is gently removed, then hemorrhage from the intraluminal staple line is checked (*Figure 6C*). If bleeding is recognized, it can be controlled by soft coagulation using suction device with a metal tip. Finally, the nasogastric tube is passed through the anastomosis to check patency (*Figure 6D*).

Closure of the entry hole (*Figure 3*)

It can be done either by interrupted or continuous suturing (normal or barbed suture). Likewise, knot-tying can be done either by intra or extracorporeal fashion according to surgeons' preference. The author prefers interrupted suture with intracorporeal knot-tying technique using 3-0 absorbable monofilament thread, 12 cm in length. First, the left side edge of the entry hole is closed (*Figure 7A*), then the right side is done (*Figure 7B*). Next, the center of the entry hole is closed by another stitch (*Figure 7C*), paying attention that the mucosa is hidden inside. After these three fundamental stay sutures, spaces between these sutures are closed by additional sutures (*Figure 7D*), usually requiring 7–13 stitches in total. It is quite important to accurately stich in full-thickness layer, particularly at the esophageal wall side. After completion of the closure, the nasogastric tube is introduced 3–4 cm distally passing the anastomosis, to conduct air-leakage test to confirm tightness of the anastomosis (*Figure 8*).

Prevention of internal hernia or torsion (*Figure 3*)

The jejunal limb is flipped to the left side of the patient, and the transverse colon is lifted up cephalad to expose Petersen's defect. The assistant holds both jejunal and colon mesentery at the peripheral side close to the intestine, which will be a termination point for the subsequent continuous

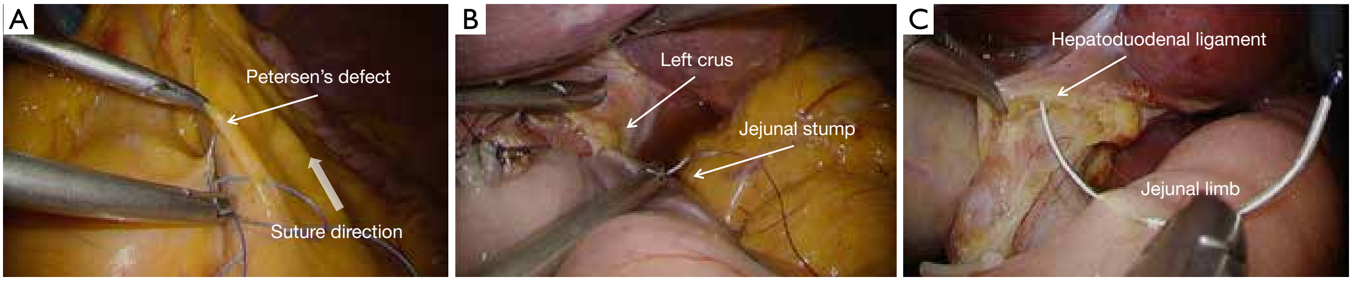

Figure 9 Prevention of internal hernia and torsion.

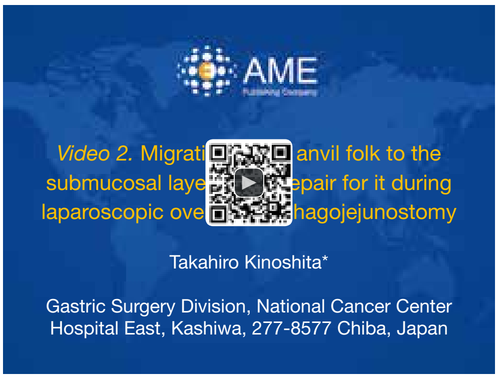

Figure 10 Migration of the anvil folk to the submucosal layer with a repair for it during laparoscopic overlap esophagojejunostomy (4). Available online: http://www.asvide.com/articles/1268

suture. As a suture material, a barbed non-absorbable thread is used for time saving, and suturing is started from the central portion of the Petersen's defect (*Figure 9A*). In order to prevent torsion of the jejunal limb, it is fixed at several points. The jejunal stump is fixed to the left diaphragmatic crus (*Figure 9B*), and outlet intestine distally is fixed to either hepatoduodenal ligament (*Figure 9C*) or fat tissue around the gallbladder, which depends on each situation. A 19 Fr Blake-type drainage tube is introduced from port A (shown in *Figure 2*), and its tip is placed behind the anastomotic site.

Postoperative management

According to our clinical pathway, water-drinking is started on 1st day and soft meal is initiated on 3rd day after surgery. The drainage tube is removed on 3rd or 4th day, if there is no unfavorable change at its contents. Patients discharge the hospital 7th–9th day, if without any complication.

Pitfalls and management for difficult situation

Involvement of a nasogastric tube in stapling

This is one of the most well-known pitfalls of this procedure, usually happens at the beginning phase. To prevent this, close communication and careful confirmation with anesthesiologists is mandatory. For recovery, if re-anastomosis seems difficult, removal of the tube using scissors may be an alternative as a compromise procedure, expecting that remaining pieces will naturally drop down.

Migration of the anvil folk to the submucosal layer (Figure 10)

To avoid this complication, guidance by the nasogastric tube is the most effective. Full-thickness stiches to the esophageal wall would be also an effective measure for prevention. According to the author's experience, if it happens, mucosal layer can be cut to create a true lumen, then mucosa should be sutured to the staple line to re-make it as normal situation (*Figure 11*).

Anastomosis after high-level resection of the esophagus (Figures 12,13)

Anastomosis in the lower mediastinal space is the most difficult scene even for this procedure. In such a situation, ensuring wider operative field with better visibility is the most important things. The diaphragmatic crus should be divided at its right, left or anterior portion using energy

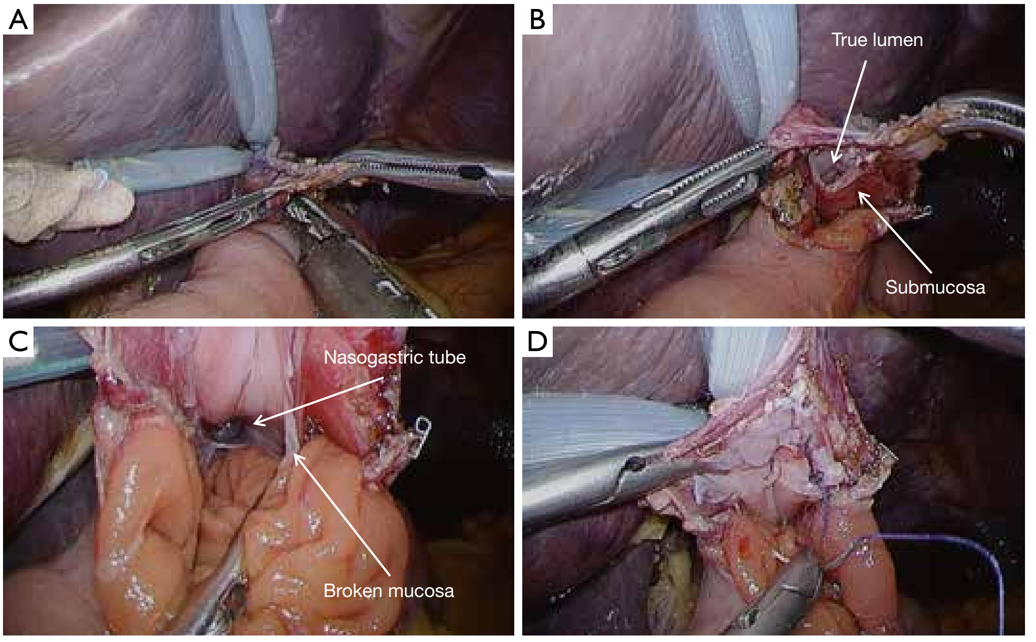

Figure 11 Migration of the anvil folk to the submucosal layer.

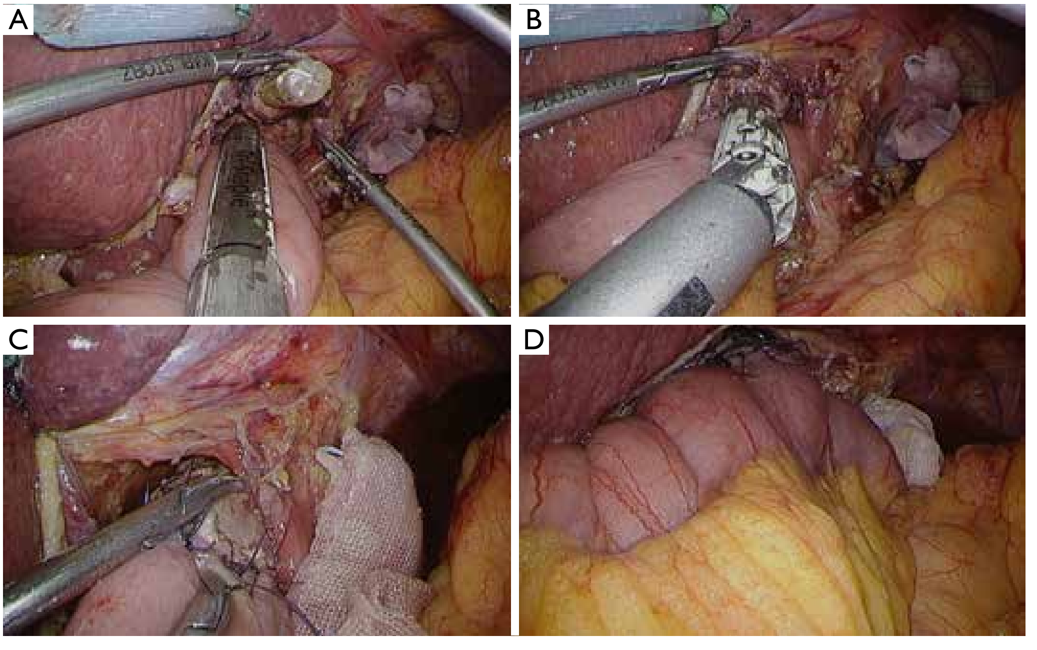

Figure 12 Anastomosis after high-level resection of the esophagus.

Figure 13 Laparoscopic overlap esophagojejunostomy after high-level resection of the esophagus (5).
Available online: http://www.asvide.com/articles/1269

device to widen the esophageal hiatus as possible. When performing high anastomosis, articulating function of the linear stapler is very useful to adjust the inserting axis to the esophageal lumen.

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Footnote

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Usage of linear stapler in laparoscopic gastrectomy in gastric cancer patients

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In 1994, Kitano *et al.* first reported the usage of laparoscopic surgery in the treatment of gastric cancer (1). Since then, laparoscopic surgery has been applied in more and more patients and has become an important method of surgery for gastric cancer, especially in East Asia. At first, most of the laparoscopic surgeries for gastric cancer were completed in the way of "laparoscopic-assistant" method, which need a small assistant incision to complete the reconstruction procedures. The advantage of "laparoscopic-assistant" method is that surgeons can perform the reconstruction procedures in the way they are more familiar in open surgery and is easier to master. However, with the development of the laparoscopic techniques, total laparoscopic surgery has become a hot research area (2). For total laparoscopic surgery, reconstruction needs to be performed intracorporeally and this limits the usage of circular stapler which is widely used in open and laparoscopic-assistant surgery. Many techniques have been developed to facilitate the usage of circular stapler in total laparoscopic surgery such as reverse puncture method and trans-oral anvil delivery system (EEA™ OrVil™), but all these techniques are too complicated to be generalized (3). The usage of linear stapler facilitates the development of total laparoscopic surgery. Compared to circular stapler, linear stapler can be inserted into the peritoneal cavity through trocars without assistant incision and the arms of linear stapler can be put into the digestive tract easily which makes it easier to be operated (4). Meanwhile, the procedures with linear stapler have little influence on pneumoperitoneal pressure.

Currently, most of the widely used techniques of total laparoscopic reconstruction methods are completed with linear staplers such as delta anastomosis, esophago-jejunal overlap anastomosis. Since 2013, over 200 cases of reconstructions of gastric cancer surgery were completed with linear staplers in Gastrointestinal Cancer Center of Peking University Cancer Hospital. Here we conclude the usage of linear stapler in reconstruction of gastric cancer surgery and build the basic models of intestinal tract reconstruction method with linear staplers that theoretically exists.

Models of intestinal tract reconstructions with linear staplers

In 1992, Goh *et al.* first reported total laparoscopic reconstruction of gastro-jejunal anastomosis (5). In 2002, Kanaya *et al.* first applied total laparoscopic reconstruction techniques in gastric cancer surgery (2). Compared with circular staplers, linear staplers are more suitable for intracorporeal reconstruction. Linear staplers can access the intestinal tract through trocars without assistant incisions and this makes it easier to complete the reconstruction under direct vision of laparoscope. The vision advantage makes sure that the reconstruction is more accurate. The incidence of postoperative intra-abdominal adhesion is low and this facilitates the fast recovery of postoperative bowel function. Besides, most of the circular staplers are with two staple lines while linear staplers are with three staple lines, which is theoretically more accurate and safer.

Although linear staplers can be applied to reconstructions of different anastomosis such as esophago-jejunal, gastro-jejunal, and jejuno-jejunal anastomosis, the basic processes of the procedures are similar. First, a small incision needs

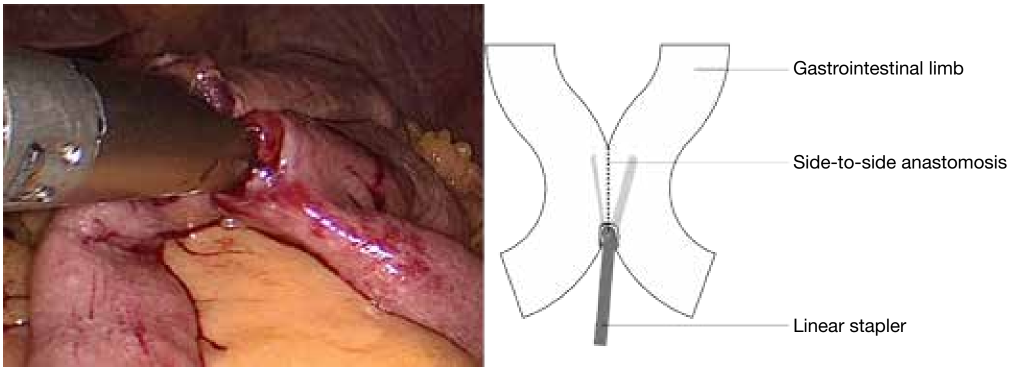

Figure 1 Basic form of anastomosis with linear stapler (jejuno-jejunal side-to-side anastomosis).

to be made at the antimesenteric border of each of the two intestinal tracts. Then the two arms of the linear stapler are inserted into the two intestinal tracts separately. Finally, the linear stapler is fired and the conjunct incision is closed. The basic procedures of different anastomosis are similar but the details vary. Here we concluded the basic forms of the procedure and modelled it. Theoretically, we introduced all the forms procedures that might exist and analyzed them together with clinical practice.

(I) Basic form (*Figure 1*): the nature of reconstructions with linear stapler is the side-to side anastomosis. Two arms of the stapler are inserted into two different intestinal tracts like showing in *Figure 1*. Both intestinal tracts are not transected and there are four limbs and no cutting lines around the anastomoses. In clinical practice, jejuno-jejunal anastomosis (Braun anastomosis) and gastro-jejunal bypass anastomosis are of this specific form (6).

(II) One limb transected (*Figure 2*): one lime around the anastomoses is transected and thus there are three limbs and one cutting line around the anastomoses. According to the directions of linear stapler inserted into the intestinal tract, there are two subtypes of this form.

- (i) In the first subtype, the small incisions are made away from the cutting line and the linear stapler is inserted towards the line, like showing in *Figure 2A*. In clinical practice, the remnant gastro-jejunal anastomosis in double-tract reconstruction of proximal gastrectomy is of this specific subtype.
- (ii) In the second subtype, the small incisions are made on the cutting line, like showing in *Figure 2B,C*. In clinical practice, the gastro-jejunal anastomosis in Billroth II reconstruction of distal gastrectomy (*Figure 2B*), the jejuno-jejunal anastomosis in Roux-en-Y reconstruction of distal or total gastrectomy and in double-tract reconstruction of proximal gastrectomy (*Figure 2C*) are of this specific subtype.

(III) Two limbs transected (*Figure 3*): two limbs around the anastomosis are transected, and there are two limbs and two cutting lines left around the anastomoses. According to the distribution of the left limbs, there are two subtypes of this form.

- (i) In the first subtype, the two limbs left are at the different side of the anastomoses (*Figure 3A,B*). In this subtype, the small incision is made on one of the cutting line and then the linear stapler is inserted. As this subtype of anastomoses is central symmetrical, the direction of linear stapler inserted does not change the formation of the anastomoses. In clinical practice, this subtype is usually called "overlap" anastomoses and is generally used in esophago-jejunal anastomosis of total gastrectomy (*Figure 3A*) and gastro-duodenal anastomosis of distal gastrectomy (*Figure 3B*) (7).
- (ii) In the second subtype, the two limbs left are at the same side of the anastomoses (*Figure 3C-E*). In this subtype, linear stapler can be inserted in two different directions. In the first one, the small incision is made on the cutting line and the linear stapler is inserted towards the direction of the left limbs, like showing in *Figure 3C,D*. In clinical practice, functional end-to-end esophago-jejunal

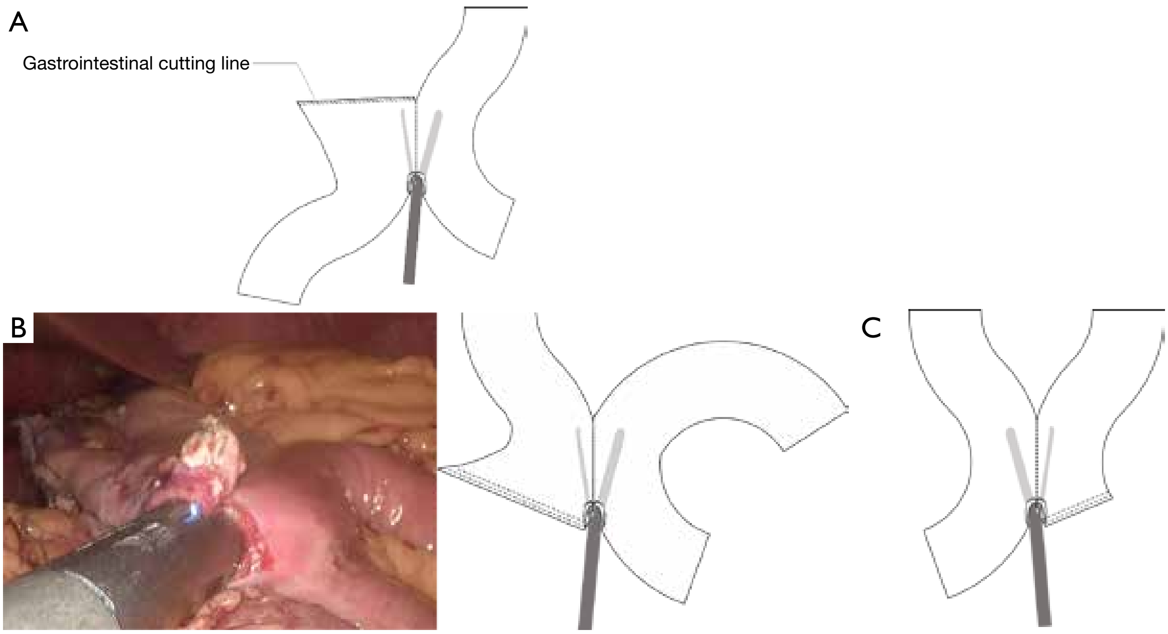

Figure 2 One limb transected. (A) Inserting the stapler arms away from the cutting line (gastro-jejunal anastomosis); (B) inserting the stapler arms on the cutting line (gastro-jejunal anastomosis); (C) inserting the stapler arms on the cutting line (jejuno-jejunal anastomosis).

anastomosis (FETE) of total gastrectomy (*Figure 3C*) and gastro-duodenal delta anastomosis of distal gastrectomy are of this specific form (8). In the second one, the small incisions are made away from the cutting line and the linear stapler is inserted towards the cutting line, like showing in *Figure 3E*. However, this method exists theoretically and currently is not applied in clinical practice.

Above are all the theoretically existing forms of anastomosis by linear stapler. In clinical practice, the specific anastomoses are modified on the basis of these forms. The modified factors include the direction of stapler inserted, symmetry variation, selection of intestinal tract wall for side-to-side anastomoses, direction of intestinal tract transection, methods of conjunct incision closure, and selection of stapler size. For example, in delta anastomoses reported by Kanaya (*Figure 3D*), the details modified on the basis of theoretical form are as follows: the direction of duodenum transection is from back wall to front wall; the intestinal walls selected for side-to-side anastomoses are back wall of gastric wall and upper wall of duodenum; the conjunct incision is closed with another linear stapler and the closure line forms the anastomoses a delta shape (2). Huang *et al.* modified the traditional delta anastomosis by moving away the duodenal stump cutting line while closing the conjunct incision (9).

The modification of details of anastomosis will bring different effect. For example, the direction of linear stapler inserted into the intestinal tract is modified according to the position of the surgeon and the relative location and direction of the intestinal tract. The intestinal tract wall for anastomosis is selected according to the blood supply, mobilization, and adjacent organs of the intestinal tract wall. The closure of the conjunct incision can be performed with linear stapler or hand-sewing according to the mobilization of the tract. Laparoscopic hand-sewing technique is more complicated and requires more experience while the application of barbed sutures facilitates the procedure a lot. The closure of conjunct incision with linear staplers is easier but requires more space and thus need the tract to be more mobilized. It is usually applied in gastro-jejunal, jejuno-jejunal anastomosis but not in esophago-jejunal anastomosis. The direction to close the conjunct incision will influence the diameter of the anastomosis. If the closure line forms the delta shape with the anastomosis lines, the anastomosis are with lower possibility of stricture. Meanwhile, the size of linear stapler selected will also influence the diameter of the tract.

In summary, the usage of linear staplers in reconstruction

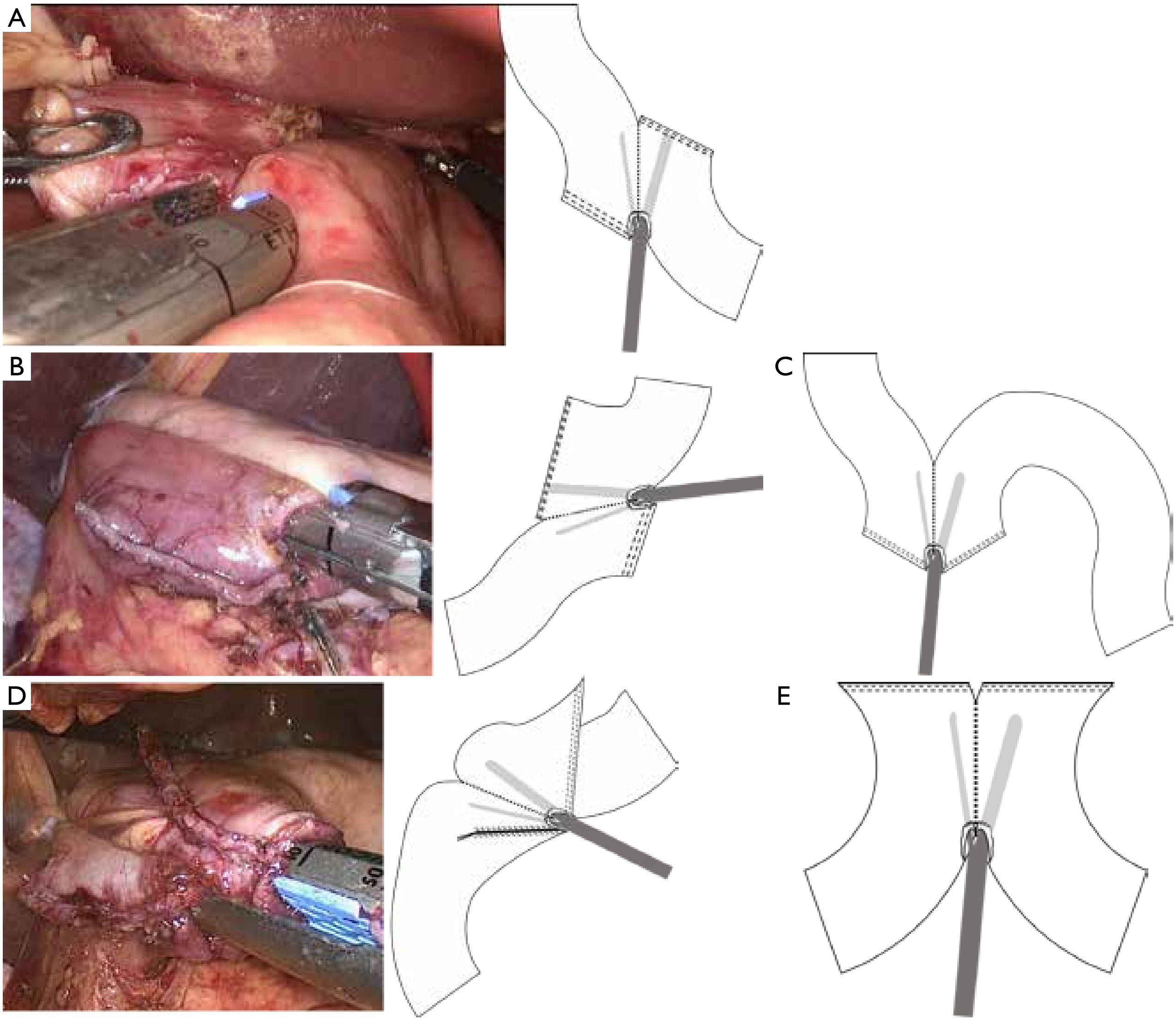

Figure 3 Two limbs transected. (A) Two limbs left at different side of the anastomosis (esophago-jejunal overlap anastomosis); (B) two limbs left at different side of the anastomosis (gastro-duodenal overlap anastomosis); (C) two limbs at the same side of the anastomosis and the stapler arms inserted on the cutting line (esophago-jejunal FETE anastomosis); (D) two limbs at the same side of the anastomosis and the stapler arms inserted on the cutting line (gastro-duodenal delta anastomosis); (E) two limbs at the same side of the anastomosis and the stapler arms inserted away from the cutting line. FETE, functional end-to-end.

is acceptable from the aspects of operation time, bowel function recovery, and postoperative morbidity. Due to the simpler process of the procedure and the basic procedures are similar in different anastomosis, the learning curve of the procedure is shorter and resulted in better operation safety. It is worthy to generalize the usage of it. With all these advantages, our center has begun to apply linear stapler in reconstruction in open surgery. The models we introduced here can provide experiences for clinical practice of linear stapler in reconstruction of gastrectomy.

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Footnote

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Laparoscopic reinforcement suture of duodenal stump using barbed suture during laparoscopic gastrectomy for gastric cancer: preliminary results in consecutive 62 patients

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Abstract: Duodenal stump leakage after gastrectomy is one of serious complications related to severe morbidity or mortality. However, definite surgical method for duodenal stump leakage is not established. Herein, we introduced a new and simple surgical technique to reduce duodenal stump leakage during laparoscopic gastrectomy for gastric cancer. We retrospectively reviewed the medical records for consecutive 62 patients who underwent laparoscopic reinforcement suture (LARS) during laparoscopic gastrectomy for gastric cancer from June 2015 to February 2016 in our institute. After cutting of duodenal stump, LARS commenced with continuous invagination method or interrupted method using barbed suture. Sixty patients underwent distal gastrectomy with B-II, and two patients had total gastrectomy. Mean operation time was 160 minutes, and the mean time for LARS was 8 minutes. Duodenal stump leakage was not observed; however, we observed one case of esophagojejunostomy leakages and one case of artificial lesser curvature leakage. LARS can be performed in a relatively short operation time without any technical difficulties. LARS on staple-line of duodenal stump can be helpful to prevent DSF after laparoscopic gastrectomy for gastric cancer.

Keywords: Laparoscopic reinforcement suture (LARS); leakage of duodenal stump; gastric cancer

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The overall incidence of duodenal stump fistula (DSF) or duodenal stump leakage is reportedly between 1.6% to 5% and is one of the most serious complications of Billroth-II or Roux en Y reconstruction after gastrectomy for gastric cancer (1,2). DSF is a rare complication but is associated with a high morbidity and mortality rate. The mortality rate of DSF is reported as 16% to 20% (1). This serious complication affects not only patients and their families, but also the surgeon especially in cases with laparoscopic gastrectomy. Several investigators presented their clinical experience, such as the clinical course and the pertinent management of DSF (3,4). It is possible to predict possibilities of DSF in some patients, such as patient's age, co-morbidity, nutritional status impairment and technical difficulties during surgery (5,6).

During the past two decades, laparoscopic gastrectomy for stage I gastric cancer has become an attractive alternative to open gastrectomy in Korea, Japan and China (7-12). Although the incidence of wound complication in laparoscopic gastrectomy is significantly lower in open gastrectomy, the incidence of overall complication is similar between the two groups (7,8). However, the incidence of major complication, such as DSF or intra-abdominal bleeding in laparoscopic gastrectomy remains unclear (9).

I have performed additional mechanical reinforcement on staple-line of duodenal stump. Herein, we introduced a new and simple surgical technique for reducing DSF during laparoscopic gastrectomy.

Surgical technique (*Figure 1*)

For laparoscopic gastrectomy in cases of gastric cancer, five trocars were used while standing at the patient's right side during the entire procedure. After cutting of duodenal stump of about 1–1.5 cm length using linear stapler, Laparoscopic reinforcement suture (LARS) commenced from upper to lower part on staple-line of duodenal stump. Continuous suture with invagination was performed using a barbed suture (*Figure 2*). In case of patient with short duodenal stump because of chronic ulcer or ectopic pancreas at duodenal bulb or cancer invasion to pylorus, 3 or 4 interrupted sutures without invagination of duodenal stump was conducted using barbed sutures.

In conclusion, DSF after laparoscopic gastrectomy for gastric cancer did not occur in my experience and LARS can be performed in a relatively short operation time without any technical difficulties. LARS on staple-line of duodenal stump can be helpful to prevent DSF after laparoscopic gastrectomy for gastric cancer.

Figure 1 After cutting of duodenal stump of about 1–1.5 cm length using linear stapler LARS commenced from upper to lower or from lower to upper part on staple-line of duodenal stump (13). A continuous suture with invagination of duodenal stump using 3-0 15 cm barbed suture was conducted. LARS, laparoscopic reinforcement suture.

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Footnote

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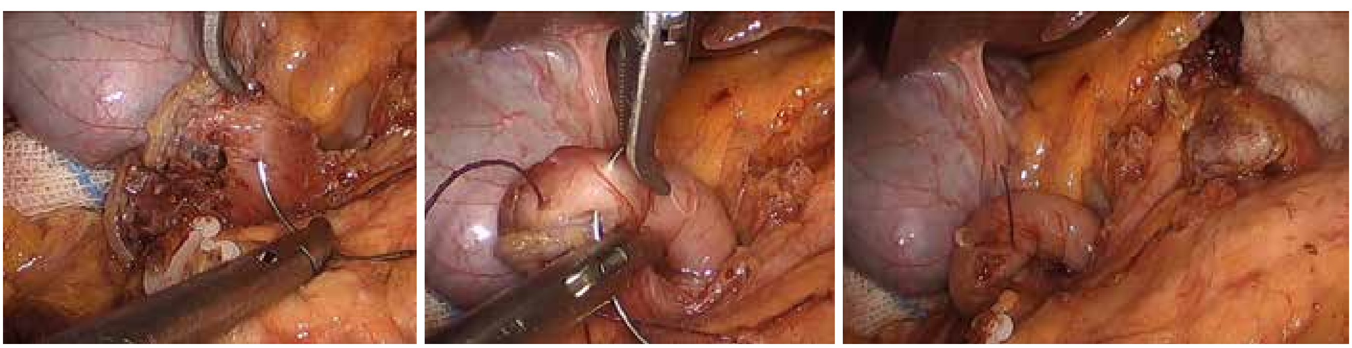

Figure 2 Laparoscopic reinforcement suture (LARS) commence from upper to lower part on staple-line of duodenal stump using barbed suture. Continuous suture with invagination is completed after 4 or 5 stitches.

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Strategies of laparoscopic spleen-preserving splenic hilar lymph node dissection for advanced proximal gastric cancer

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Abstract: For advanced proximal gastric cancer (GC), splenic hilar (No. 10) lymph nodes are crucial links in lymphatic drainage. According to the 14th edition of the Japanese GC treatment guidelines, a D2 lymphadenectomy is the standard surgery for advanced GC, and No. 10 lymph nodes should be dissected for advanced proximal GC. In recent years, the preservation of organ function and the use of minimally invasive technology are being accepted by an increasing number of clinicians. Laparoscopic spleen-preserving splenic hilar lymph node dissection has become more accepted and is gradually being used in operations. However, because of the complexity of splenic hilar anatomy, mastering the strategies for laparoscopic spleen-preserving splenic hilar lymph node dissection is critical for successfully completing the operation.

Keywords: Gastric neoplasm; laparoscopic; splenic hilus; lymphadenectomy; strategy

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Background

On the basis of the 14th edition of the Japanese gastric cancer (GC) treatment guidelines, a D2 lymphadenectomy is the normal surgery for advanced GC and No. 10 lymph nodes should be dissected for advanced proximal GC. Recently, the use of minimally invasive technology and the preservation of organ function are increasingly accepted by clinicians. Laparoscopic spleen-preserving splenic hilar lymph node dissection has become more identified in gastrectomy. As well as, it is critical that surgeons master flexibly the strategies of laparoscopic spleen-preserving splenic hilar lymph node dissection for a successful operation, as a consequence of the complexity of splenic hilar anatomy.

Value of spleen-preserving splenic hilar (No. 10) lymph node dissection for advanced proximal GC

Value of No. 10 LN dissection for advanced proximal GC

The foremost purpose of radical operations for GC is to prolong patients' long-term survival. A patient's postoperative survival rate is connected with the thoroughness of LN dissection during the surgery. No. 10 LN dissection is an important but difficult process of a D2 radical resection for advanced proximal GC. No. 10 LN metastasis rate has been reported to be 9.8–27.9% (1-3). Shin *et al.* (4) reported that of 319 patients with proximal gastric adenocarcinoma, 41 (12.9%) had No. 10 LN metastasis which is not apparent in early GC. Data from Japanese patients also revealed that the No. 10 LN metastasis rate in early proximal GC is so low (0.9%) that the No. 10 LN does not need to be dissected. However, in advanced GC, the No. 10 LN metastasis rate is 13.4% in stage T3 and 34.4% in stage T4 (5). A 346-case analysis of laparoscopic spleen-preserving No. 10 LN dissection for proximal GC conducted by our center showed that the incidence of No. 10 LN metastasis is 10.1%, and all of which had an advanced proximal GC (6). Age, tumor size, depth of invasion, No.4sb lymphatic metastasis are the independent risk factors of No. 10 LN metastasis. In addition, the rate of GC in the upper region is significantly higher than that in the lower third of the stomach (7). Koga *et al.* (8) reported that the incidence of No. 10 LN metastasis was highest in those patients with cancer of the whole stomach, Borrmann type IV or serosal invasion. Okajima *et al.* reported a highest No. 10 LN metastasis rate (26.7%) in GC of the entire stomach (9). Moreover, the survival rate is significantly associated with No. 10 LN metastasis. Shin *et al.* (4) reported that the 5-year survival rate was significantly lower for a No. 10 LN metastasis group (11.04%) compared with a non-metastasis group (51.57%) (P<0.05). Chikara *et al.* (10) reported that the 5-year survival rate of patients with No. 10 LN metastasis was 23.8%, whereas the rate in patients without No. 10 LN metastasis was 41.4% (P<0.05). Thus, the No. 10 LN metastasis status is a significant prognostic factor for GC. No. 10 LN dissection which is necessary in advanced upper GC because the radical excision of a tumor seems to be insufficient. Kosuga *et al.* (11) reported that there was no significant difference was found in the 5-year survival rates between patients with and without No. 10 LN metastasis (51.3% and 42.1%, respectively). Nonetheless, this study also suggested that patients with primary tumors localized on the greater curvature and Borrmann type 4 cancers might obtain a relatively high survival benefit from lymph node dissection at the splenic hilus by splenectomy. However, Ikeguchi *et al.* (12) reported a study of patients who underwent curative total gastrectomy with splenectomy in treatment of GC. The 5-year survival curves showed that the survival of No. 10 LN-positive patients did not differ from those of No. 10 LN-native patients. Therefore, the value of LN dissection in this area is significant. No. 10 LN dissection is becoming more accepted by an increasing number of clinicians.

Value of spleen-preserving No. 10 LN dissection for advanced proximal GC

Before the 1990s, the addition of splenectomy or pancreaticosplenectomy to total gastrectomy in patients with advanced GC aimed at facilitation of No. 10 LNs or No. 11 LNs dissection. Studies suggested that such dissection does not significantly improve the 5-year survival rate. There was not significantly different in the 5-year survival rate between the DP and DS groups (35.6% *vs.* 42.4%, P=0.6224). However, the morbidity rate was higher. Additionally, this surgical method increases the risk of distal pancreatectomy-associated complications such as pancreatitis, pancreatic fistula, intra-abdominal infection or abscess and postoperative diabetes. Currently, this surgical method is only performed when direct invasion of the spleen or of the body and tail of the pancreas is observed. Many subsequent studies have reported that the survival rates of patients undergone total gastrectomy in splenectomy group were higher than the spleen-preserving group (33.4% *vs.* 20.7%, P<0.05) (13). Moreover, compared with pancreatosplenectomy, pancreas-preserving splenectomy with No. 10 LN dissection has a similar survival rate and morbidity but significantly lower incidence of complications and mortality (14). Therefore, pancreas-preserving splenectomy with No. 10 LN dissection has been recommended as a curative procedure for standard D2 dissection instead of pancreatosplenectomy (9,15,16). However, Yang *et al.* (17) reported a meta-analysis of 466 patients showing that gastrectomy with splenectomy has not yet shown superiority on 5-year overall survival rate compare to splenic preservation, with an RR of 1.17 (95% CI: 0.97–1.41, P<0.05). Splenectomy could not facilitate prolongation of survival. This analysis also showed splenectomy had no significant influence on postoperative morbidity and mortality based on a 5-year overall survival rate outcome compared to splenic preservation for proximal and whole GC (RR =1.14, 1.76 and 1.58, respectively). Recently, many subsequent studies showed that the spleen is an important component of the peripheral immune system and it is the largest peripheral immune organ in the human body (18,19). The spleen contributes to normal operation of the circulatory system for immune regulation and plays roles in the immune and endocrine systems. Additionally, it contains numerous immune cells, the role of which in anti-tumor immunity is considerable. The Dutch scholar H.H. Hartgrink conducted a multicenter randomized controlled trial that followed up 1,078 patients with gastric adenocarcinoma for more than 10 years and found that splenectomy generated higher morbidity and mortality (20). In contrast, pancreas- and spleen-preserving LN dissection (D2) improved patient prognosis. Roderich *et al.* (21) reported that spleen-preserving No. 10 LN dissection is technically feasible based on the improvement of surgical techniques, with a curative effect similar to splenectomy. It lacks survival benefits after splenectomy (48.3% *vs.* 54.8%; P=0.503), but patient morbidity and mortality were significantly increased. Therefore, spleen-preserving No. 10 LN dissection is becoming more accepted by an increasing number of clinicians.

Value and procedure of laparoscopic spleen-preserving No. 10 LN dissection

Value of laparoscopic spleen-preserving No. 10 LN dissection

Along with the further study of the disease, the technique of surgery and surgical instruments has made tremendous progress. Hence, this operation tends to be more feasible and safer. Moreover, this is beneficial for reducing surgical trauma and protecting organ function. Traditional open operations can not no longer meet the needs of patients. Laparoscopic D2 LN dissections are conducted by many surgeons who have a good command of laparoscopic technology. Based on laparoscopic amplification and the superior effects of ultrasonic scalpels for cutting and hemostasis, surgeons can preferably clearly visualize the perigastric fascia, intrafascial space, vasculature, nerves and other structures, which makes the operation more smoothly. The splenic vessels and their branches can therefore be comfortably exposed, and the meticulous procedure of No. 10 lymphadenectomy can be carefully and efficiently completed. Therefore, spleen-preserving No. 10 LN dissection can get benefit from the use of laparoscopy. Hyung *et al.* (22) in 2008 firstly describe the detailed procedure of laparoscopic spleen-preserving splenic hilar LN dissection regarding the treatment of GC in the upper third of the stomach. A mean number of retrieved LNs at station 10 by laparoscopic spleen-preserving gastrectomy were similar to those by open gastrectomy (2.7 *vs.* 2.2). Besides, in laparoscopic operations, the surgery without mobilization of the spleen can achieve a smaller incision, minimal invasiveness and a shorter operating time. Furthermore, laparoscopic spleen-preserving No. 10 lymphadenectomy has been demonstrated technically feasible and safe. In our study, the average number of LNs retrieved using laparoscopic surgery was 3.6 per patient, and there was no patient required an open conversion because of an injury of the spleen or its vessels. No complications such as hemorrhage, splenic ischemia or splenic necrosis associated with dissection of the splenic hilar region were observed postoperatively, indicating favorable short-term outcomes (23). To date, however, the debate over the prognostic benefit of laparoscopic splenic hilar lymph node dissection for advanced GC is fierce. Hence, our center conducts a randomized controlled trial on laparoscopic spleen-preserving No. 10 lymph node dissection for advanced middle or upper third GC (No. NCT02333721). We believe that this trial could demonstrate the prognostic benefit of spleen-preserving No. 10 lymph node dissection. Moreover, we hope that this procedure has potential benefit for those patients without increasing in morbidity in experienced center.

Operative procedure of laparoscopic spleen-preserving No. 10 LN dissection

Some experts select a medial approach concerning the choice of surgical approach, the surgeon operates on the patient's right side in which, and places an additional trocar below the xiphoid. Then, dissection of the No. 11p, 11d, and 10 LNs is performed with ultrasonic shears along the root of the splenic artery (SpA) toward its distal end. For a safe procedure, the surgeon cuts off the short gastric vessels (SGVs) prior to LN dissection, which is facilitated when the surgeon operates on the patient's right side. Other experts choose a retropancreatic approach in which the surgeon operates on the patient's left side and the assistant operates on the right. This procedure starts with separating the gastrosplenic ligament (GSL) and severing the left gastroepiploic and SGVs. The inferior border of the pancreas is then divided, which is better to entry into the retropancreatic space (RPS) and enable subsequent division of the SpA and splenic veins (SpV) and LN dissection within the RPS. For a better exposure, this approach requires removal of the entire stomach after severing the SGVs. However, this requirement violates the principle of an oncological en bloc resection. Moreover, as the appearance of metastatic No. 10 LNs, it may be inconvenient to expose anatomical plane and excise LN on account of inadequate traction on the GSL and the posterior wall of the gastric fundus. We enter the RPS through a left-sided approach, along the superior border of the pancreatic tail. We resect the LNs from the SLA toward the root of the SpA, and the SGVs are severed at their roots. This procedure, completing the removal of No. 10 LNs and the stomach, is consistent with the principle of oncological radical resection. Additionally, the assistant supports to providing better exposure by drawing the GSL, which maintains proper tension in the operative field.

Our center completed more than 500 laparoscopic GC surgeries in January 2010, meanwhile, we performed laparoscopic spleen-preserving No. 10 LN dissections. Based on our experience, we have summarized an effective procedure called Huang's three-step (24) maneuver for performing laparoscopic spleen-preserving No. 10 lymphadenectomies in clinical practice. The patient is

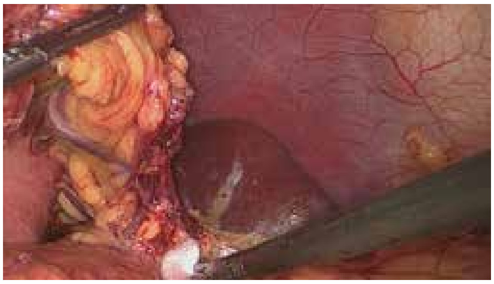

Figure 1 First step: exposure of the inferior pole region of the spleen.

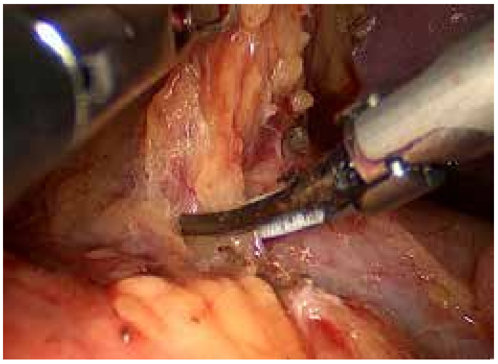

Figure 2 The APF is peeled until the superior border of the pancreatic tail is reached. APF, anterior pancreatic fascia.

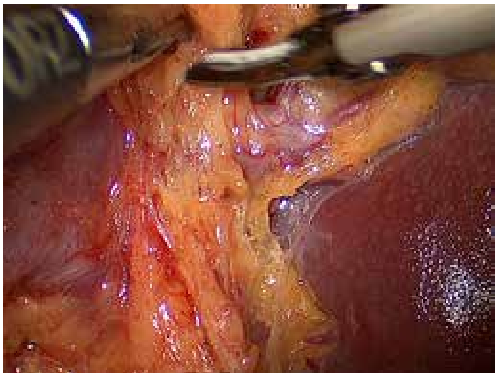

Figure 3 The exposure of the LLVSs. LLVS, lower lobar vessels of the spleen.

Figure 4 The exposure of the roots of the LGEVs. LGEV, left gastroepiploic vessel.

placed in the reverse Trendelenburg position with his head elevated approximately 15 to 20 degrees and tilted left side up at approximately 20 to 30 degrees, which can better fully expose the superior border of the abdomen. The surgeon operates between the patient's legs, the camera operator is on the patient's right side just beside the left side of the operator, and the assistant is also on the patient's right side. Step one is to dissect the LNs in the inferior pole of the spleen. The assistant puts the free omentum in the anterior gastric wall and uses his or her left hand to pull the GSL so that there is a greater space for operating .The surgeon gently presses the tail of the pancreas by gauze and separates the greater omentum along the superior border of the transverse mesocolon toward the splenic flexure of the colon (*Figure 1*).

Next, along the direction of the pancreas, the surgeon peels the anterior pancreatic fascia (APF) off toward the superior border of the pancreatic tail (*Figure 2*).

Then, the lower lobar vessels of the spleen (LLVSs) or lower pole vessels of the spleen can then be exposed which follows the peeled anterior lobe of the transverse mesocolon (ATM) and APF are completely lifted from the pancreas so that the RPS is entered (*Figure 3*).

The assistant with his right hand lifts up the lymphatic fatty tissue on the surface of the vessels, and the surgeon dissects these lymphatic tissues by the non-functional face of the ultrasonic scalpel, sweeping toward the vessels. Therefore, the left gastroepiploic vessels (LGEVs) are revealed (*Figure 4*).

Then, the assistant pulls the LGEVs gently, and the surgeon separates the fatty lymphatic tissue meticulously from the LGEVs to completely denude them. The surgeon uses vascular clamps to divide the LGEVs at their roots (*Figure 5*).

We transected 1 to 2 branches of the SGVs in the direction of the splenic hilum (*Figure 6*).

We should clamp the smallest amount of tissue possible, simultaneously, shear and divide the tissue step-by-step, which is preferable to reduce wound effusion. Avoiding excessive tension could prevent vessel tearing and

Figure 5 Divides the LGEVs at their roots with vascular clamps. LGEV, left gastroepiploic vessel.

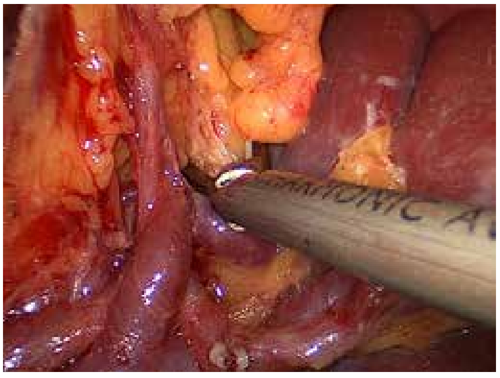

Figure 6 The first branch of SGVs is revealed. SGV, short gastric vessel.

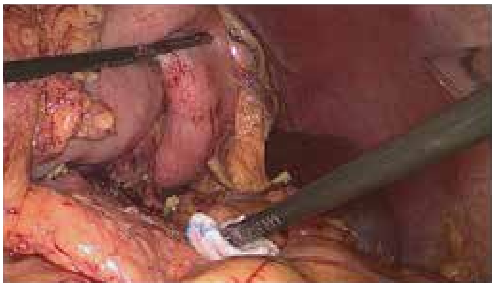

Figure 7 Second step: exposure of the region of the SpAT.

uncontrollable hemorrhaging before the completion of coagulation and shearing with the ultrasonic scalpels.

The second step is to dissect the LNs in the region of the SpA trunk. The assistant puts the free omentum between the inferior border of the liver and the anterior gastric wall and continually pulls the greater curvature of the fundus to the upper right, while the surgeon presses the body of the pancreas with his left hand (*Figure 7*).

Figure 8 Denude the middle of the splenic artery trunk until the fork of the splenic lobar arteries.

Figure 9 The PGA is exposed and denuded. PGA, posterior gastric artery.

The assistant with his right hand draws the isolated fatty lymphatic tissue on the surface of the SpA trunk. The surgeon denudes the middle of the SpA trunk along the latent anatomical spaces on the splenic vessel surface until the fork of the splenic lobar arteries lies along the latent anatomical spaces on the splenic vessel surface (*Figure 8*).

The posterior gastric artery (PGA) derived from the SpA, is always encountered in this region (*Figure 9*).

At this time, the assistant clamps and draws the vessels upward, and the surgeon denudes the vessels and closes toward the SpA trunk. Then, the surgeon divides the roots of the vessels with vascular clamps and dissects the fatty lymphatic tissue completely around the splenic vessels (No. 11d).

The third step is to dissect the LNs in the superior pole of the spleen. The assistant continually pulls the greater curvature of the fundus to the lower right, while the surgeon uses his left hand to gently press the vessels of the splenic hilum (*Figure 10*).

Then, the assistant, using the division point of the LGEVs as the starting point, gently pulls up the fatty lymphatic tissue at the surface of the terminal branches of

Figure 10 Third step: exposure of the superior pole region of the spleen.

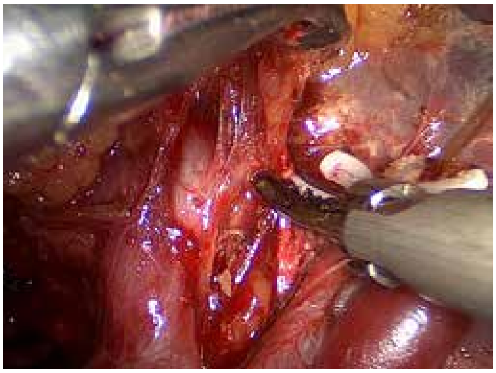

Figure 11 Sharp peeling of the lobar vessels in the superior lobar area of the spleen.

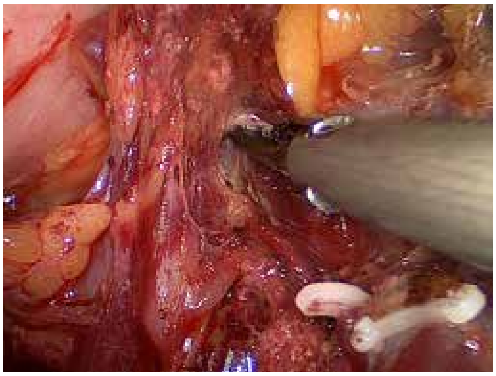

Figure 12 Blunt peeling of the lobar vessels in the superior lobar area of the spleen.

the splenic vessels and keeps the tissue under tension while the surgeon cuts the surface of the terminal branches of the splenic vessels by the non-functional face of the ultrasonic scalpel.

Figure 13 The exposure of the last SGV in the superior pole region of the spleen. SGV, short gastric vessel.

This meticulous sharp or blunt dissection of the lobar vessels in the superior lobar area of the spleen completely skeletonizes the vessels in the splenic hilum (*Figures 11,12*).

In the time of the dissection procedure, two or three branches of the SGVs derives from the terminal branches of the splenic vessels and entering the GSL. Meanwhile, the assistant clamps and pulls the vessels upward, consequently, the surgeon particularly dissects the surrounding fatty lymphatic tissue, near the roots of the SGVs. After confirming the destinations of the roots in the stomach wall, the surgeon then divides the vessels at roots with vascular clamps. Especially, the last SGV in the superior pole of the spleen is usually too short that easy to damage, which results in bleeding (*Figure 13*). Subsequently, the assistant pulls the fundus to the lower right, which is better to completely expose the vessel and assist the surgeon with careful separation. Then, the separation makes it possible to complete dissection of the fatty lymphatic tissue in front of the splenic hilum.

Dissection of the LNs behind the splenic vessels can be performed when the tail of the pancreas, which is a certain distance from the splenic hilum, is located in the inferior border of the spleen. The assistant, with his left hand, ventrally lift the termini of the splenic vessels by atraumatic grasping forceps, and the surgeon, with his left hand, press Gerota's fascia (*Figure 14*). Then, the ultrasonic scalpel is applied to dissect the adipose tissue behind the splenic vessels and in front of Gerota's fascia.

It is essential to be attentional during this step to prevent the separation plane from exceeding Gerota's fascia. Exceeding Gerota's fascia damages the kidneys and adrenal glands, as well as the related vessels or the nerves behind the vessels. By this time, the No. 10 lymphadenectomy is finished (*Figures 15,16*).

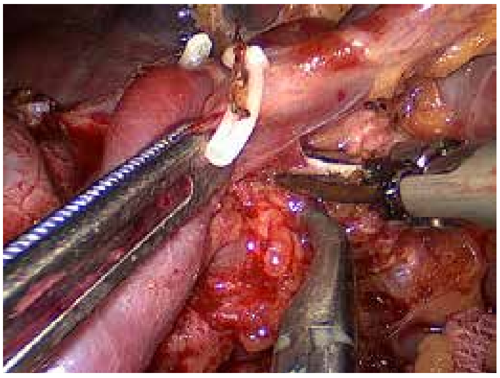

Figure 14 Dissection of the LNs behind the splenic vessels along the front of Gerota's fascia.

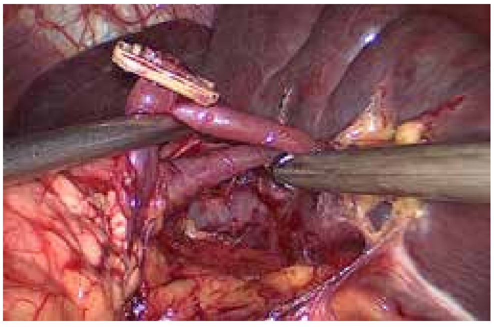

Figure 15 The LNs behind the splenic vessels are excised.

Figure 16 Dissection of the No. 10 and No. 11d LNs is completed.

Strategies of laparoscopic spleen-preserving No. 10 LN dissection

The following points should be considered for safely and effectively performing laparoscopic spleen-preserving No. 10 LN dissection.

Importance of teamwork

Four instruments used by the surgeon and assistant are placed together in the location, deep and narrow, of the operative site within the abdominal cavity in the left upper abdomen. This phenomenon is known as the "chopsticks effect". Hence, the camera assistant should adjust the orientation of the optical fiber and lens to avoid this problem. For our center, stable and automatic teamwork are known to be valuable in laparoscopic spleen-preserving No. 10 LN dissection. Above, we not only introduced the concrete operative steps taken by each participant but also indicated the scope and methodology of each technique to simplify the complicated No. 10 LN dissection procedure and to increase the efficiency of the operation. By presenting this information, we hope the procedure of laparoscopic spleen-preserving No. 10 LN dissection to be programmed, which will become prevalent in this field.

Step over the learning curve

The surgeon have to develop adequate and stable skills through an initial learning phase, called the learning curve of laparoscopic surgery, for performing laparoscopic spleen-preserving No. 10 LN dissection. This learning phase is usually measured by the number of surgical operations required before a beginner surgeon's skills become relatively stable. Thus, when the surgeon achieves a certain number of surgeries, his or her operative technique will be significantly improved, typically reaching a plateau over time. Therefore, the surgeon has better mastered the technique. Indicators used to evaluate the learning curve include the operative time, blood loss, laparotomy rate, complication rate, time until first liquid diet, and length of postoperative hospitalization. With respect to achieving proficiency in laparoscopic GC surgical techniques, a surgeon can be regarded as a person with stable skills, following 40 surgical training procedures (25). To shorten the learning curve and ensure the safety, the surgeon should perform the procedure on patients in good condition who are younger with fewer complications, smaller tumors, and leaner Figures. These criteria reduce surgical risks, increase surgeon's confidence and help them to eventually achieve proficiency. An adequate ability to summarize one's experiences and lessons and to explore the operative position and anatomical approach that are most suitable for oneself will help the surgeon to gradually establish relatively stable surgical abilities.

Be familiar with the complex anatomy in this region

This area located in a narrow and very deep operating space adjacent to the splenic hilum is complex. The spleen usually adheres to the omentum or peritoneum, making it vulnerable to be injured, and even has a complicated relationship with the adjacent organs and tissues. Therefore, it is actually a bit difficult to expose the splenic hilar area, adequately and effectively. The dissection of No. 10 LN is in danger of injuring the splenic parenchyma or adjacent organs such as the pancreas and adrenal gland. In addition, the splenic vessels exhibit a tortuous course, and their branches are complicated, which may lead to a high risk of vessel injury and result in uncontrollable hemorrhage during laparoscopic dissection in this region. Therefore, we hypothesize that 3-dimensional computed tomography (3DCT) reconstruction can be used preoperatively to estimate the distribution of the splenic vessels. Indeed, this technique will reduce the difficulty and time-consuming nature of the surgery, as well as the risk of injury to the splenic hilar vessels, and even increase the surgeon's confidence in the laparoscopic surgical technique. The research outcomes of our unit also revealed that compared with the non-3DCT group, the operative time and intraoperative blood loss were significantly decreased in the 3DCT group (26).

Prospect of laparoscopic spleen-preserving No. 10 LN dissection

Presently, in the evidence-based medical research although the long-term curative effect of laparoscopic spleen-preserving No. 10 LN dissection for advanced proximal GC is still not fully supported, the development of minimally invasive technology, represented here by laparoscopic technology, is an inevitable trend in GC surgery. Therefore, we should conduct a randomized controlled trial for spleen-preserving No. 10 LN dissection for advanced proximal GC to further confirm the efficacy of laparoscopic spleen-preserving No. 10 LN dissection.

Moreover, not all centers presently can independently complete laparoscopic spleen-preserving No. 10 LN dissection. Despite the substantial learning curve, surgeons at these centers must first master techniques for laparoscopic spleen-preserving No. 10 LN dissection. Grasp of these techniques is the key to completing the operation successfully. It is critical to provide professional training for GC surgeons, establish an active, hands-on training program and employ experienced and senior surgeons who can share their knowledge and experience to young doctors. Improving the level of integration of laparoscopic spleen-preserving No. 10 LN dissection is also a challenging target. Therefore, laparoscopic spleen-preserving No. 10 LN dissection will likely become one of the standard treatments for advanced proximal GC following improvement of the standardized operation training system and laparoscopic technology and the promotion of Huang's three-step technique.

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Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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Laparoscopic spleen-preserving splenic hilum lymph nodes dissection in total gastrectomy

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Abstract: Complete removal of splenic hilum lymph nodes (LN) while preseraving the spleen and pancreas during laparoscopic total gastrectomy is considered challenging and technical demanding. Based on our accumulated laparoscopic surgical experiences and anatomical understanding of peripancreatic structures, we developed a strategy using retro-pancreatic approach for laparoscopic spleen-preserving splenic hilum LNs dissection for locally advanced proximal gastric cancer.

Keywords: Stomach neoplasm; laparoscopy; lymph node excision (LN excision); splenic hilum

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Introduction

Splenic hilum (No. 10) lymph nodes (LN) dissection should be conducted in order to achieve complete D2 lymphadenectomy in total gastrectomy for locally advanced proximal gastric cancer (1). The recent popularization of laparoscopic surgery should follow the identical treatment principles. Traditional No. 10 LN dissection was mainly achieved through combined resection of pancreas and/or spleen. However, due to the increased postoperative morbidity, and no significant survival benefit, spleen-preserving gastrectomy was subsequently suggested through JCOG 0110 (2). Nevertheless, spleen-preserving No. 10 LN dissection in laparoscopic total gastrectomy was considered difficult due to the tortuous splenic vessels and possibility of parenchymal injury to the spleen or pancreas. Based on our anatomical understanding of peripancreatic structures, we combined the characteristics of laparoscopic surgery and developed a strategy using retro-pancreatic approach for laparoscopic spleen-preserving splenic hilum LNs dissection for locally advanced proximal gastric cancer since 2009 (3). With the accumulated experiences, we have also made several modifications to this procedure in the past two years. Here we would describe our procedure in detail

Case presentation

In 2015, a 37-year-old female patient with upper abdominal pain was incharged in our department. Gastroscopy with biopsy identified a poorly-differentiated adenocarcinoma with a diameter of 1.5 cm located at the middle-third of the stomach near the lesser curvature. Enhanced abdominal computed tomography (CT) showed no distant metastasis, gross involvement of the gastrosplenic ligament or LN No. 4sb, at the splenic hilum or along the splenic artery (SA). The estimated clinical stage was cT2N1M0.

Surgical procedure

Under general anesthesia, the patient was placed in the supine position with legs set apart in a reverse Trendelenburg position. The surgeon stood on the patient's left side; the assistant surgeon took the patient's right side; and the camera operator stood between the patient's legs. After pneumoperitoneum was established with carbon dioxide insufflated at a pressure of 12 mmHg, five working ports were introduced (4). Exploration of abdominopelvic cavity was conducted to exclude distant metastasis and carcinomatosis.

Figure 1 Laparocscopic total gastrectomy with D2 lymphadenectomy (5). Available online: http://www.asvide.com/articles/1343

In order to better expose the surgical field and facilitate the assistant, liver retraction was introduced as shown in the video to lift up the left lobe of the liver, which would help in the following dissection of LN No. 1 and 3 (*Figure 1*).

The greater omentum was then divided along the border of the transverse colon toward the splenic flexure. By dividing the gastrocolic ligament, the less sac was entered. The stomach was then overturned cephalad, the left gastroepiploic vessels (LGeA &V) was identified near the pancreatic tail, which were then ligated at the root and allowing dissecting LN No. 4sb. Then the dissection continued rightward toward the duodenum. the right gastroepiploic vein was identified by dissecting the mesogastrium inferior to the gastric antrum off the transverse mesocolon. The ligation point of RGeV should be above the abouchement of ASPDV. The right gastroepiploic artery (RGeA) was usually identified posterior to the vein, which was also divided to allow the removal of LN No. 4d and 6. Subsequently, the gastroduodenal artery (GDA) could be located in the groove between duodenum and pancreatic head, which served as a clue to trace the common hepatic artery (CHA) and proper hepatic artery (PHA). Then the stomach was placed in its original position to allow the supra-pyloric mobilization. The duodenum was transected 2 cm distal to the pylorus using an endoscopic linear stapler (Power Echelon 60 Endopath Stapler), By following the PHA, right gastric artery (RGA) could be located and ligated at its origin allowing complete removal of LN No. 5. After the assistant turned the mobilized stomach antrum cephalad again and lift up the gastropancreatic fold, the supra-pancreatic area could be better exposed, continue the dissection by opening the sheath of CHA, at the junction of CHA and the origin of SA, the retropancreatic space near the top of the pancreatic arch was entered, in this surgical plane, splenic vein (SV) could also be exposed and LN No. 8a and 11p were removed. Opening the Gerota's fascia, celiac artery (CA) could be seen and the root of left gastric artery (LGA) was ligated and cut, allowing dissection of LN No. 7 and 9. Also, by opening the sheath of left gastric vein (LGV), portal vein (PV) was traced. Ligation of LGV and removal of LN No. 12a was subsequently achieved. Then continued the dissection of LN No. 11d by following SA toward the spleen.

By retracting the pancreas meticulously in the caudal direction by the assistant, the surgeon dissected near the lower border of the pancreas and entered the retropancreatic space which was anterior to the fatty renal capsule until the pancreatic tail was mobilized. SA sheath was opened and skeletonized from the proximal portion towards the distal portion. When the bifurcation was reached, two secondary branches of the SA could be seen. The inferior branch had two third-grade branches. These secondary and third-grade branches of the SA were then skeletonized cautiously until they reached the spleen parenchyma. Meanwhile, the short gastric arteries (SGA) originating from the SA were all ligated. By skeletonizing the SA, fatty tissues bearing LN No. 10, 11d, 4sa were removed and all vessels in the splenic hilum area were saved with the preservation of the spleen.

Subsequently, the left cardia was mobilized and both vagus nerves were divided and LN No. 2 was dissected. The Roux-en-Y esophagojejunostomy and jejunojejunostomy were carried out extracoporeally through a 5 cm midline minilaparotomy just below the xiphoid process.

Results

The operating time was 173 min and estimated blood loss was 20 mL. Pathological findings suggested the TNM stage was T1aN0M0 (stage IA) according to AJCC cancer staging manual-7th edition, the number of retrieved total LN and No. 10 LN was 71 and 5 respectively. Postoperatively, the patient experienced the first flatus on day 2, began oral intake of liquid diet on day 3 and discharged on day 7. Within 30 days after surgery, no complication was observed. At the last follow-up of 13 months, the patient didn't experience recurrent disease.

Discussion

With the treatment innovations including the popularity of minimally invasive surgery for fighting against gastric cancer, the prognosis was greatly improved. However, the situation in China, where the majority of GC patients suffered from advanced stage diseases, still poses great challenges for Chinese clinical practitioners. The role of laparoscopic surgery for advanced gastric cancer is still controversial due to the lack of powerful evidence on the comparable long-term oncologic outcomes with open surgeries. Although the interim result of CLASS-01 trial showed promising safety and feasibility of laparoscopic surgery, the final results are awaited (6).

In treating locally advanced proximal gastric cancer, total gastrectomy with D2 lymphadenectomy is considered standard procedure (1), however, the achievement of No. 10 LN dissection has been heatedly debated. Results of JCOG 0110 suggested no necessity of performing splenectomy added evidence to this topic (2), however, laparoscopic spleen-preserving splenic hilum LN dissection in total gastrectomy is still challenging and technical demanding. Only a few experienced laparoscopic surgeons from high volumn centers have reported this procedure through various approaches, including left, medial and retropancreatic approaches (3,7,8).

In our center, pancreas- and spleen-preserving laparoscopic total gastrectomy with D2 lymphadenectomy was first attempted in 2009 using retropancreatic approach. The benefit of our strategy could gain sufficient control of the splenic pedicle and thus better expose the splenic hilum area together with the inferior secondary and third-grade branches of SA (3). Also, if unexpected bleeding occurred during dissection, the mobilized pancreatic tail and splenic pedical could allow in-time handling with less difficulties to prevent severer consequences. On this basis, we also made small modifications to this procedure: (I) routine liver retraction at the beginning of the surgery; and (II) duodenum transection after finishing infra-pyloric LN dissection. These two small tips could both achieve better exposure of the surgical field and pose less challenges for the assistant. To be specific, after retraction of the liver, when dissection LN No. 1 and 3, the assistant could easily expose the hepatogastric ligament with the left hand atraumatic clamp without fearing causing device-related injury to the left lobe of the liver. Similarly, after transection of the duodenum beforehand, and folding the mobilized gastric antrum toward the left upper quadrant of the patient's abdomen, the assistand could just use the clamp to insert between the two leaves of gastropancreatic fold and lift up to expose the suprapancreatic area without fearing the cephalad turned stomach may fall down and interrupted the surgical procedure. These tips might be helpful for surgeons who wish to perform similar procedures.

Conclusions

Laparoscopic total gastrectomy with spleen-preserving splenic hilum LNs dissection through retro-pancreatic approach could be technically safe and feasible in experienced hands.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Informed Consent: Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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Laparoscopic spleen-preserving complete splenic hilum lymphadenectomy for advanced proximal gastric cancer

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Abstract: For advanced proximal gastric cancer, total gastrectomy with D2 lymphadenectomy is the standard surgical therapy containing splenic hilum lymph nodes (LNs) dissection. However, laparoscopic spleen-preserving complete splenic hilum LNs dissection for advanced proximal gastric cancer is technically challenging. Herein, we introduced an omnibearing method for laparoscopic spleen-preserving complete splenic hilar lymphadenectomy in racial total gastrectomy. The order of lymphadenectomy was No. 4d and 6 LNs-No. 12a, 8a, 9 and 7 LNs-No. 1, 3 and 5 LNs-No. 4sb, 4sa and 2 LNs-No. 10 and 11 (anterosuperior) LNs-No. 10 and 11 (posterior) LNs. During dissecting No. 10 and 11 LNs, we divided them into two parts, namely LNs anterosuperior and posterior to the splenic vessel. Laparoscopic total gastrectomy with spleen-preserving splenic hilum LNs dissection using an omnibearing method for advanced proximal gastric cancer was safe and technically feasible in experienced hands. Further studies in terms of its clinical significance are needed.

Keywords: Laparoscopy; gastric cancer; total gastrectomy; spleen-preserving; splenic hilum lymph node dissection (splenic hilum LN dissection)

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Introduction

With the improvement of minimally invasive technique and its potential minimally invasive advantages, laparoscopic radical distal gastrectomy is more and more popular, especially in East Asia. The short-term outcomes of CLASS-01 trial were encouraging and demonstrated the safety and feasibility of laparoscopic distal gastrectomy for advanced gastric cancer (1). Total gastrectomy with standard D2 lymph nodes (LNs) dissection including LNs along splenic artery and splenic hilum dissection is recommended in the 3rd version of Japanese gastric cancer treatment guidelines for advanced middle and upper gastric cancer (2). Nevertheless, because of the deep location of spleen, circuitous splenic vessels and easy splenic and pancreatic parenchyma damage, complete removal of the LNs along splenic artery and splenic hilum is technically demanding. In last century, splenectomy with partial pancreatectomy was recommended to remove these regional LNs, but it resulted in terrible complication and death rate and there were no survival benefits. As a consequence, the clinical significance of this procedure was controversial.

Spleen-preserving splenic hilum lymphadenectomy has been gradually accepted because of the advancement of anatomical comprehension and the improvement of surgical techniques (3). Nevertheless, laparoscopic total gastrectomy with D2 lymphadenectomy was yet not widely performed due to the technical difficulty of spleen- and pancreas-preserving splenic hilum lymphadenectomy and totally laparoscopic Roux-en-Y esophagojejunostomy. Herein, we present our technical characteristics and initial experience of laparoscopic radical total gastrectomy with spleen-preserving complete splenic hilum lymphadenectomy for advanced gastric cancer.

Patient selection

The inclusion criteria of present study were described as follows: primary gastric adenocarcinoma confirmed pathologically by endoscopic biopsy; tumor was located in the upper and middle third of stomach; preoperative TNM stage was T1–4aN0–3M0 according to 7th Edition AJCC Cancer Staging Manual based on computer tomography and endoscopic ultrasonography. Patients proved with distant metastases or obvious invading of adjacent organ based on preoperative computer tomography or intraoperative exploration were not suitable for this procedure. An informed consent about the potentially surgical risks and the technical details of operation was provided for every patient. The protocol of this procedure obtained the approval from Guangdong Provincial Hospital of Chinese Medicine Ethics Committee.

Pre-operative preparation

Pre-operative preparation was performed according to the concept of fast track surgery. No normal bowel preparation was used and patients were fasting one night before operation. Intravenous antibiotics were infused 30 minutes before operation.

Equipment preference

Operative equipment contain: HD camera and display system, pneumoperitoneum machine, laparoscopic standard instruments, ultrasonic scalpel, circular stapler, linear stapler and other conventional surgical instruments.

Surgical technique

The local LNs in this procedure were defined as the 3rd edition of Japanese Classification of Gastric Carcinoma (4).

After general anesthesia, patient was placed in a supine position with legs apart and 20° head-up tilt. A standard method of five trocars was used (5). The dominant surgeon stood at the left side of patient with the assistant at the right side and the camera holder between the legs. The CO_2 pneumoperitoneum was established and maintained at a pressure of 12 to 15 mmHg. The procedure was performed as our previous study (5). While performing No. 10 and 11 LNs dissection, these special LNs were divided into two parts, namely anterosuperior LNs and posterior LNs according to the position relationship with splenic vessels (6). Before operation, the intraperitoneal exploration was performed to examine the primary tumor and know if there were distant metastases.

The gastrocolic ligament was dissected firstly at the left part and divided from left to right until to the inferior region of pylorus. Then the pedicle of right gastroepiploic artery and vein were exposed and ligated with the infrapyloric fatty tissue removed. And the No. 4d and No. 6 LNs were dissected.

The plica gastropancreatica was exposed through over-turning the body of the stomach cranially and ventrally by the assistant surgeon. With the introduction of right gastroepiploic artery, the gastroduodenal artery was indentified. Along the pathway of the gastroduodenal artery, the supra-pancreas area was exposed and the proper hepatic artery and common hepatic artery were traced with the left gastric vessel and splenic artery indentified. These primary vessels were ligated at roots and the fatty tissue along them was removed as well as the tissue along the celiac trunk. As a consequence, No. 7, 8a, 9 and 12a LNs were completely removed. Then, the duodenohepatic ligament and gastrohepatic ligament were dissected and the No. 1, 3 and 5 LNs along the lesser gastric curvature were removed.

Anterosuperior No. 10 and 11 LNs dissection

The location of the surgeons was adjusted. The dominant surgeon stood between legs and the camera holder stood at beside the patient's right leg. The camera view was focused on the inferior pole of spleen. The greater curvature of the stomach was overturned cranially and ventrally to make the gastrosplenic ligament under an appropriate tension. The left gastroepiploic vessels and short gastroepiploic vessels were exposed and ligated at root with No. 4sb and 4sa LNs dissection. Along the left gastroepiploic vessels, the splenic vessels and the superior border of pancreas were exposed.

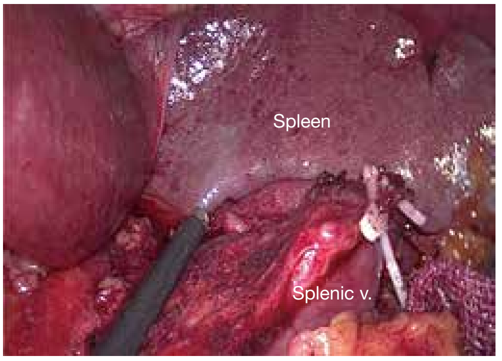

Figure 1 Dissection of LNs anterosuperior to splenic vessel. LN, lymph node; v, vein.

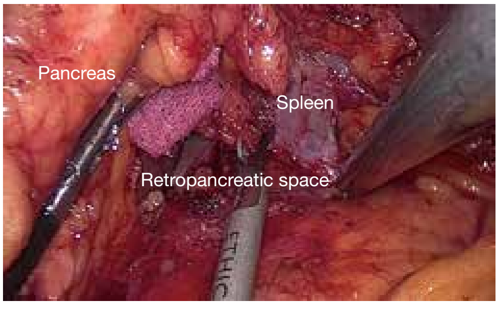

Figure 2 Retropancreatic space.

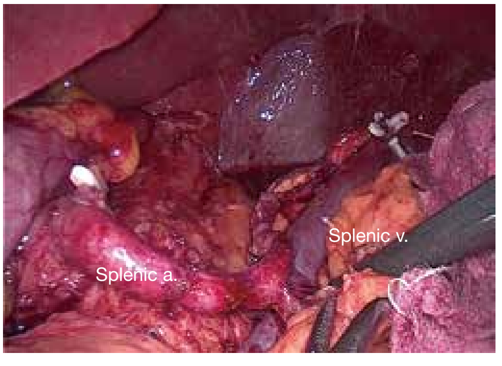

Figure 3 Dissection of LNs posterior to splenic vessel. LN, lymph node; a, artery; v, vein.

The sheath of the splenic artery trunk was dissected. Then the tissue anterosuperior to the splenic vessel and splenic hilum was removed along the pancreatic tail from the vessel trunk to its terminal branches with the posterior gastric vessels ligation. The anterosuperior No. 11 and 10 LNs were completely dissected (*Figure 1*).

After anterosuperior No. 10 and 11 LNs dissection, the linear staplers were used to transect the duodenum 2 cm distal to the pylorus and the esophagus with adequate tumor free margin. Then the specimen extraction was performed with a midline mini-incision.

Posterior No. 10 and 11 LNs dissection

After specimen extraction, the pneumoperitoneum was rebuilt and the dominant surgeon exchanged to the right side. The distal pancreas was completely mobilized by separating the fascia between the retroperitoneum and the pancreatic tail (*Figure 2*) (5). After exposing the retro-pancreatic space, the posterior paries of splenic vein was exactly identified. The soft tissue between splenic vein and artery and the LNs posterior to the splenic vessels was completely removed by skeletonizing the splenic vessels with the great pancreatic artery and the pancreatic tail artery preserved. At last, posterior No. 10 and 11 LNs were dissected with all splenic vessel branches saved (*Figure 3*).

After laparoscopic radical total gastrectomy with spleen-preserving complete splenic hilum lymphadenectomy, totally laparoscopic Roux-en-Y esophagojejunostomy was performed with circular stapler and the jejunojejunostomy was carried out in a side-to-side fashion using linear stapler.

Role of team members

Our multi-disciplinary team consisted of surgeons, iconography doctors, anesthetists, physicians of oncology, nurses, pathologists and other allied health professionals. The pre-operative examination and evaluation were performed by surgeons and iconography doctors. The specimen evaluation was performed by surgeons and pathologists. Peri-operative nursing care and management was performed by nurses and surgeons. Postoperative adjuvant chemotherapy was performed by physicians of oncology if necessary.

Post-operative management

Post-operative management was performed according to the concept of fast track surgery. One more time of intravenous antibiotics was performed within 24 hours after operation. The gastric tube and urinary catheter were removed on the first post-operative day and liquid diet was beginning at the same time. Ambulation as early as possible was advocated.

Tips, tricks and pitfalls

Laparoscopic total gastrectomy for advanced gastric cancer still confronted with many controversies, including morbidity, adequate tumor margin, standard lymphadenectomy and long-term survival, especially complete peri-splenic hilum (containing No. 10 and 11d) LNs dissection for advanced proximal tumor. Due to the technical difficulties in complete removal of peri-splenic hilum LNs, only a fewer surgeons in East Asian, such as China, Korea and Japan, focused on laparoscopic radical total gastrectomy with spleen-preserving complete splenic hilum lymphadenectomy.

As the characteristics of laparoscopic technique, laparoscopic splenic hilum lymphadenectomy has its technical difficulty, but also has its special advantages. In laparoscopic gastrectomy, only four work ports were used, so the traction is lacking and the exposure is poor. It is easy to affect the operation and increases the unexpected injury rate to splenic vessel, parenchyma of the pancreas and spleen. However, minimally invasive surgery has a valid magnifying effection. When performing laparoscopic lymphadenectomy along peri-splenic area, surgeons can clearly identify all various branches of the splenic vessels, as well terminal branches, so that they can effectively reduce the accident of vascular injury as well as reducing the rate of damage to the pancreas and spleen.

In our initial experience, the postoperative outcomes showed that the mean operative time was slightly longer than other relative studies (7-9). One of the reasons may be that the small sample of our series study and we have not crossed over the learning curve and another one reason may be our more complete removal of the splenic hilum LNs compared with other studies. However, the other short-term outcomes containing blood loss, number of LNs harvested and rate of postoperative complication were satisfactory. Therefore, laparoscopic spleen-preserving complete peri-splenic hilum lymphadenectomy was safe and technically feasible.

When No. 10 and 11 LNs dissected, the anterosuperior and posterior portions of No. 10 and 11 LNs were dissected respectively. After the left gastroepiploic vessels and short gastroepiploic vessels were ligated at roots, the splenic artery and vein were exposed and identified. No. 10 and No. 11 anterosuperior LNs were dissected from the splenic vessel primary trunk to its branches with the introduction of the splenic vessel.

Compared with the anterosuperior LNs dissection, the posterior LNs dissection was more difficult and technically demanding. The retropancreatic space was deep and narrow and the pancreas could not be easily grasped make it difficult to achieve completely removal of these special LNs. Our strategy was separating the retropancreatic space with priority and using the suction/irrigation tube for traction. And the posterior parietes of splenic vessel were completely exposed so that we could easily remove the posterior LNs. Opening the sheath of splenic artery and skeletonizing the spleni vessel from the primary trunk to its branches, the soft tissue along splenic vessels could be dissected by entering vascular intrathecal space. During operation, surgeons must keep visual field clear with the irrigation and suction technique and the small bleeding trauma could be handled with electrocoagulation and attraction.

In laparoscopic splenic hilum lymphadenectomy, skilled master of the ultrasonic scalpel was very important. When dissection, the non-functional face should be near to the key structures, which is an effective way to avoid damaging the pancreas, spleen and splenic vessels. Because of the tortuous splenic vessel, exposure of the splenic hilum area was difficult. We used an elastic band for traction which made lymphadenectomy safer and easier. In our series, one case of intro-operative splenic vessel injury was occurred and handled with laparoscopic vessel suture technique successfully. When unexpected bleeding occurred, surgeons must stay calm and keep the operative field clear using aspirator and skillful laparoscopic suture and knot tying technique were necessary. In addition, operative team building is important for this difficult laparoscopic operation.

In this laparoscopic procedure, surgeons must well understand the complex variations of splenic vessels trunk and its branches and different pancreatic parenchyma and shape. These variations might increase the injury rate of splenic vessels and the possibility of unexpected pancreatic fistula. The distance from the tail of pancreas to spleen and the difference of splenic lobar vessels must be carefully identified when performing splenic hilum LNs dissection. Generally, splenic artery was divided into several branches at the lienorenal ligament. Some scholars explored the different anatomical variations of the splenic artery and its clinical implications in 320 cadavers (10). They clearly suggested that there was variation in terminal distribution pattern of the splenic artery. In 9 (2.8%) cadavers, the splenic artery passed through the splenic hilum without diving. The splenic artery divided into terminal branches in 311 (97%) cadavers, containing two terminal branches (63.1%), the most common fashion followed by four branches (18.8%), six branches (9.7%) and more than six branches (5.6%). Apparently, the more terminal branches the splenic artery divided into, the more demanding of splenic hilum lymphadenectomy might be. To identify the fat tissue or pancreatic tissue carefully was also very significant.

There were portion of No. 10 and No. 11 LNs deeply behind the pancreas. By separating retro-pancreatic space, complete removal of these LNs was simple and easy. In our series, the posterior portion of No. 10 and 11 LNs were dissected and examined alone. Several previous reports have demonstrated that the metastasis rate of No. 10 LNs was 9–20.9% in proximal gastric cancer (11-14). However, there were still no study about the metastasis rate of posterior portion of No. 10 and 11 LNs. Therefore, future studies about the metastasis rate and its clinical significance of these special LNs dissection are needed (6).

In conclusion, for skilled laparoscopic surgeon, laparoscopic total gastrectomy and D2 lymphadenectomy with spleen-preserving complete splenic hilum LNs dissection is safe and technically feasible.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Strategy of laparoscopic suprapancreatic lymph node dissection for advanced gastric cancer

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Abstract: The lymph nodes (LNs) that distribute along the celiac artery (CA) system in the suprapancreatic area include LNs around the root of the left gastric vessels (No. 7, No. 8a, No. 9 and No. 11p) and the right gastric vessels (No. 5 and No. 12a). Due to the high rate of LNs metastasis and the various vascular anatomies in this area, the suprapancreatic LN dissection is a crucial and demanding procedure for radical resection in the treatment of patients with advanced gastric cancer (AGC). Laparoscopic gastrectomy with D2 LN dissection has not yet been widely adopted for advanced stages because it is technically complicated. The initial segment of the splenic artery (SpA) approach is recommended as the ideal approach for laparoscopic suprapancreatic LN dissection in AGC.

Keywords: Stomach neoplasms; laparoscopy; suprapancreatic lymph node dissection (suprapancreatic LN dissection); the proximal splenic artery approach (the proximal SpA approach); vascular anatomy

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Introduction

The lymph nodes (LNs) that distribute along the celiac artery (CA) system in the suprapancreatic area include LNs around the root of the left gastric vessels (No. 7, No. 8a, No. 9 and No. 11p) and the right gastric vessels (No. 5 and No. 12a) (1) (*Figure 1*). There is a high rate of lymph node metastasis (LNM) in this area (No. 5, 7, 8a, 9, 11p, and 12a) for patients with advanced gastric cancer (AGC). We retrospectively analyzed the clinic and pathological features of 1,551 cases with AGC, and the result showed the suprapancreatic LNM rate was 51.8% (804/1,551) (2) (*Figure 2*). Based on the 3th edition of Japanese Gastric Cancer Treatment Guidelines, complete clearance of LNs in the suprapancreatic area is crucial importance during radical gastrectomy with D2 LN dissection for gastric cancer (3). Clinically, LN dissection in this area is both greatly important and technically demanding for laparoscopic radical gastrectomy for patients with gastric cancer.

Operative approach to suprapancreatic lymphadenectomy

Selecting the appropriate surgical approach is the beginning of successful surgery, and also the premise of smooth procedure in laparoscopic radical resection for gastric cancer. We dissected the suprapancreatic LNs using a left approach during laparoscopic gastrectomy with D2 LN dissection for gastric cancer (4). In this approach, the initial segment of the splenic artery (SpA) was firstly exposed at the posterior pancreatic space on the left side of gastropancreatic fold (GPF) (*Figure 3*). From left to right, we removed the

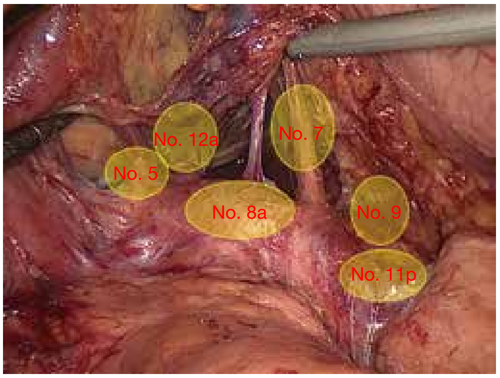

Figure 1 The LNs in the suprapancreatic area. LN, lymph node.

Figure 2 The positive LNs in the suprapancreatic area. LN, lymph node.

Figure 3 Exposure of initial segment of the SpA. SpA, splenic artery.

No. 11p LNs at first, then followed by the No. 9, 7 and 8a LNs. And the removal of the No. 5 and 12a LNs was completed finally (*Figure 4*). Lymphadenectomy in

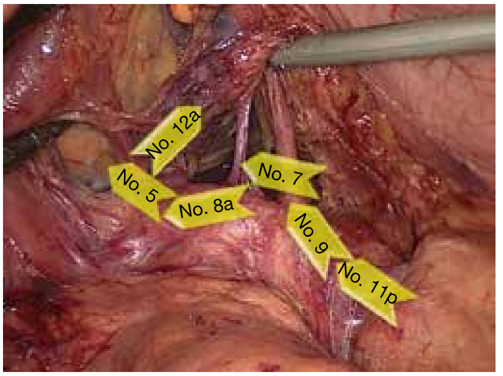

Figure 4 The sequence of LN dissection using a left approach. LN, lymph node.

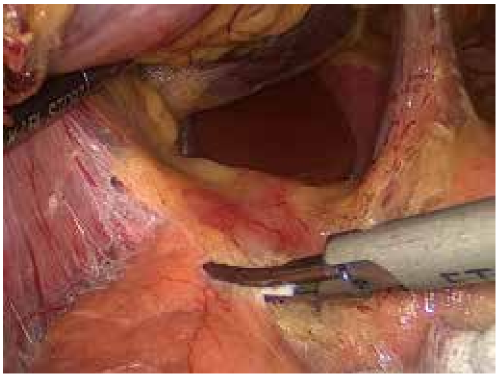

Figure 5 The LNs are removed from the rear of the stomach. LN, lymph node.

each station in this order would provide convenience for subsequent station. During this procedure, we don't transect the duodenum from the beginning in order to ward off the left lateral liver by using the hepatogastric ligament, by this way we denude the vessels and remove fatty lymphatic tissue from the rear of the stomach (*Figure 5*).

Patient's position and surgeons' locations

The patient is commonly maintained in the supine position with two legs separated. The operating table inclines about 10°–20° into the reverse Trendelenburg position (*Figure 6*). Generally, the surgeon and the assistant stand on the patient's left and right side, respectively. While the camera operator located between the patient's legs (*Figure 7*). Five trocars are usually inserted in patient's abdominal wall (*Figure 8*).

Figure 6 Patient in the supine and reverse Trendelenburg position.

Figure 7 Surgeon and assistant general locations.

Figure 8 Locations of the trocars.

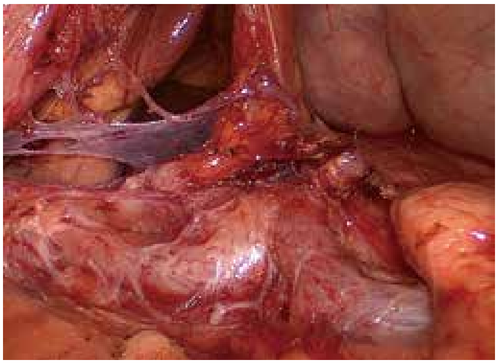

Figure 9 The initial segment of SpA with lesser anatomic variation. SpA, splenic artery.

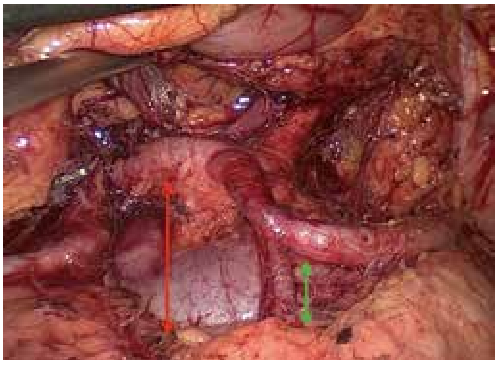

Figure 10 The initial segment of SpA with closest distance to the suprapancreatic border. SpA, splenic artery.

Advantages of the left approach

In our center, the initial segment of the SpA is chosen as the ideal approach for the LNs dissection in the suprapancreatic area mainly based on the following five reasons (2,4,5); firstly, its location is relatively constant with less anatomic variation and as well larger diameter (*Figure 9*); secondly, it is located the closest to the suprapancreatic border and thus easy to be exposed after the pancreatic capsule being peeled off (*Figure 10*); thirdly, there is a low risk of bleeding because of fewer branching vessels in this area, and which provides a large operating field and clearly exposed vision after the dissection of No. 11 LN (*Figure 11*); fourthly, the initial segment of the SpA may serve as the anatomic landmark for further rightward exposing the CA, the left gastric artery (LGA) and the common hepatic artery (CHA) (*Figure 12*); lastly in our previous literature, the result showed there was the lowest rate of LNM in No. 11p LN among all the suprapancreatic LNs, which would decrease the difficulty of lymphadenectomy here (2).

Procedure of suprapancreatic area LN dissection

The application of reasonable and programmed procedure

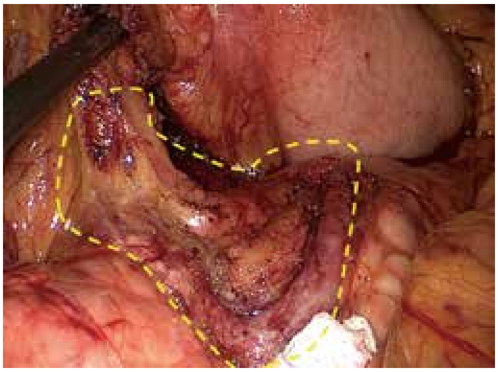

Figure 11 This area with a low risk of bleeding because of fewer branching vessels.

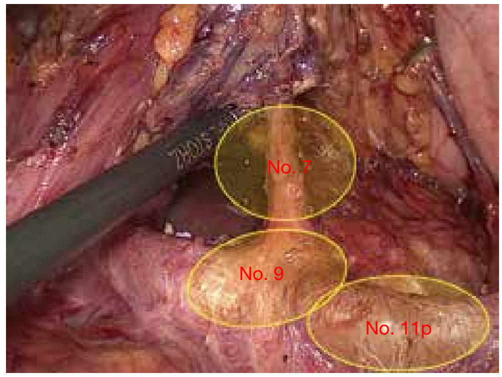

Figure 13 The dissection of No. 7, No. 9, and No. 11p LNs. LN, lymph node.

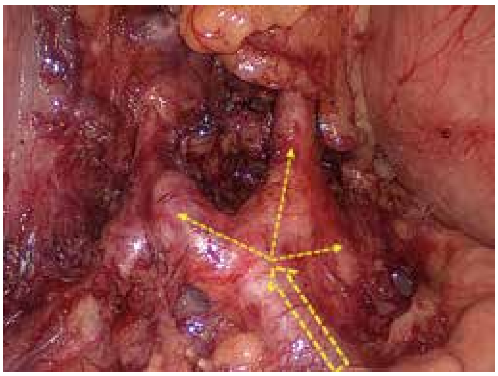

Figure 12 Serving as the anatomic landmark for searching CA, LGA and CHA. CA, celiac artery; LGA, left gastric artery; CHA, common hepatic artery.

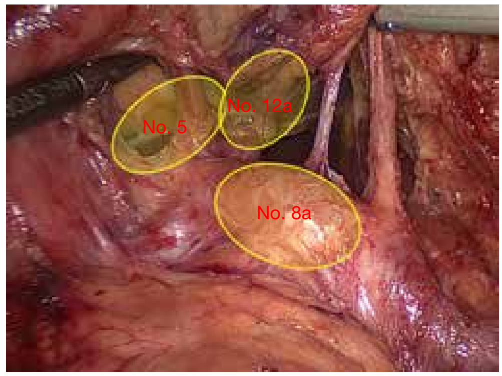

Figure 14 The dissection of No. 5, No. 8a, and No. 12a LNs. LN, lymph node.

would simplify the operation process, which makes the complex laparoscopic surgery simple and routine, and further improves the operation efficiency. In order to enable the procedure to achieve routinization, we separate the process of LN dissection in the suprapancreatic area with a left approach into two steps (4,6). The first step is to remove the left-side LNs in this area including No. 7, No. 9 and No. 11p (*Figure 13*), and the second step is to remove the right-side LNs in this area including No. 8a, No. 5 and No. 12a (*Figure 14*).

Dissection of the No. 7, No. 9 and No. 11p LNs

Exposure methods

Using noninvasive grasper forceps, the assistant's left hand lifts upward the junction of upper and middle GPF, and the right hand pushes the posterior wall of duodenal bulb rightward. The operator's left hand presses gently downward the bulging body of the pancreas with a small gauze. In this way, the GPF will be sufficiently kept tensed and the suprapancreatic area can be spread out to facilitate the LN dissection (*Figure 15*). During the process, the assistant's right hand can flexibly use different techniques (such as lifting, holding, pulling, and pushing) with a forceps or an aspirator to aid the surgeon in separating and exposing the surgical field.

Operative procedures

The operator uses the ultrasonic scalpel to smoothly peel off the pancreatic capsule closely on the pancreatic surface

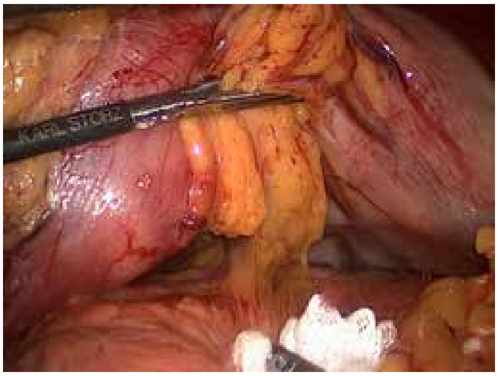

Figure 15 The assistant lifts upward the GPF, the operator presses the pancreas body. GPF, gastropancreaticf fold.

Figure 16 Peeling off the pancreatic capsule.

Figure 17 The exposure of the initial segment of SpA. SpA, splenic artery.

up to its superior border (*Figure 16*), and then open the GPF to enter the posterior pancreatic space, where the

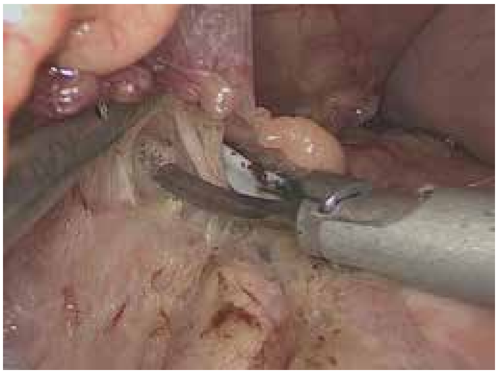

Figure 18 LN dissection of the No. 11p. LN, lymph node.

Figure 19 LN dissection of the No. 9 along the left edge of CA. LN, lymph node; CA, celiac artery.

initial segment of the SpA is further separated and exposed (*Figure 17*). Next, the operator uses non-functional face of the ultrasonic scalpel to carefully remove the fatty lymphatic tissue along the surface of the SpA until near the posterior gastric artery (PGA), and finish the dissection of the No. 11p LNs (*Figure 18*). The No. 9 LNs is dissected directly from the origin of the SpA. Then, the operator uses the ultrasonic scalpel to remove fatty lymphatic tissue along anatomical space on the left edge of the CA (*Figure 19*) toward the crus of the diaphragm, until the left edge of the LGA root is exposed (*Figure 20*). Subsequently from the origin of the CHA, the operator separates and exposes the left gastric vein (LGV) along the anatomical space on the right edge of the CA (*Figure 21*). The connective tissues around the LGV are removed on the superior edge of the CHA, and the LGV is vascularized then divided at its root with the clips (*Figure 22*). After that, the operator dissects

Figure 20 LN dissection of the No. 7 along the left edge of LGA. LN, lymph node; LGA, left gastric artery.

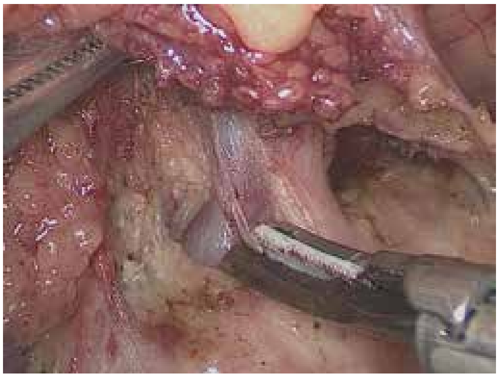

Figure 21 The separation and exposure of the LGV. LGV, left gastric vein.

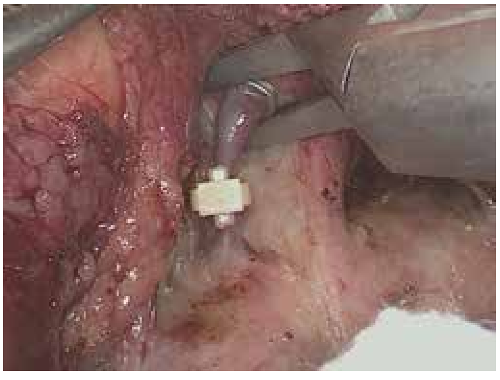

Figure 22 The division of the LGV on the superior edge of CHA. LGV, left gastric vein; CHA, common hepatic artery.

the fatty lymphatic tissue along the right edge of the CA surface (*Figure 23*). The LGA is then denuded on its right edge and divided at its root with the clips (*Figures 24,25*).

Figure 23 Dissecting the No. 9 LN along the right edge of CA. LN, lymph node; CA, celiac artery.

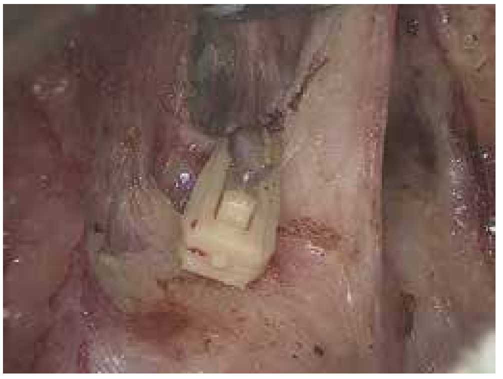

Figure 24 Dissecting the No. 7 LN along the right edge of LGA. LN, lymph node; LGA, left gastric artery.

With this, the dissection of the No. 7 and No. 9 LNs is completely finished.

Dissection of the No. 8a, No. 5 and No. 12a LNs

Exposure methods

Using noninvasive grasper forceps, the assistant's left hand lifts upward the posterior wall of gastric antrum, meanwhile the right hand pushes the duodenal bulb rightward. The operator's left hand presses gently downward the bulging head of pancreas near the fork of CHA with a small gauze. In this way, the hepatoduodenal ligament (HDL) will be kept tensed and the suprapyloric area can be sufficiently exposed at the rear of the stomach to facilitate the LN dissection (*Figure 26*). During the process, the assistant's right hand can flexibly use different exposure ways to help the operator to dissect No. 8a, No. 5 and No. 12a LNs.

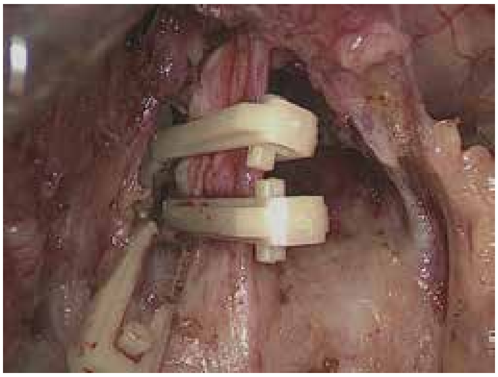

Figure 25 The division of the LGA at its root. LGA, left gastric artery.

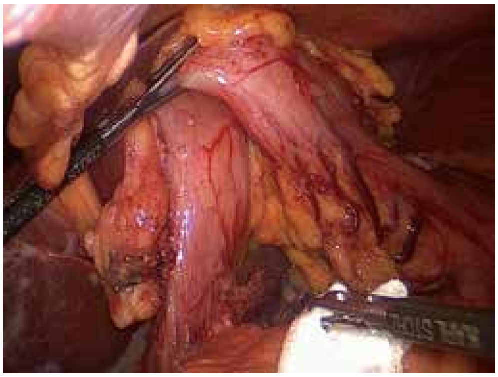

Figure 26 The assistant lifts the posterior wall of gastric antrum, the operator presses gently the pancreas head.

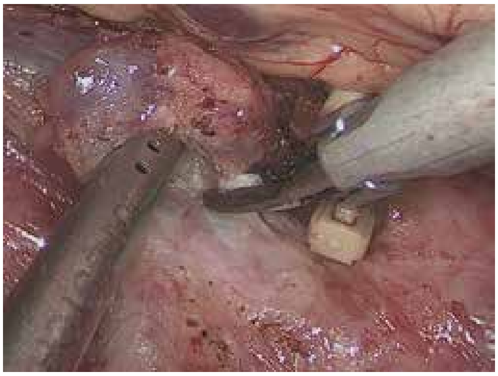

Figure 27 Dissection of the No. 8a LNs. LN, lymph node.

Operative procedures

Along the anatomical space on the anterosuperior surface of the CHA, the operator uses the ultrasonic scalpel to meticulously remove fatty lymphatic tissue toward the duodenum (*Figure 27*), until it reaches the fork where the CHA gives off the gastroduodenal artery (GDA) and proper hepatic artery (PHA) (*Figure 28*). The anterosuperior LNs along the CHA is completely removed, and we finish the dissection of No. 8a LNs. From the medial border of PHA original part, the operator uses the ultrasonic scalpel to open the medial border of the HDL along the course of the PHA (*Figure 29*), then separate and expose the root of the right gastric artery (RGA) (*Figure 30*). The RGA is carefully vascularized and divided at its root with the clips (*Figure 31*). At this point, we finish the dissection of No. 5 LNs. Then along the anatomical space on the anterosuperior surface of PHA, the operator uses the ultrasonic scalpel to meticulously dissect fatty lymphatic tissue toward the hepatic hilum, until it reaches the fork where the PHA gives off the left and right hepatic arteries (HA) (*Figure 32*).

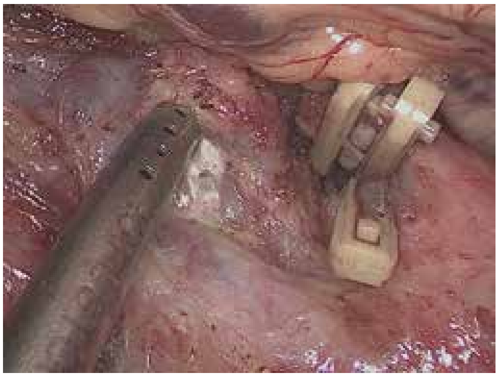

Figure 28 Dissection of the No. 8a LNs until the fork of CHA. LN, lymph node; CHA, common hepatic artery.

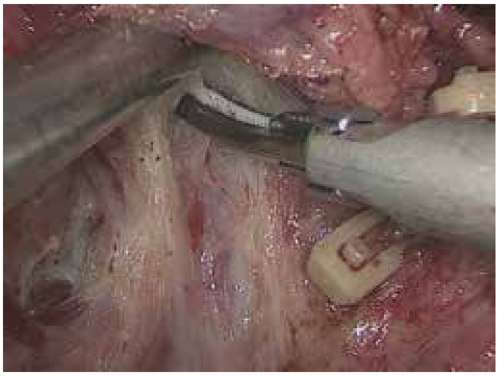

Figure 29 Opening the medial edge of the HDL along the CHA. HDL, hepatoduodenal ligament; CHA, common hepatic artery.

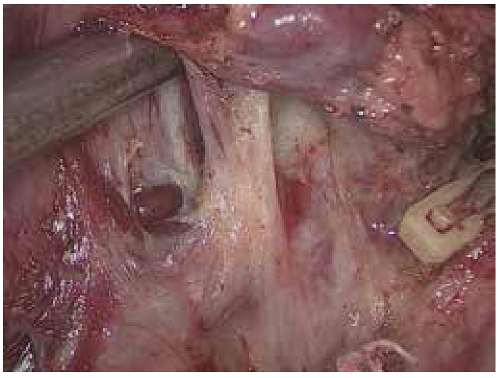

Figure 30 Exposure and denuding of the root of RGA. RGA, right gastric artery.

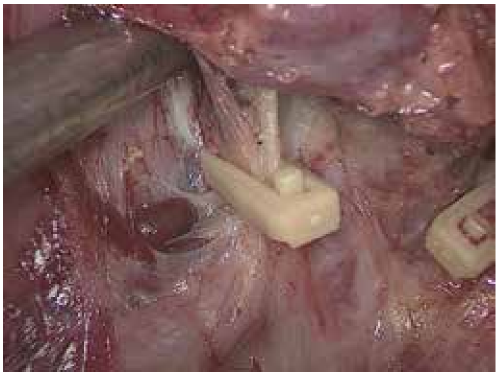

Figure 31 The division of RGA at its root. RGA, right gastric artery.

Figure 32 The dissection of No. 12a LNs along the PHA. LN, lymph node; PHA, proper hepatic artery.

The anterosuperior LNs along the PHA are removed *en bloc*, and we finish the dissection of No. 12a LNs. By this time, suprapancreatic LN dissection is achieved smoothly (*Figure 33*).

Figure 33 The accomplishment of LN dissection in the suprapancreatic area. LN, lymph node.

Familiar with normal anatomy and anatomic variation of suprapancreatic vessels

During the laparoscopic radical gastrectomy for gastric cancer, we should not only understand well normal anatomy and trend of perigastric vessels, but also be very familiar with their variations. Clinically, lack of sufficient understanding of vascular anatomical variations would usually cause vascular injury to bleeding and make the process of procedure unfavorable. Based on clinical practice of more than 3,000 cases undergoing laparoscopic gastrectomy in our center, we summarized the anatomical variations of perigastric vessels in detail. In our opinions, we should pay attention to two kinds of common trend and three kinds of variable trend of LGV (5-7), as well six types of replaced HA due to absence of CHA (5,8) during laparoscopic suprapancreatic LN dissection using a left approach, which facilitates surgeons to decrease the incidence of intraoperative bleeding from injured vessels and improve the surgical safety at to the greatest extent.

Summary

In summary, laparoscopic suprapancreatic LNs dissection using a left approach could be technically safe and feasible. Additionally, without transecting the duodenum might be more convenient in laparoscopic procedure for AGC. Finally, the stable team and harmonious cooperation should be the most crucial for this procedure.

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Footnote

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How to step over the learning curve of laparoscopic spleen-preserving splenic hilar lymphadenectomy

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Introduction

As the reported incidence of No. 10 lymph node metastases is about 9.8–20.9% (1), the lymph nodes in the splenic hilar area should be dissected for D2 LN dissection during total gastrectomy for advanced proximal gastric cancer (2). Spleen-preserving splenic hilar lymphadenectomy is now widely used in total gastrectomy with D2 LN dissection since its first introduce in 2008 (3), due to the significantly increased postoperative morbidity and mortality after splenectomy (4-6). Meanwhile, with the rapid development of minimally invasive surgery, the laparoscopy-assisted gastrectomy for gastric cancer is gradually accepted. However, due to vessel variation, complicated anatomy and deep location of splenic hilum, as well as the difficulty to manage splenic or vascular bleeding at the splenic hilum, the procedure of laparoscopic spleen-preserving No. 10 lymph node dissection remains a challenge for gastric surgeons. Recently, professor Huang and his colleagues have introduced "Huang's three-step maneuver" for laparoscopic spleen-preserving No. 10 lymph node dissection for advanced proximal gastric cancer (7). It does make the procedure easier. But it seems that skilled surgeon and well-coordinated team are needed for the performance. With the aim to help unskilled surgeons to step over the learning curve for laparoscopic spleen-preserving No. 10 lymph node dissection, here we introduce our experiences in the procedure.

Patient selection and workup

Patients for this operation should be diagnosed as proximal gastric cancer, which have a pre-operative stage of cT2-3NxM0, with gastroscopic biopsy and contrast computed tomography, including cancers of the esophagogastric junction (EGJ, Siewert type III).

Inclusion criteria: (I) proximal gastric adenocarcinoma (including Siewert type Ⅲ EGJ cancer) with biopsy; (II) pre-operative stage of cT2-3NxM0 with contrast computed tomography; (III) age from 20 to 70 years old.

Exclusion criteria: (I) T1 orT4 tumor; (II) distal metastasis detected before or during operation; (III) apparent lymph nodes fusion; (IV) history of previous gastrectomy; (V) pre-operative neoadjuvant chemotherapy or radiotherapy; (VI) age beyond 70 years old; (VII) with severe systemic problems that can't endure major operations.

Pre-operative preparation

- Careful pre-operative examinations to exclude any contraindication;
- Proactive preparation of respiratory system for 3 days;
- Proactive mental preparation of the patients before operation;
- Inserting gastric tube and urethral catheter right before operation;
- Preparation of all instruments needed for the operation.

Equipment preference card

- Laparoscopy system, including a high-definition camera, display system, and pneumoperitoneum machine;
- Irrigation and suction devices;
- Image and video storage devices;

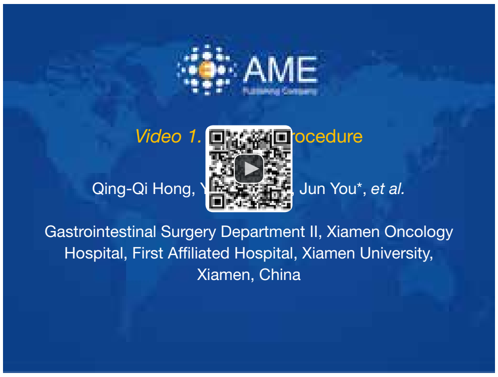

Figure 1 Routine procedure (9). In patients with normal BMI and without many difficulties for splenic hilum exposure, we follow routine procedure. In this video, the surgeons' position is different from that of classical laparoscopic splenic hilar lymphadenectomy, with surgeon on the patient's right side and assistant on the left and camera operator between the patient's legs. We think it'll be more suitable for fresh surgeons. The procedure is composed of three parts, firstly the No. 4sb LNs dissection, secondly the No. 11d LNs dissection, then finally the No. 10 LNs dissection.
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- Ultracision;
- Bioactive coagulation set;
- Intestinal Endo-GIA;
- Circular staplers;
- 5–12 mm trocars;
- Intestinal forceps;
- Maryland forceps;
- Noninvasive grasping forceps;
- Scissors;
- Needle holder;
- Absorbable suture;
- Aspirator;
- Absorbable clip applier;
- Titanium clip applier;
- Vascular clamps;
- Small gauzes.

Procedure

Patient's position

Patient position is very important for intraoperative exposure during laparoscopic gastrectomy. A reverse Trendelenburg position with the head elevated up approximately 15 degrees and tilted left side up at approximately 25 degrees is used. This position allows the intestine and omentum to move toward the lower right abdominal cavity and it will help to expose the splenic hilar area.

Trocar locations

As the trocars' position, here we make a little change. In routine procedure, the 5-port method (8) is generally used. We lower the observation port to 2–3 cm below the umbilicus. We also move the major hand port (with the surgeon on the patient's right side) closer to the splenic hilar area, which is located in the middle of the observation port and the tractive one, to overcome the shortness of the ultracision during splenic hilar lymphadenectomy.

Surgeons' locations

During the most part of the operation, the surgeon stands on the patient's left side with the assistant on the right and the camera operator between the patient's legs. But the surgeon and the assistant change their locations when it comes to the splenic hilar lymphadenectomy without any change of the camera operator.

Operation procedure

Routine procedure (*Figure 1*): in patients with normal BMI and without much difficulty for splenic hilum exposure, we follow routine procedure.

Step 1. Exposure of the cauda pancreatis and dissection of No. 4sb lymph nodes and lymph nodes around the inferior lobar splenic vessels. The assistant puts the omentum on the anterior wall of the stomach. His or her right hand pulls up the gastrosplenic ligament and gastrocolic ligament at the point close to the stomach, and pulls down and caudalward the transverse and splenic flexure of colon with his or her left hand, then the surgeon divides the gastrocolic ligament along the transverse colon to expose the cauda pancreatis and the inferior pole of the spleen, then peels the anterior pancreatic fascia of the pancreatic cauda from the inferior margin of the pancreas up to the superior margin and enters the upper retropancreatic space. At this time the inferior lobar splenic vessels will usually be exposed. Then the surgeon can continue to dissect the vessels towards the splenic hilum until they enter the spleen. The left gastroepiploic vessels usually derive from the inferior lobar splenic vessels and can be seen then. The assistant's right

Figure 2 Modified procedure (10). In patients with high BMI or bulky stomach that causes difficulties for splenic hilum exposure, we suggest modified procedure. In this video, we divide the gastrosplenic ligament in advance after finishing the No. 4sb LNs dissection. We think it'll be easier for fresh surgeons to perform the lymphadenectomy successfully, for the exposure of splenic hilum will become simpler and the assistant's right-hand grasper forceps can be freed to help the surgeon.
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hand pulls up the lymphatic fatty tissue on the surface of the vessels gently at the point close to the stomach, and his or her left hand pulls down and caudalward the splenic flexure of colon or the cauda pancreatis. Then the surgeon meticulously dissects the vessels to their roots and divides them at the roots.

Step 2. Exposure of the trunk of splenic vessels and dissection of No. 11d lymph nodes. The assistant's right hand moves to the upper gastric body at the greater curvature side, and his or her left hand pulls down and caudalward the mesentery of transverse colon at the root. Then the surgeon can peel the fascia of pancreatic body from the inferior margin of the pancreas up to the superior margin and enter the upper retropancreatic space to expose the trunk of splenic vessels and then continue to dissect No. 11d lymph nodes. After entering the upper retropancreatic space, the assistant's left hand will press down and caudalward the pancreatic body with small gauze. To be convenient, we suggest opening the sheath of the splenic vein trunk during lymphadenectomy. The surgeon's left hand can lift up the fatty lymphatic tissue around the trunk of splenic vessels and his or her right hand can dissect along the splenic vessels with ultracision towards splenic hilum until the crotch of the inferior and superior lobar splenic vessels appears. The inferior lobar splenic vessels have already been revealed during the dissection of No. 4sb lymph nodes.

Step 3. Dissection of No. 10 lymph nodes and management of the upper pole of the spleen. The assistant's right hand then pulls up the gastrosplenic ligament gently at the point close to the stomach, and his or her left hand presses down and caudalward the cauda pancreatis with small gauze. And the surgeon dissects along the superior lobar splenic vessels carefully and gently. During the dissection, we will encounter several short gastric vessels, which are derived from the superior lobar splenic vessels. The surgeon should denude them and divide them at their roots.

The uppermost short gastric vessel is usually the shortest one and is easily to be injured. Thus, when the surgeon dissects close to the upper pole of the spleen, the assistant's left hand should pull the stomach to the lower right of the abdominal cavity to attain well exposure. And then the surgeon can dissect and denude the uppermost short gastric vessel meticulously and divide it at its root. Then the laparoscopic spleen-preserving splenic hilar lymphadenectomy can be completed successfully.

Modified procedure (*Figure 2*): in patients with high BMI or bulky stomach that causes difficulties for splenic hilum exposure, we suggest modified procedure.

Step 1. In this step, the procedure is the same with step1. In routine procedure.

Step 2. Division of the gastrosplenic ligament in advance and exposure of the trunk of splenic vessels and dissection of No. 11d lymph nodes. When we are in trouble for splenic hilar lymphadenectomy, especially in patients with high BMI or bulky stomach, the exposure of the splenic hilum will be difficult, we can consider dividing the gastrosplenic ligament after we finish step 1 procedure. After exposure of the cauda pancreatis and dissection of No. 4sb lymph nodes, the assistant's right hand grasps the stomach at the greater curvature side, and his or her left hand pulls down and caudalward the splenic flexure of colon. Then the surgeon can easily divide the gastrosplenic ligament along the greater curvature of the stomach and dissect the No. 2 lymph node passingly to expose the left side of the cardia with ultracision. And then exposure of the trunk of splenic vessels and dissection of No. 11d lymph nodes can be continued as described in step 2 of routine procedure.

Step 3. Dissection of No. 10 lymph nodes and management of the upper pole of the spleen. The assistant can put the stomach lower right of the abdominal cavity to gain a well visual field of the splenic hilum and his or her right hand can be freed to assist the surgeon to finish the dissection of No. 10 lymph nodes and to manage the upper pole of the spleen, and even when the bleeding of the splenic vessels occurs, the assistant's right hand can help the surgeon to manage the situation well to avoid conversion to open surgery. The assistant's right hand pulls up the divided gastrosplenic ligament, and his or her left hand presses down and caudalward the cauda pancreatis with small gauze. The surgeon dissects along the superior lobar splenic vessels carefully and gently and denudes all the short gastric vessels, which are derived from the superior lobar splenic vessels and divides them at their roots to finish the lymphadenectomy.

Role of team members

- Surgeon: perform the major part of the operation;
- Assistant: help to expose the visual fields of the operation and assist the surgeon to perform the operation successfully;
- Camera operator: in charge of the camera system to gain a sharp and comfortable view of the operation;
- Anesthetist: in charge of the patient's anesthesia to make sure the patient is under well anesthetic state during the operation;
- Nurses: in charge of the devices needed for the operation before and during operation.

Post-operative management

- Parenteral nutrition for 5–7 days after operation;
- Out-of-bed activity on day 2;
- Extract gastric tube after passage of gas by anus;
- Liquid diet the next day after extraction of gastric tube;
- Semi-liquid diet on day 7 and extract peritoneal cavity drainage tubes;
- Discharge on day 8.

Tips, tricks and pitfalls

Due to vessel variation, complicated anatomy and deep location of splenic hilum, laparoscopic splenic hilar lymphadenectomy has become one of the difficulties of laparoscopic radical gastrectomy for gastric cancer. How to step over the learning curve of laparoscopic splenic hilar lymphadenectomy becomes a challenge for gastric surgeon. For two years' clinical practices, we have already successfully performed 56 cases of laparoscopic spleen-preserving splenic hilar lymphadenectomy, 49 ones with 2D laparoscopy and 7 ones with 3D laparoscopy respectively, without any severe complications and conversion to open surgery. But three cases of bleeding of lobar splenic vessels occurred and five cases of partly spleen ischemia (which was considered as the ischemia range reached almost 1/4 of the spleen, but focal spleen ischemia was not included in that) were found after splenic hilar lymphadenectomy. No infarction of spleen occurred in all these cases. The followings are our experiences for stepping over the learning curve of laparoscopic splenic hilar lymphadenectomy.

Firstly, the surgeons should be familiar with the anatomy of splenic hilum. The splenic vessels go along the pancreas in the retropancreatic space at the superior border of the corpus and cauda pancreatis, and give off lobar splenic vessels when they are close to the splenic hilum. The two-branch type possesses highest ratio (11-13) [in our data, it takes 83.99% (47/56)], but the one-branch (5.36%, 3/56), three-branch (7.14%, 4/56), or multiple-branch (3.57%, 2/56) is infrequent (*Figure 3*). The two-branch one is typical type of splenic hilar vessels. The inferior lobar branch is usually short and thick. The left gastroepiploic vessels and one to two lower short gastric vessels are usually derived from the inferior lobar splenic vessels. And the superior lobar branch is usually long and thin. This branch does not enter the spleen immediately but go upwards along the surface of the spleen and gives off short gastric vessels and then enters the superior pole of the spleen. The uppermost short gastric vessel is always the shortest one so that it's easily to be injured. In addition, in several patients, there's splenic polar vessel (*Figure 4*). It's vessel that does not pass by the splenic hilum but enter the spleen directly. The inferior polar splenic vessel is usually short and thick and close to the spleen, it won't increase the difficulties for splenic hilar lymphadenectomy. The superior polar splenic vessel is usually long and thin and distal to the splenic hilum, and is not easily to be distinguished from posterior gastric vessels. We do find that in several patients, the superior polar splenic vessels are too thin that it does not affect the blood supply of the spleen even when they are cut off. So when we find a thin superior polar splenic vessel during the lymphadenectomy, we can try to clamp the vessel to observe the color of the spleen. If the color does not change, then we can cut off the vessel directly so as to simplify the procedure.

Secondly, we can divide the gastrosplenic ligament in advance if it's necessary (*Figure 5*). When we are in trouble with splenic hilar lymphadenectomy, especially in overweight patients or patients with bulky stomach and the exposure of the splenic hilum is difficult, we can consider

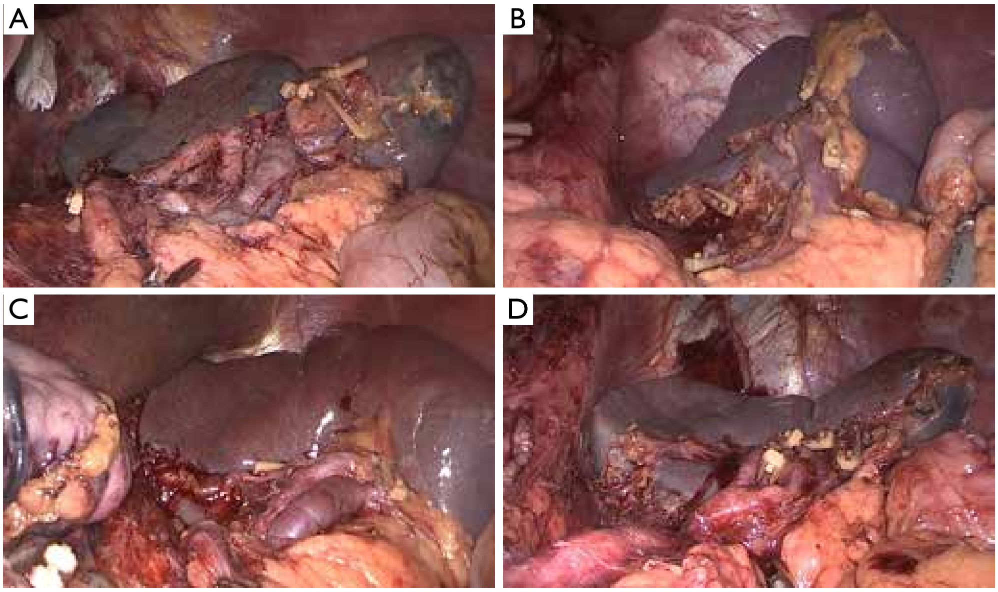

Figure 3 Type of splenic hilar vessels. (A) Multiple-branch; (B) single-branch; (C) two-branch; (D) two-branch.

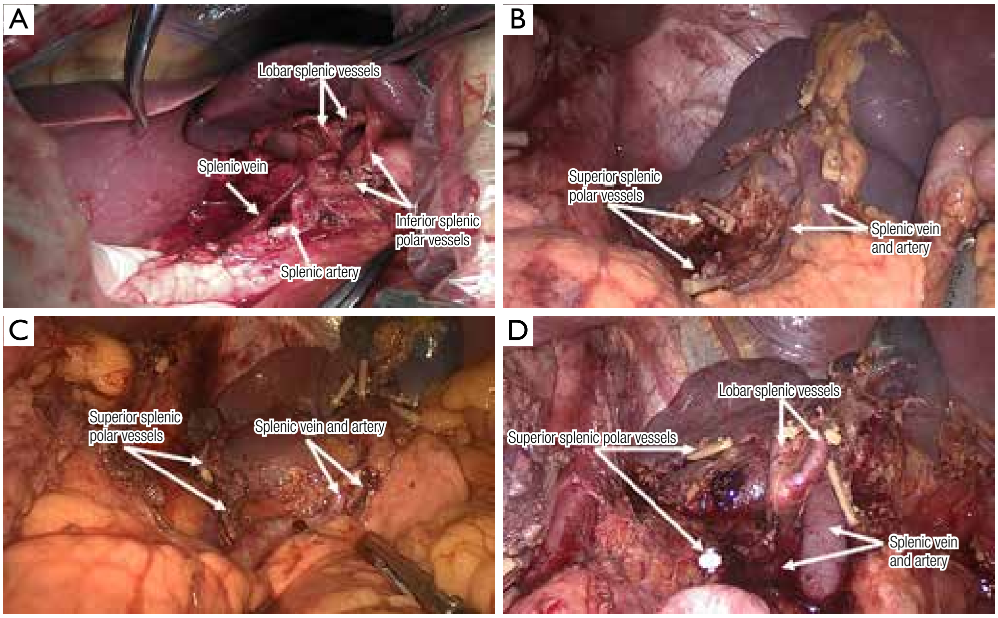

Figure 4 Splenic polar vessels.

dividing the gastrosplenic ligament in advance. Due to the relative easiness for No. 4sb lymph node dissection, we usually dissect the No. 4sb lymph node firstly and then divide the gastrosplenic ligament, and dissect the No. 2 lymph node to expose the left side of the cardia. Then we can put the stomach in the lower right of the abdominal cavity and continue the splenic hilar lymphadenectomy. In this step, the assistant's right hand can be freed from exposure of the hilum to assist the surgeon to perform the lymphadenectomy. Even when the vessel injury occurs, it would be easier to control the bleeding and avoid conversion to open surgery (*Figure 6*).

But there are two disadvantages for this method. The first one is that en-block dissection cannot be achieved.

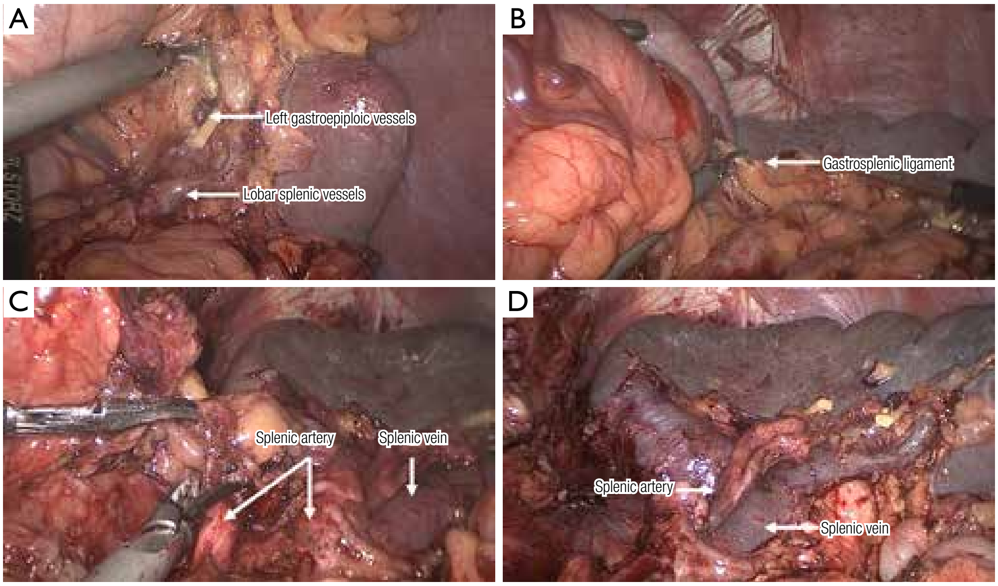

Figure 5 Division of the gastrosplenic ligament in advance. (A) Dissection of No. 4sb LN; (B) division of gastrosplenic ligament; (C) dissection of No.11, 10 LN; (D) visual field of splenic hilum after lymphadenectomy.

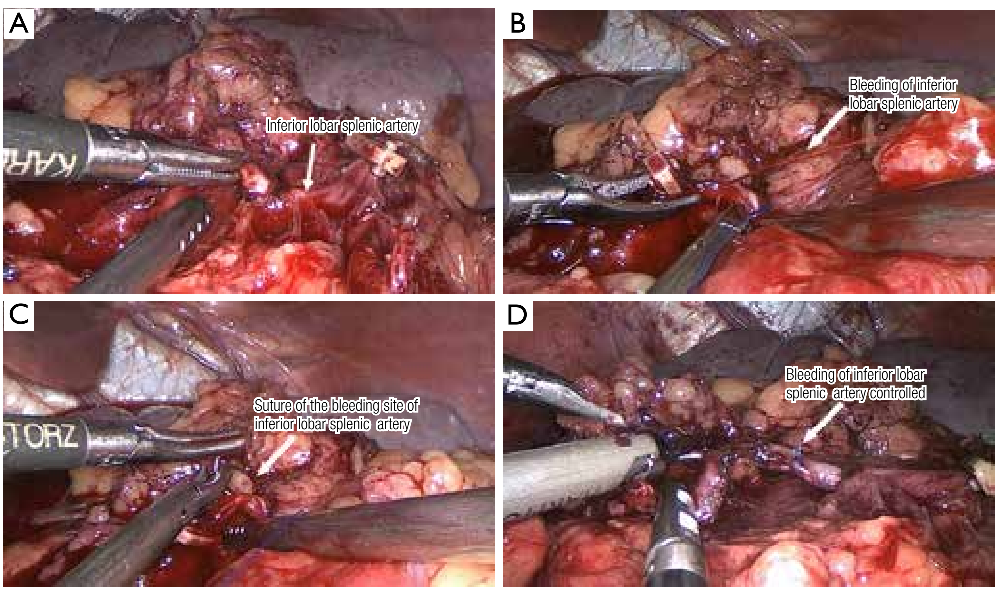

Figure 6 Management of the bleeding of lobar splenic vessel.

The second one is that the favorable tension provided by the assistant's pulling up the gastrosplenic ligament will be lost. Therefore, we prefer to consider this method as a tool for stepping over the learning curve of laparoscopic splenic hilar lymphadenectomy.

Thirdly, we can change the surgeon and the assistant's position. In classical laparoscopic splenic hilar lymphadenectomy, the surgeon usually stands between the patient's legs, and both the assistant and the camera operator stand rightward. In this kind of position, due to the narrow space, the assistant and the camera operator will interfere with each other. And the surgeon's right and left hands present a kind of up and down relationship, it will be inconvenient for operating. Besides, the angle of

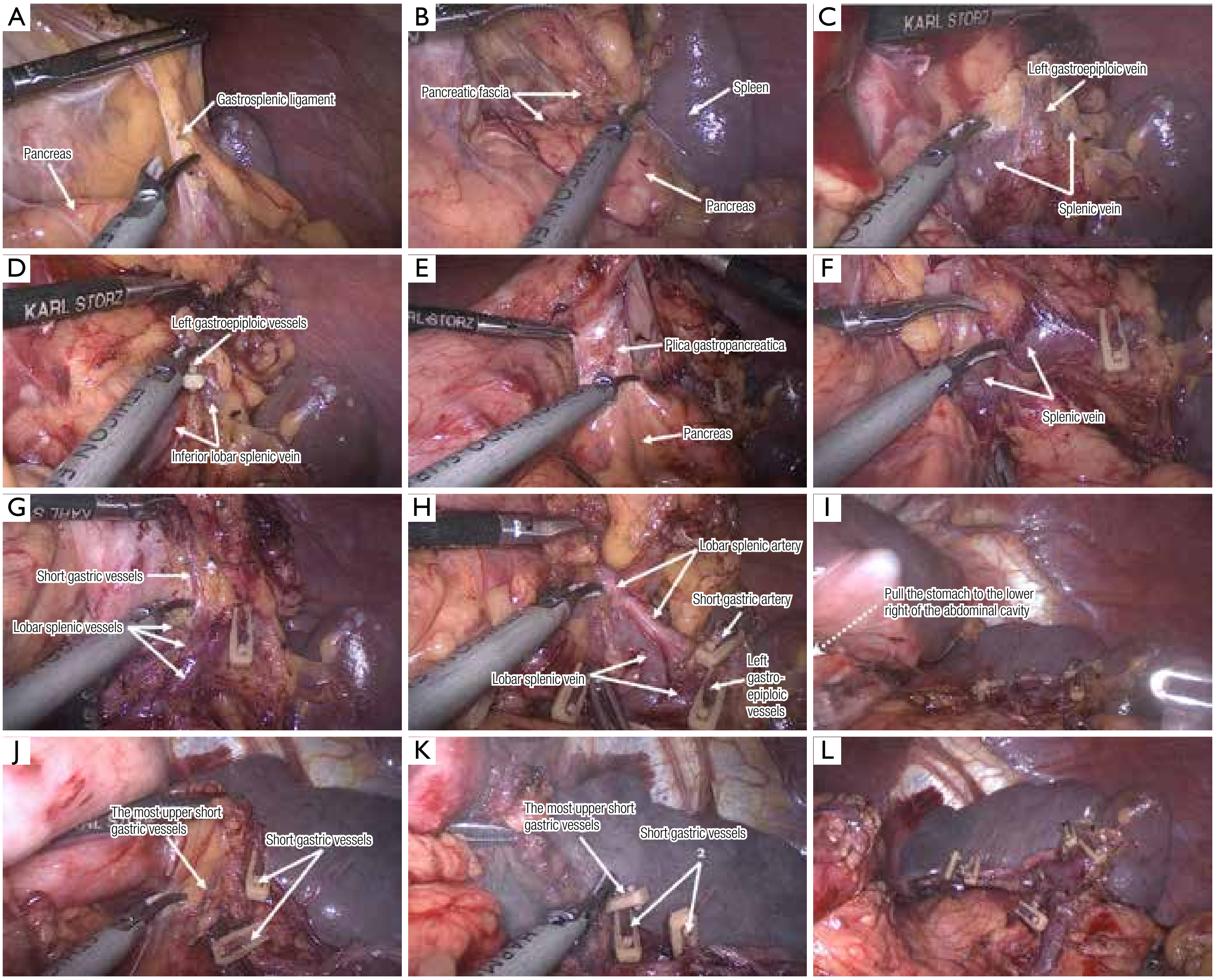

Figure 7 Programmed procedure of splenic hilar lymphadenectomy. (A,B) Exposure of the cauda pancreatis and inferior pole of the spleen; (C,D) dissection of No. 4sb lymph nodes; (E,F) dissection of No. 11d lymph nodes; (G,H) dissection of No. 10 lymph nodes; (I-K) management of the upper pole of the spleen; (L) visual field after lymphadenectomy.

the ultrasonic scalpel's operating direction and the splenic vessels' direction will be larger, it'll bring inconvenience for the dissection and exposure of splenic vessels.

We take the position that the surgeon stands on the right side of the patient, with the camera operator between the patient's legs and the assistant on the left side. In this kind of position, the surgeon, the assistant and the camera operator will not interfere with each other. And the left and right relationship of the trocars for the surgeon will provide convenience for operating. In addition, the angle of the ultrasonic scalpel's operating direction and the splenic vessels' direction will be smaller, it'll bring convenience for the dissection and exposure of splenic vessels.

Fourthly, we should routinize the splenic hilar lymphadenectomy. We divide the splenic hilar lymphadenectomy into several relatively regular operating steps to make the operating procedure more rationalized and the team cooperation more unhindered, as described in the operation procedure part (*Figure* 7).

In conclusion, we introduce our experiences in the procedure of laparoscopic spleen-preserving splenic hilar lymphadenectomy, and with more than 50 cases' practice we find it does can make the procedure easier. We sincerely hope that it would help unskilled surgeons to step over the learning curve of the procedure.

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None.

Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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The technical characteristics and clinical analysis of laparoscopic bursectomy for advanced gastric cancer

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Background: Bursectomy is a mature procedure in open radical gastrectomy in eastern countries such as Japan, Korea and China. However, laparoscopic bursectomy is technically demanding because it is not liable to expose the complicated gastric anatomy under laparoscopy. The objective is to analyze technical characteristics and clinical experience of laparoscopic bursectomy for advanced gastric cancer.

Methods: From the year of 2010, we carried out the clinical research of laparoscopic bursectomy as well as D2 lymphadenectomy for advanced gastric cancer. According to retrospectively studying the clinicopathologic characteristics of these cases, we analyze the technical characteristics and clinical experience of laparoscopic bursectomy for advanced gastric cancer.

Results: There are 73 cases have been successfully performed the procedure in our center. The mean operation time was 223.5±38.6 min and the blood loss was 165.0±27.3 mL respectively. The number of lymph nodes dissected was 28.3±4.1. The overall percentage of postoperative complications related to operation was 11.7%.

Conclusions: The laparoscopic bursectomy in radical gastrectomy is technically safe and feasible.

Keywords: Laparoscopic bursectomy; D2 lymphadenectomy; gastric cancer

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Introduction

Whether patients with advanced gastric carcinoma should receive bursectomy or not has existed for a long time (1-4). There are anatomical, physiopathological and clinical practice reasons for this: (I) anatomically speaking, bursa omentalis (5) is constituted by anterior lobe of transverse mesocolon, pancreatic capsule, greater momentum, lymph connective tissue of hepatoduodenal ligament, hepatogastric ligament, phrenogastric ligament, hepaticopancreatic fold and gastropancreatic fold. These are all originated from the same embryonic layer. There are gastric vessel branches, lymphatic vessels, lymph nodes, fat, fascia and so on inside these ligaments, folds and perigastric mesogastriums. On the other hand, outside bursa omentalis there are fascias and intrafascial space and there are no vessels and lymphatic vessels in it. So to speak, the safe dissective planes in gastric surgery, should be subjected to outside bursa omentalis along the fascias and intrafascial space to achieve an en bloc resection of bursa omentalis, lymph nodes, gastric tissue and so on. (II) Physiopathologically speaking, perigastric mesogastriums and fusion fascia is barrier to keep cancer cells from spreading and metastases. But, it is likely for gastric cancer cells invasion and lymph node metastasis in fascias and intrafascial space between the perigastric mesogastriums and perigastric organs (6). Also gastric cancer cell metastasis occurs on the pancreatic capsule and anterior lobe of transverse mesocolon through lymphatic vessels which connect bursa omentalis and gastric serosal. For these patients with posterior gastric wall trans-serosal cancer, exfoliative cancer cells always colonize in the bursa omentalis. Therefore, an en-bloc removal of free cancer cells, micrometastases and lymphatic metastases contained in the bursa omentalis, is potential surgical procedure in radical gastrectomy. (III) Clinically speaking, exfoliative cancer cells, cancer cells inside the vessels and lymphatic ducts may flow into the abdominal cavity with blood and lymphatic fluid during operation, this is the important factor of postoperative intraperitoneal recurrence (3).

Furthermore, the Japanese Classification of Gastric Carcinoma (the 14th edition) also suggests that patients with gastric posterior wall sensor invaded (T3–T4a) should receive bursa omentalis resection in order to clean up the micrometastasis in bursa omentalis. In Japan, Korea and China, bursectomy and D2 lymphadenectomy are regarded as a standard surgical procedure during radical open gastrectomy for serosa-positive gastric cancer. It has been reported that bursectomy could prevent cancer cells scattered and removed peritoneal micro-metastasis (7,8) but there is much difficulty performing bursectomy in radical operation for gastric cancer of laparoscopy. Currently, some surgeons of Japan, Korea and China try to perform laparoscopic resection of pancreatic capsule and anterior transverse mesocolon.

Based on our previous experience of more than 300 cases laparoscopic surgery for gastric cancer every year in our medical center and the clinical research of laparoscopic bursectomy (9,10), we analyze technical characteristics and clinical experience of laparoscopic bursectomy for advanced gastric cancer.

Patient selection and workup

The patient selection and workup are: (I) patients were diagnosed with advanced gastric cancer without metastasis; (II) CT and endoscopic biopsy diagnosed; (III) TNM staging is T3–T4a; (IV) patients agree with surgery and sign the consent form.

Pre-operative preparation

The pre-operative preparation is same as the general abdominal surgery, ruled out surgery contraindications.

Equipment preference card

The equipment preference card is same as the laparoscopic gastrectomy.

Ethics

Ethics Committee of Guangdong Provincial Hospital of Chinese Medicine Hospital approved this study. The information of patients was written consent to be stored in the hospital database and used for research.

Procedures

Laparoscopic bursectomy (LP) is highly technically demanding, the surgeon and its team should be skilled and experienced in open bursa omentalis resection and have well-knit basic skills in using laparoscope. It is better that the surgeons who had previously completed more than 100 cases of laparoscopic radical gastrectomy for gastric cancer. The detailed operation steps are as follows.

Trocar and operator's position

Patients were placed in the reverse Trendelenburg position and the location of the Trocar adopts five-hole method. First the surgeon stands on the right side, and then in the middle of the legs of the patients (*Figure 1*).

Main steps

Step one

Triangle pull the greater momentum on the right side of transverse colon, dissect the clearance between the transverse mesocolon and distal gastric membrane from right to left with the No.6 LNs dissection, enter the duodenal posterior clearance to dissect the capsule of pancreas and the anterior lobe of transverse mesocolon from right to left (*Figure 2*).

Step two

Enter the anterior space of pancreas with dissect the capsule of the pancreas and the anterior lobe of transverse mesocolon from left to right, converge the separated panes from right to left. To this moment, the pancreas capsule and the anterior plane of transverse mesocolon were completely separated outside bursa omentalis (*Figure 3*).

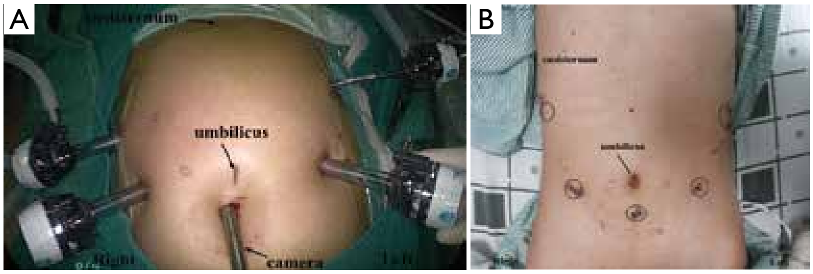

Figure 1 Trocar and incision.

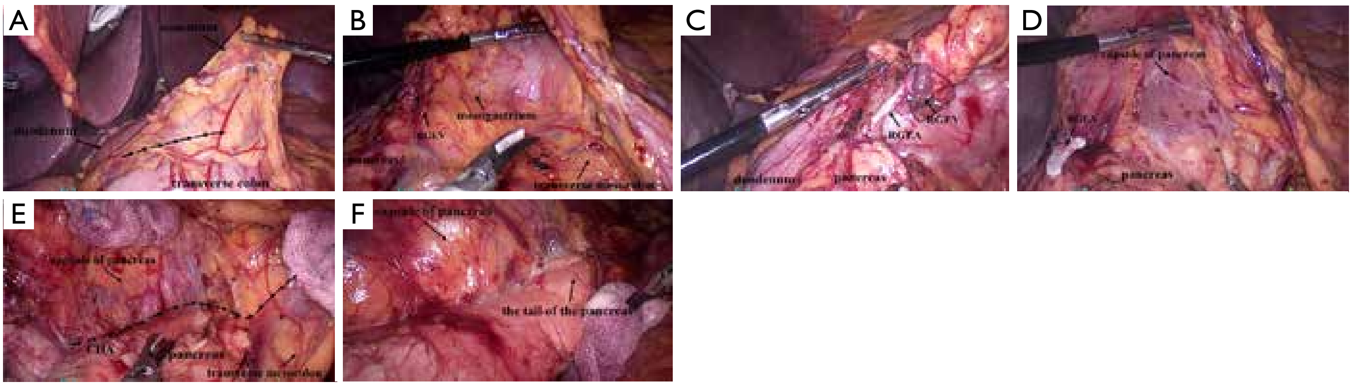

Figure 2 Step one of the procedure. RGEA, right gastroepiploic artery; RGEV, right gastroepiploic vein.

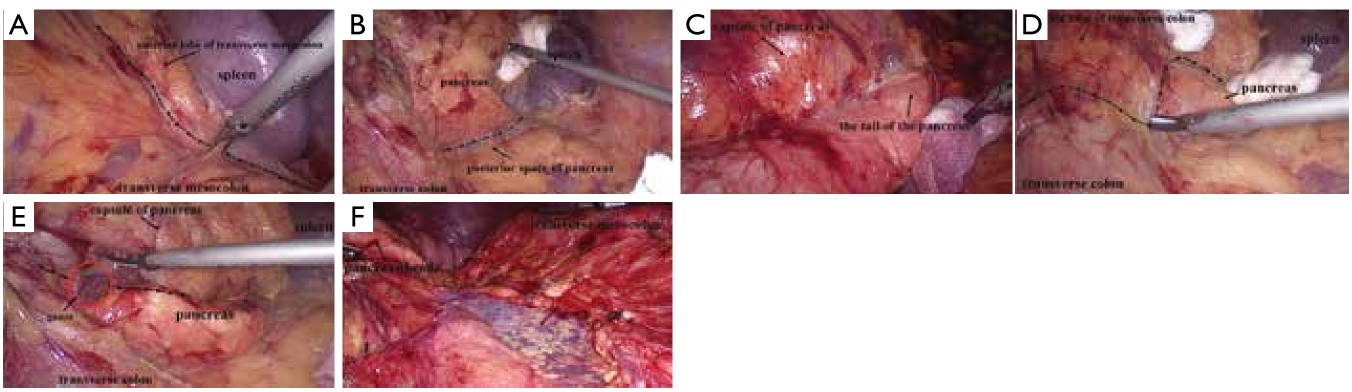

Figure 3 Step two of the procedure. RGEA, right gastroepiploic artery.

Step three

For radical distal gastrectomy, enter the posterior of stomach with the No. 4, No. 7, No. 9 and the No. 8 LNs. For radical total gastrectomy, outside bursa omentalis to enter the posterior of stomach and splenic hilar with No. 11d, No. 10 and No. 1 LNs dissection with spleen-preserving, mobilizing the left side of abdominal esophagus (*Figure 4*).

Step four

Expose the right lateral of bursa omentalis with the No. 5, No. 12 LNs dissection, transect the duodenum with linear cutter and dissect the No. 8, No. 9, No. 7, No. 11p LNs under the assistant's Triangle pull the distal end of the stomach to the left outside bursa omentalis, separate right abdominal esophagus with the No. 3 and No. 1 LNs dissection (*Figure 5*). At this point, for radical total

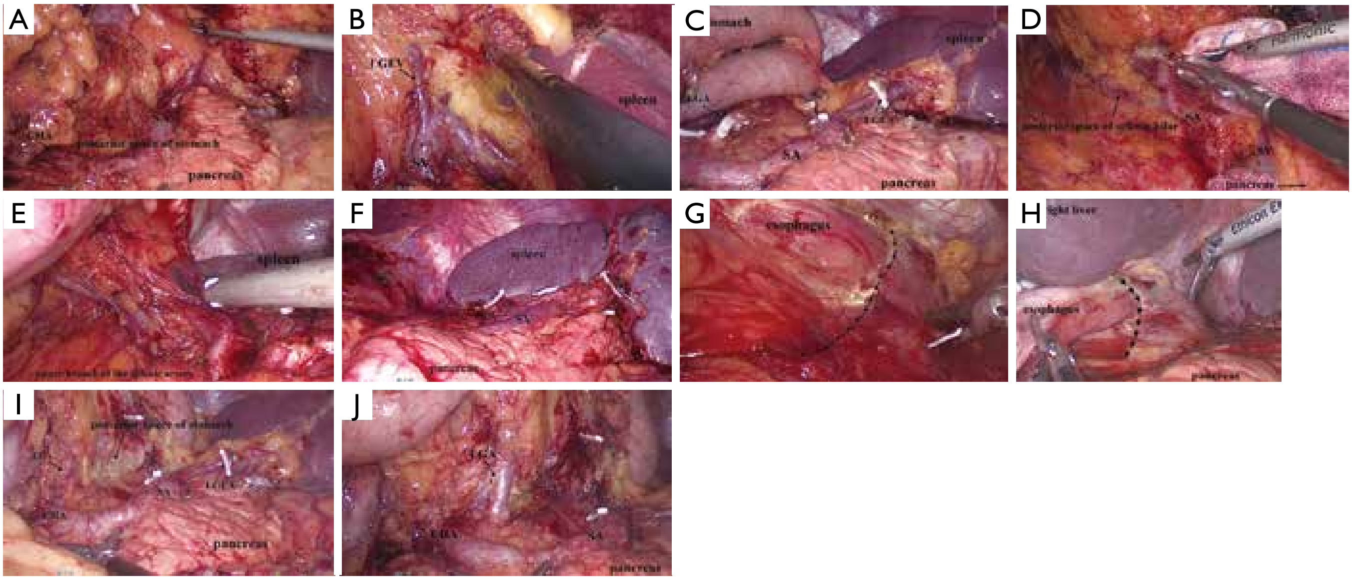

Figure 4 Step three of the procedure. CHA, common hepatic artery; LGV, left gastric vein; LGA, left gastric artery; SA, splenic artery; LGEA, left gastroepiploic artery; SV, splenic vein.

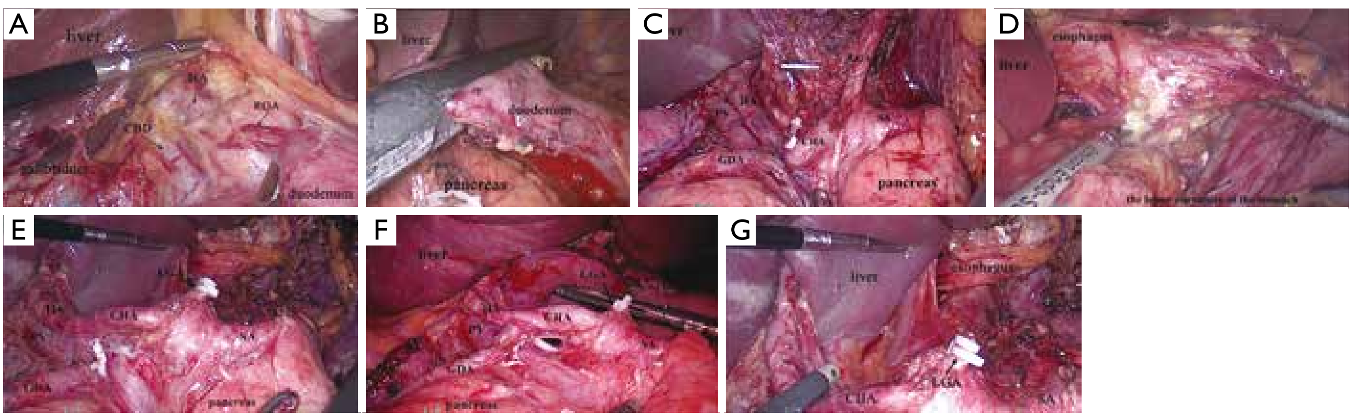

Figure 5 Step four of the procedure. GDA, gastroduodenal artery; PV, portal vein; HA, hepatic artery; CHA, common hepatic artery; LGV, left gastric vein; LGA, left gastric artery; SA, splenic artery; SV, splenic vein.

gastrectomy, bursectomy and D2 lymphadenectomy were completed. Surgeon reconstructs the digestive tract under laparoscopy with Billroth II or Billroth I for distal radical gastric resection, Roux-en-Y esophagus jejunum anastomosis for radical total gastric resection (*Figure 6*).

Role of team members

Liao-Nan Zou, GI surgeon, MD:

- ❖ A member of China South Cooperation Team of Laparoscopic Colon Surgery.
- ❖ A member of the Institute of Clinical Research of Sun Yat-Sen University.
- ❖ A member of the Editorial Board Certificate of *Journal of Laparoscopic Surgery*.
- ❖ A member of Upper Gastrointestinal Surgeon Committee of China Medical Doctor Association.
- ❖ A member of Anal Rectal Physicians Committee of China Medical Doctor Association.
- ❖ Peer-reviewer of *Chinese Journal of Colorectal Disease* (Electronic Edition).
- ❖ Peer-reviewer of Disease of Colon &Rectum (DCR).

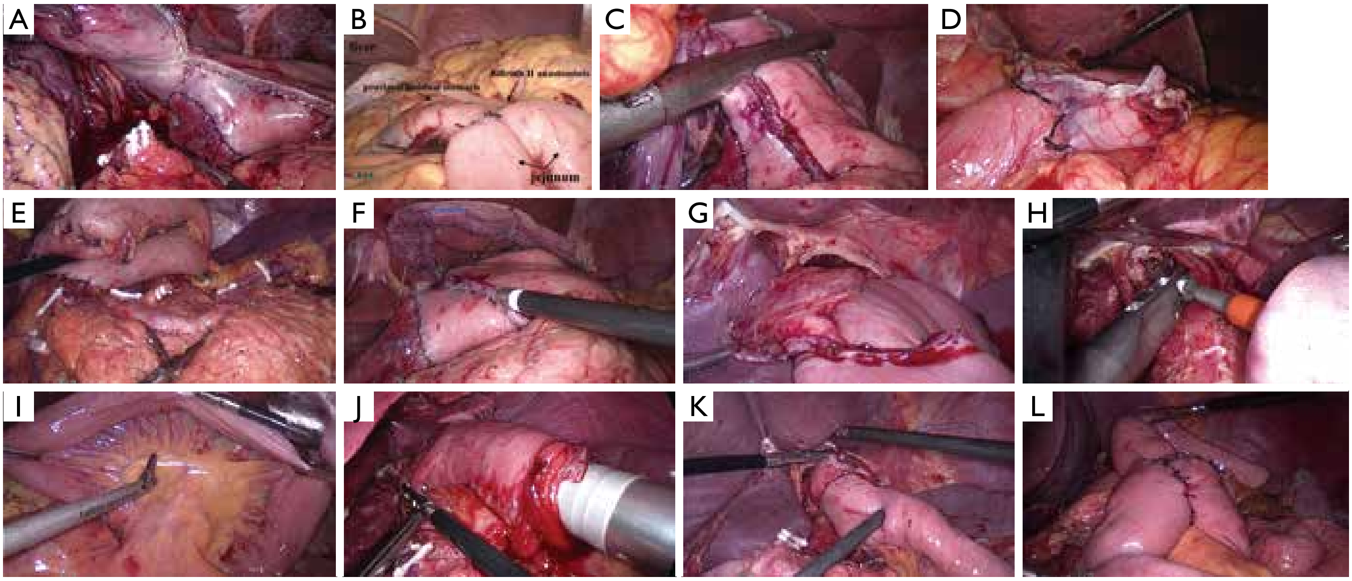

Figure 6 Approach for the procedure.

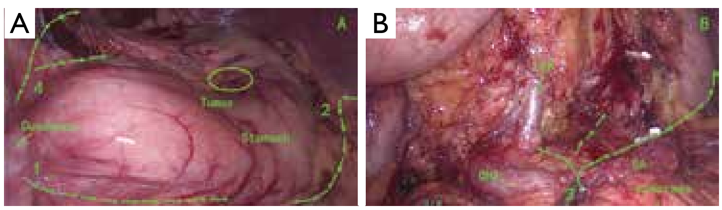

Figure 7 Exposure for the procedure.

Jin Wan, GI surgeon, PhD:

- ❖ Vice Chairman of the Colon Cancer Committee of the Guangdong Province Anti-cancer Association.
- ❖ Vice Chairman of the Minimally Invasive Surgery of the Guangdong Province Medical Doctor Association.

Post-operative management

Helping patients get out of bed to take physical activities from the first day after the operation; stop gastrointestinal decompression after the first postoperative flatus, giving fluid diet in order to make transition from parenteral nutrition (PN) to enteral nutrition (EN).

Tips, tricks and pitfalls

Approach for the procedure (bursectomy)

During the whole procedures, dissect around the pancreas as it serves as the main anatomical landmark. Dissecting the anterior lobe of transverse mesocolon and the Pancreatic Capsule on both flank (first from their right and then from their left), it makes easy to dissect according to the characteristics of its anatomical features. Dissect from the greater curvature of the stomach to the lesser curvature of the stomach, from the distal to the proximal stomach, bursectomy and dissection of lymph nodes at the same time. Distal stomach (*Figure 7*).

Tips, tricks and pitfalls for surgical exposure and dissection

During the procedure, surgical exposure is very important for the dissection. Besides the Hang liver, the triangle pull by the surgeon and the assistant is applied all through the procedure. It makes it easier to dissect the bursa omentalis and lymph nodes. Sometimes, the surgeon dissect with pulling by a gauze, this is not only to expose but also not

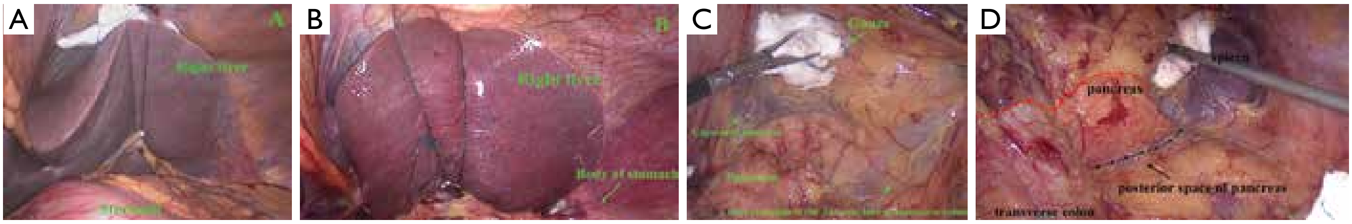

Figure 8 Tips, tricks and pitfalls.

to break the bursa omentalis, especially for dissecting the anterior lobe of transverse mesocolon and the pancreatic capsule (*Figure 8A-C*).

In the first step, the completion of the No. 6 LN dissection makes it easy to dissect the head of the pancreatic capsule. Entering the right anatomical structure is a key step to begin the procedure and maintain bursa omentalis's integrity.

In the second step, it is liable to enter the posterior of the pancreatic space when dissecting the capsule of the tail of pancreas (the red line is the right approach to dissect (*Figure 8D*).

Outside bursa omentalis enter the gastric posterior space and mobilize the splenic hilar posterior. This makes it easy for laparoscopic spleen-preserving splenic hilar lymph node dissection for radical total gastrectomy for proximal gastric cancer.

Overall, the procedure should carry out in the fascial space outside bursa omentalis, using the combination of sharp and blunt dissection. Generally speaking, complete bursectomy will not achieved without total radical gastrectomy, because the complete resection of the bursa omentalis including not only the capsule of pancreas and the anterior lobe of transverse mesocolon, but also the greater momentum, the lymph connective tissue of hepatoduodenal ligament, the hepatogastric ligament, the phrenogastric ligament, the hepatopancreatic fold, the gastropancreatic fold and the extension of the caudate lobe of the liver capsule. But we can finish the resection of the tissue mentioned above except for the extension of the caudate lobe of the liver capsule, because it is impossible to do that. Therefore, the scope of its procedure is larger than the D2 radical gastrectomy which is recommended by the guideline, besides the tissue mentioned above, the scope also includes such as the No. 8P LNs and No. 12P LNs. However, whether the resection of the bursa omentalis is completed may be decided by the patients' physical condition and the surgeons' skill, including the nature and amount of the case's mesenteric fat, degree of bleeding tendency and degree of fascial porosity.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by Ethics Committee of Guangdong Provincial Hospital of Chinese Medicine Hospital (No. T2016-002-01) and written informed consent was obtained from all patients.

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Totally laparoscopic intragastric surgery for gastric submucosal tumors located near the esophagogastric junction

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Background: Laparoscopic partial gastrectomy (LAP) is a standard treatment for gastric submucosal tumors (SMTs). However, for SMTs located in the special parts such as the esophagogastric junction (EGJ) or the lesser curvature, LAP is difficult to approach with considerable risk of causing deformity or stenosis, tumor must be exposed via gastrotomy or handled by laparoscopic intragastric surgery (LIGS). We designed the totally laparoscopic intragastric surgery (T-LIGS), and describe this procedure and its clinical outcomes for gastric SMTs.

Methods: Fourteen consecutive patients with gastric intraluminal SMTs located near the EGJ underwent T-LIGS at our center from January 2012 to December 2014. The clinicopathological results of these 14 cases were analyzed.

Results: T-LIGS was successfully performed on all the patients. The mean operation time was 71.1±22.2 min (range, 45–110 min) and the mean blood loss was 9.3±7.0 mL (range, 5–30 mL). There was no death or intraoperative complications in our series. One patient experienced a postoperative complication of gastroparesis, one patient experienced surgical site infection, both recovered after conservative treatment. The mean postoperative length of hospital stay was 6.6±1.7 days (range, 5–11 days). All patients received complete resection with a negative margin. Histopathologic diagnoses were gastrointestinal stromal tumor (GIST) in nine cases, neurofibroma in two, neuroendocrine tumor (NET) in two, and mucosa associated lymphoid tissue lymphoma in one. There was one case of stenosis of the EGJ, and no case of tumor recurrence, during a mean follow-up of 13.9±7.4 months (range, 6–30 months).

Conclusions: T-LIGS is a safe, feasible, and effective procedure, its suitable for treatment of gastric SMTs located near the EGJ.

Keywords: Laparoscopic intragastric surgery (LIGS); gastric submucosal tumors (gastric SMTs); esophagogastric junction (EGJ)

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Introduction

Gastric submucosal tumors (SMTs) are a relatively rare type of tumors and account for less than two percent of gastric tumors. Surgical resection is the main treatment, however no standard surgical approach could be refer due to the feature of particular entity and demanding technique. With the progress of laparoscopic instrument and the improvement of surgical technology, the less invasive laparoscopic or endoscopic method, accounting to the different growth pattern, had been widely used in the management of gastric SMTs and been considered as standard approach (1). However, for SMTs located in special parts such as the lesser curvature or posterior, the original laparoscopic or endoscopic approach is difficult to perform, and may lead to complications such as cardiac stricture or fistula, although rendezvous maneuver or transgastric approach had been reported, and various advances in the devices and techniques used for endoscopic ESD, proximal gastrectomy or total gastrectomy were reported with impaired quality of life. Intragastric resection was first introduced by Ohashi (2) in 1995, and this procedure had evolved to a more maturely procedure, and make the local resection of gastric SMTs in special parts possible without disturbing or impairing the cardia function. Herein, we design the total laparoscopic intragastric surgery (T-LIGS), this procedure was conduct without the use of gastroscope, the 'pneumogastrium' was established by rigid laparoscope, and the tumors were resected by conventional laparoscopic instruments. We applied this procedure to 14 cases, and the clinicopathological results were analyzed as described underneath.

Methods

General information

T-LIGS was conducted in 14 consecutive patients including 4 males and 10 females, the diagnosis was made by gastroscopy and the distance from the cardia and the caliber of the SMTs were measured. All cases of this novel procedure were conducted in the Department of Gastrointestinal Nutrition and Hernia Surgery, the Second Hospital of Jilin University. Extra-preoperative workup including endoscopic ultrasound (EUS) and enhanced computer tomography (CT) of the stomach, is all in a bid to confirm the feature of SMT including the location diameter and the circumferential setting, also to estimate the lymph node metastasis or involvement of adjacent organs. Data were retrieved preoperatively, including information on patient demographics, preoperative workup, operative findings, postoperative course, morbidity, and mortality, pathologic findings and follow-up. Informed consent and ethic committee approval was obtained before the initiation of this review. The clinicopathological feature was showed in *Table 1*.

A protocol for the application of this novel procedure

Table 1 Demographic data of patients who underwent TLIGS for gastric SMT

Parameter	n
No. of patients	14
Age (years)	55.8±8.8
Sex	
Male	4
Female	10
Body mass index (kg/m^2)	21.0±3.0
Chief complaint	
Epigastric discomfort	4
Epigastralgia	5
Positive fecal occult blood	2
Physical examination	3
Co-morbidity	5/9
Diabetes	1
Coronary artery disease	1
Cirrhosis	1
Hypertension	2
Previous operation history	
Appendicectomy (open/laparoscopic)	1/1
Cholecystectomy	1
Oophorocystectomy	1
Cesarean section	1
Tumor size (mm)	16.4±5.3 [15–25]
Distance from the EGJ (mm)	15.3±7.9 [0–30]
Tumor location	
Posterior wall	5
Anterior wall	3
Lesser curvature	3
Greater curvature	0
Fundus	2
EGJ	1
Preoperative CT confirmation (yes/no)	9/5
Preoperative gastroscopy positioning (yes/no)	4/10

TLIGS, totally laparoscopic intragastric surgery; SMT, submucosal tumor; EGJ, esophagogastric junction; CT, computer tomography.

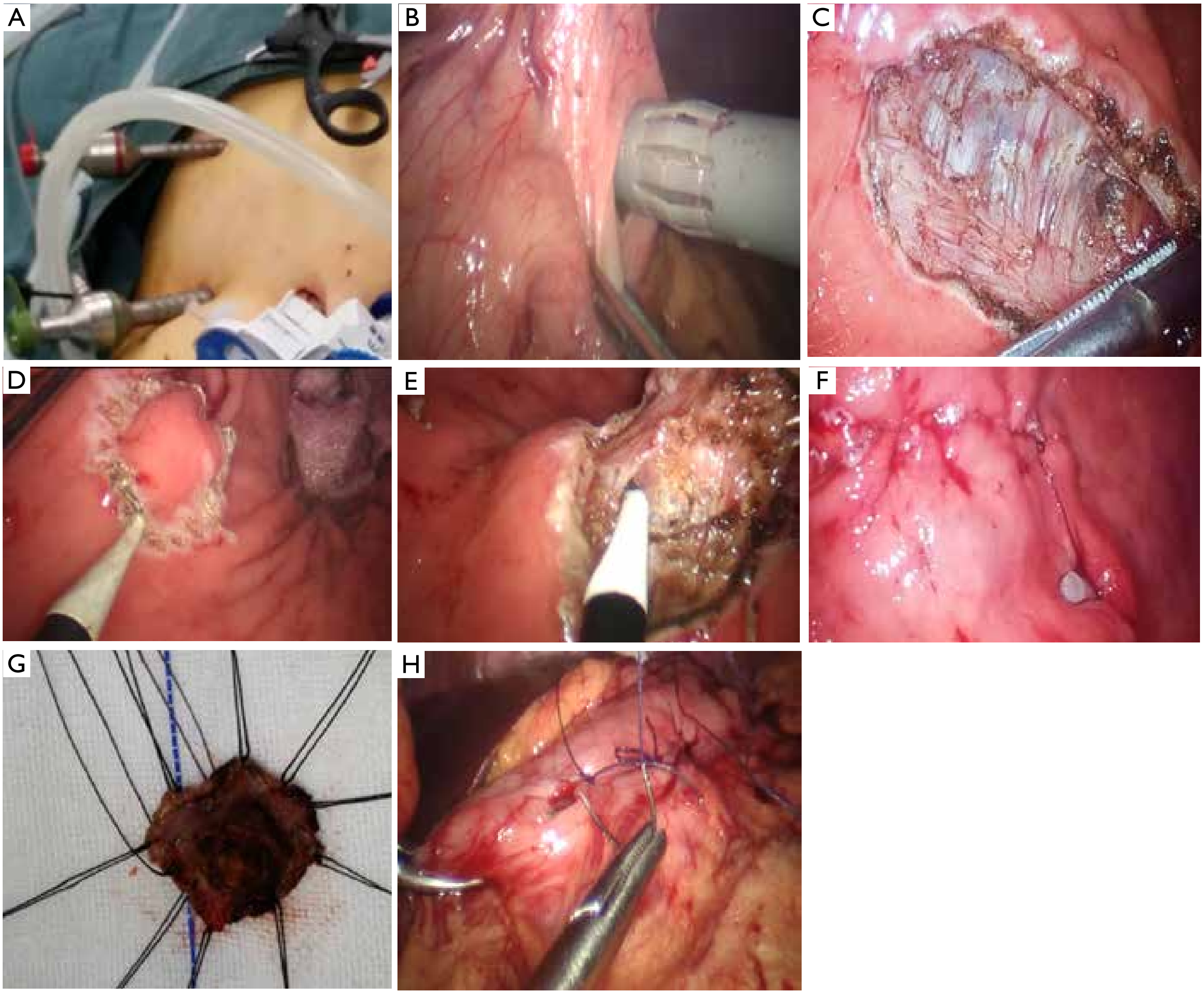

Figure 1 The technique of totally-LIGS. (A) Position of trocar (fix-aid trocar on the left for intraluminal operation); (B) trocar introduction into the stomach and establishment of pneumostomach; (C) confirmation of the gastric SMT and marked its margin circumferentially; (D) dissection of the gastric SMT by monoploar electrocautery with adequate margins; (E) the mucosal defect in the surgical site after dissection of the gastric SMT; (F) the closure of the mucosal defect and its distance from the EGJ (note the tube); (G) the specimen and its circumferential margin for pathological examination; (H) the gastric puncture point was closed by continuous sutured. LIGS, laparoscopic intragastric surgery; SMT, submucosal tumor; EGJ, esophagogastric junction.

was approved by the Ethics Committee of the Second Hospital of Jilin University and written informed consent was obtained from each patient.

Surgical methods

The laparoscopy was performed under general anesthesia with intravenous antibiotic prophylaxis. The patient was in modified Trendelenburg position with legs separated, and the surgeon was positioned on the left with the camera operator between the legs and the first assistant on the right side. The protocol of the T-LIGS procedure were summarized as follows (*Figure 1*): (I) a umbilical 10 mm trocar with self-fixing device (fix-aid trocar) was inserted into the abdominal cavity as the observation hole and a 30° laparoscope was introduced, pneumoperitoneum was instituted and set at 12 mmHg. Two 5 mm trocar (conventional) was insert in the right upper quadrant to assist in the exposure of the surgical field and subsequent gastric puncture, two additional 5 and 12 mm fix-aid trocar was inserted in the left upper quadrant with a distance of 3 cm or larger, and expected as the main and auxiliary operation hole for introgastric surgery. (II) Abdominal adhesions around and stomach was separated if exist, and stomach mobilization with exploration of the gastric SMTs showed by preoperative CT or gastroscope positioning was achieved, the growth pattern was also probed. Jejunum blockage was achieved by using laparoscopic intestinal blocking to clamp the proximal jejunum about 10–20 cm distal from the ligament of Treitz. (III) Suitable puncture point was chosen in the anterior wall of the stomach, and 2 traction suture was used before full-thickness incision of the gastric wall by electric hook with length about 0.5 cm; the observation hole was switch to the conventional in the right abdomen, and the insertion of the first intraluminal trocar was conducted under the surveillance of laparoscopy; "pneumogastrium" was instituted through this trocar and set at 12 mmHg, and the two additional 5 and 12 mm fix-aid trocar was switched into the gastric cavity at a reasonable distance with the assistance procedure from the conventional trocar. (IV) The location of gastric SMT and its growth pattern was confirmed, the tumor size and the distance from the esophagogastric junction (EGJ) was calibrated under intraluminal laparoscopy. The proposed resection line was marked by electrocautery circumferentially and the maximum resected specimen size (mm) was measured to confirm adequate margins, the non-expose semi-thickness dissection of gastric SMT was initiated from the proximal circumferential with adequate surgical margins by monopolar electrocautery, caution and meticulous manipulation was paid to avoid bleeding, perforation, or rupture. (V) A retrieval bag was inserted into the gastric lumen through and the specimen was placed into it, the surgical site of the mucosal defect was examination to exclude bleeding or perforation before continuous suture was used to close the wound. Intraoperative frozen section pathological examination was proceeding, and the gastric puncture point was closed by sutured.

For all the patients, the operating time (min), blood loss (mL), tumor growth pattern, intraoperative complications, maximum resected specimen diameter (mm), minimum surgical margin (mm) were measured, and the postoperative complication, pathological diagnosis, the time of resumption to oral intake (days) and postoperative hospital stay (days) were measured postoperatively.

Results

All the 14 patients underwent successful T-LIGS without open conversion or operative failure. The operation time was 71.1±22.2 min and the blood loss was 9.3±7.0 mL. All patients received complete resection with a negative margin. No operation-related mortality or severe morbidity was observed in our series. One patient experienced postoperative gastroparesis, another patient experienced surgical site infection, both patient recovered after conservative treatment. The mean postoperative length of hospital stay was 6.6±1.7 days. In pathology there were nine cases of gastrointestinal stromal tumor (GIST), two cases of neurofibroma, two cases of neuroendocrine tumor (NET), and one case of mucosa associated lymphoid tissue lymphoma. In follow-up, one patient experienced of stenosis of the cardia, no tumor recurrence was confirmed during a mean follow-up of 13.9±7.4 months. The result of T-LIGS was list on *Table 2*.

Discussion

As a relatively rare tumor gastric SMTs is often diagnosed incidentally by routine gastroscopy (3), the preoperative pathological diagnosis were often difficult to confirm (4), in order to insure adequate margin surgeons often removed moderate surrounding tissues, once the diagnosis of gastric SMTs was made, although lymphadenectomy was not generally required. The gastric SMTs can be classified into exogenous, endogenous and transgastric growth based on its growth pattern, with the endogenous was much more difficult to cope with. The pathology of gastric SMTs can be divided into two categories, respectively the mesenchymal tumors and non-mesenchymal tumors, and GIST was the most common type of mesenchymal tumors. Endoscopic resection had becoming an important means of treatment of gastric SMTs, however, when a tumor is too large or located in the posterior wall or gastric fundus, gastroscopy is very difficult to achieve, even using special equipment by experienced doctors, it still carry a certain degree of intraoperative or delayed complications such as perforation and abscess, which limited its application in special parts of the gastric SMTs (5). The ESD treatment of SMT has a high morbidity such as massive bleeding and perforation of

Table 2 Surgical outcomes for patients who underwent T-LIGS for gastric SMT

Parameter	Outcomes
Operating time (min)	71.1±22.2 [45–110]
Blood loss (mL)	9.3±7.0 [5-30]
Maximum resected specimen size (mm)	27.5±7.0 [20-40]
Minimum surgical margin (mm)	6.4±2.3 [5-10]
Intra-operative complication	
Bleeding	0
Perforation	0
Resort to gastroscope	1
Open conversion	1
Tumor growth pattern	
Endogastric	12
Exogastric	0
Transgastric	2
Pathological diagnosis	
GIST	9
Neurofibroma	2
NET	2
MALT-L	1
Postoperative complication	
Fistula	0
Bleeding	0
Surgical site infection	1
Gastroparesis	1
Resumption of oral intake (days)	3.3±1.2 [2-5]
Postoperative hospital stay (days)	6.6±1.7 [5-11]
Follow-up	
Visit/loss	11/3
Follow-up period (months)	6.0±2.3 [3-9]
Long-term complications	
Recurrence	0
Cardiac stricture	1

T-LIGS, totally laparoscopic intragastric surgery; SMT, submucosal tumor; GIST, gastrointestinal stromal tumor; NET, neuroendocrine tumor; MALT-L, mucosa associated lymphoid tissue lymphoma.

stomach, and not suitable for resection of muscle. With the progress of laparoscopic technology and the improvement of equipment, a variety of ways of laparoscopic treatment of gastric SMTs had been derived from the operation of the traditional laparoscopic partial gastrectomy (LAP), and either transgastric or intragastric resection can be selected accounting to the position and growth pattern of gastric SMTs (6,7). The selection of surgical approach for gastric SMTs was basically on the operating surgeon's discretion. For gastric SMTs located near the EGJ, the posterior, or the lesser curvature, especially in the endogenous growth pattern, where the operative field is limited and the expose of the tumor is difficult, the use of traditional method is restricted, proximal gastrectomy or total gastrectomy may need to avoid the complications such as cardiac stricture or fistula (8). Ohashi (2) first reported the intraluminal use of laparoscopic electrocauterization for the treatment of early cancer in 1995, and named it as laparoscopic intragastric surgery (LIGS). And various methods of intragastric wedge resection have been reported depend on the characteristics of the tumor. However, all these methods depend on endoscope, either for the inflated of airflow via oral endoscopy, or for provide an endoscopic view of surveillance for intragastric resection, and the specimens were retrieved through the oral route (9). However, in particular situations even when the stomach was inflated, the application of an endo-linear stapler is not easy, because of the relatively large of the tumor comparing to the restriction of the length of the stapler in a narrow operation field (10). We use the rigid laparoscope to substitute the endoscope to establish the "pneumogastrium", and all the procedure was carried out within the conventional laparoscopic instrument under, name it as the T-LIGS.

The results and the clinical effect of T-LIGS technology was evaluated and showed in the table. In our application experience, T-LIGS had some drawbacks: firstly, it does not provide "full-thickness" but "semi-full" thickness resection of the stomach. Secondly, the possible spillage of gastric content during intragastric access or procedure may cause intra-abdominal infection or surgical site infection. Thirdly, it is hard to handle and open conversion may be needed, when incidentally exposed the pseudocapsule of gastric SMTs. These deficiencies are common problems of LIGS, technically, T-LIGS can comply with all the oncologic principles of surgical management of gastric SMTs, and there is no obvious inferiority of T-LIGS as compare to traditional LIGS. We only experienced one case of surgical site infection in the umbilical trocar site which symptomatic remit after drainage and dressing change. As far as open conversion be concerned, although we do not encounter, we regard that oncological principle be prior to minimally invasive, and we insist that T-LIGS is not an technique-damned procedure, and laparoscopic surgeons can master it easily after learning curve. Compared with other procedure T-LIGS has some of its own characteristics (11): firstly, the operation time T-LIGS is shorten as a result of compromising the intraoperative endoscopy without increasing the trauma; it is applicable to the gastric SMTs located <1 cm from the EGJ, which is the forbidden zone for conventional LAP, and it is suitable for SMTs with diameter >2 cm and superior to the existing endoscopic ESD technology. Secondly, the establishment of pneumoperitoneum as the initial step T-LIGS not only facilitate the gastric puncture, but also provide favorable conditions for exploration of the gastric SMTs and associate lymph node, which is suitable for patients with abdominal operation history; It can meet the special requirements of lymph node dissection, and simultaneously procedure can be conducted for concomitant disease such as obesity (12,13). Thirdly, the indication of T-LIGS can be expanded to the surgical management of foreign body, bezoar, and incarcerated gastric band (14); and it is suitable for proposed full-thickness excision, after phased exogastric seromuscular layer resection and endogastric submucosal dissection and wall-inversion maneuver, without causing deformity or perforation and provide excellent oncological outcome (15).

In conclusion, T-LIGS is an safe and feasible procedure that may coincidence with the oncological demand and may expanded indications of laparoscopic surgery for gastric SMTs (16), however as a small sample study , the results of this study should be carefully interpreted ,before strong evidences be provided by more well-design and large-scale studies.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by the Ethics Committee of the Second Hospital of Jilin University and written informed consent was obtained from each patient.

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Intracorporeal hand-sewn esophagojejunostomy after total laparoscopic total gastrectomy: a retrospective case-series study

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Background: To evaluate the safety and feasibility of intracorporeal hand-sewn esophagojejunostomy for total laparoscopic total gastrectomy (LTG).

Methods: From September 2012 to April 2016, 64 consecutive patients (52 men and 12 women) with gastric cancer underwent TLTG using intracorporeal hand-sewn sutures. Then patients' characteristics, perioperative outcome and histopathologic data were analyzed retrospectively. This procure was performed by a single surgical team.

Results: The mean age was 62.1 years and mean body mass index (kg/m^2) was 22.7. The mean operation and reconstruction were 273.4 and 61.4 min, respectively. Intraoperative blood loss was 80.3±67.4 mL and there was not an open conversion. The average time until the first flatus was 3.1 d. The average times to start liquid and soft diets were 4.2 and 7.4 d, respectively. The average postoperative hospital stay was 8.1 d. There was no sign of pancreatic or anastomotic leaks and strictures in any patient.

Conclusions: Intracorporeal hand-sewn esophagojejunostomy after LTG can be a safe, feasible and promising option for patients with gastric cancer.

Keywords: Hand-sewn; gastric cancer; intracorporeal esophagojejunostomy

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Introduction

In recent years, laparoscopic gastrectomy has become widely accepted for the treatment of gastric cancer. Today laparoscopic distal gastrectomy and even laparoscopic total gastrectomy (LTG) are used as routine methods for the treatment of gastric cancer (1,2). Nevertheless, LTG is still challenged by the intro-corporeal esophagojejunostomy, so that laparoscopic assisted total gastrectomy is still a mainstay (3-5).

To solve this problem, various techniques and instruments for intracorporeal esophagojejunostomy, linear stapling, and circular stapling have been developed (1). All of them were developed to make the procedure safer and simpler, but they still have their applicable limitations. Circular stapling is difficult to perform on patients who are obese and possess larger diameter anteroposteriors. Also there is the possibility of high cost injury to the esophageal mucosa, bacterial contamination in the abdominal cavity. Linear stapling has bigger anastomotic stoma and may decrease the rate of postoperative complications. However, it may cause distortion of the mesenterium and limited surgical margins.

Based on our extensive laparoscopic experience obtained from performing several laparoscopic pancreatic, gastric, and other operations (6-13), we developed intracorporeal hand-sewn esophagojejunostomy after totally laparoscopic

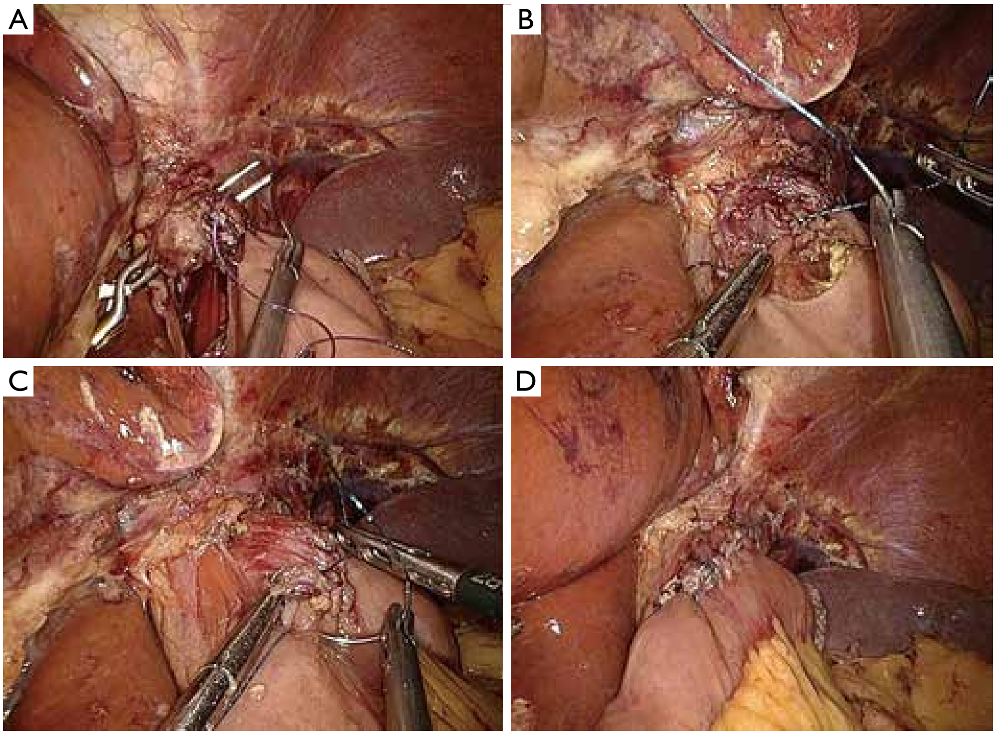

Figure 1 Hand-sewn end-to-side method. (A) The jejunum was anchored to the esophageal stump by several serosal muscularis interrupted sutures placed in the posterior layer of the esophageal stump; (B) the posterior wall was closed by several full-thickness interrupted sutures; (C) closure of the anterior wall was carried out by a full-thickness continuous suture; (D) the seromuscular layer was strengthened with interrupted sutures to reduce tension.

total gastrectomy (TLTG) (14). The details of this technique are described herein.

Methods

Patients

From September 2012 to April 2016, 64 consecutive patients (52 men and 12 women) with gastric cancer underwent TLTG using intracorporeal hand-sewn sutures. Esophagojejunostomy was performed by a single surgical team at Sir Run Run Shaw Hospital and Zhejiang Provincial People's Hospital. This research was approved by Zhejiang University's Ethics Committee. Written consent was obtained from every patient prior to enrollment in the study. Patient selection was based on preoperative examinations; including computed tomography, endoscopic ultrasonography, and gastrointestinal radiography. Patients with an ASA score of 4 or more points, extensive esophageal invasion, and extensive lymph node metastasis were excluded. Additionally we retrospectively analyzed the patients' characteristics, as well as their intraoperative and postoperative outcomes. Pathological and clinical staging was determined based on the American Joint Committee on Cancer (the 7th edition) and the tumor-node-metastasis (TNM) classification scheme.

Surgical procedures

The patient was placed in the supine position and put under general anesthesia. The surgeon and the scopist stood on the right side of the patient while the first assistant stood on the left side of the patient. A CO2 pneumoperitoneum was set at 15 mmHg. Five major trocars were inserted in a routine V shaped arrangement (7,13) (*Figure 1*). The lymphadenectomy was conducted, followed by total gastrectomy based on the guidelines of gastric cancer procedures set in Japan, which contained the dissection of D1 and No. 8a, 9, 10, 11p, 11d, and 12a,. The duodenum was transected within 3 cm of the pylorus using an endoscopic linear stapler, the jejunum was then stapled at

Table 1 Patient characteristics

Variable	Value (%)
Sex	
Male	52 (82.5)
Female	11 (17.5)
Age (yr)	62.1±9.66
BMI (kg/m^2)	22.7±3.22 (17.3–31.2)
ASA score (I/II/III)	37 (57.8)/25 (39.1)/2 (3.1)

Data are expressed as mean ± SD (range) or n (%). BMI, body mass index; ASA, American Society of Anesthesiologists.

Table 2 Operative and postoperative data

Variable	n
Operation time (min)	273.4±52.3 [210–435]
Reconstruction time (min)	61.4±19.2 [45–110]
Intraoperative blood loss (mL)	80.3±67.4 [30–210]
Open conversion	0
Postoperative complications	4
Anastomotic leakage	0
Intraluminal bleeding	2
Pulmonary complication	1
Ileus	1
Anastomotic stricture	0
Pancreatitis	0
First flatus after operation (d)	3.1±0.9 [2–5]
Liquid diet (d)	4.2±1.0 [2–7]
Soft diet (d)	7.4±2.2 [4–15]
Postoperative hospital stay (d)	8.1±2.4 [7–17]

Data are mean ± SD (range).

20 cm from the Treitz's ligament.

The jejunal loop was brought up to reach the esophageal stump. The jejunum was anchored to the esophageal stump with several serosal muscularis interrupted sutures that were placed in the posterior layer of the esophageal stump (*Figure 1A*). A hole matched with the esophageal stump was created (*Figure 1B*). The posterior wall was latterly closed with a number of full thickness sutures (*Figure 1C*). In addition, the closure over the anterior wall was completed via full thickness sustainable sutures. Finally, the seromuscular layer was strengthened with interrupted sutures to decrease the tension (*Figure 1D*).

Results

A total of 63 consecutive patients underwent TLTG with Intracorporeal hand sewn end to side esophagojejunostomy at our institute. Patient characteristics are summarized in *Table 1*.

Operative outcomes and postoperative clinical course

There is not a conversion to open surgery or laparoscopy assisted surgery. The mean operation time was 273.4±52.3 min. The mean reconstruction time was 61.4±19.2 min, and the mean intraoperative blood loss was 80.3±67.4 mL. The average time until the first flatus was 3.1 d. The average times to start liquid and soft diets were 4.2 and 7.4 d, respectively. The average postoperative hospital stay was 8.1 d.

The rate of postoperative morbidity was 6.3% and there were no cases of postoperative death. Morbidity included intraluminal bleeding (n=2), pulmonary infection (n=1), and ileus (n=1). There was no sign of pancreatic or anastomotic leaks and strictures in any patient (*Table 2*).

Pathological characteristics

The distal and proximal margins were checked in frozen sectors, with R0 resection realized in each case. The mean length of proximal margins was 4.1±1.8 cm. The depths of invasions were submucosal in 10 patients, within proper muscle in 7 patients, subserosal in 4 patients and serosal in 42 patients. The mean number of retrieved lymph nodes was 35.6 (range, 6–104). The final pathologic stage according to the 7th UICC TNM staging system was stage I in 13 patients, stage II in 1 patient, and stage III in 49 patients (*Table 3*).

Discussion

During the past decade the use of LTG for gastric cancer has been gradually accepted because of the short-term benefits and comparable oncological results reported in retrospective studies (8,15). We had reported that TLTG with intracorporeal reconstruction is better than

Table 3 Histopathologic data

Variables	n (%)
Tumor invasion depth	
Submucosa (T1b)	10 (15.9)
Muscle propria (T2)	7 (11.1)
Subserosa (T3)	4 (6.3)
Serosa exposed (T4)	42 (66.7)
Nodal metastasis	
0 (N0)	29 (46.0)
1–2 (N1)	4 (6.3)
3–7 (N2)	13 (20.6)
>8 (N3)	17 (27.0)
TNM stage	
I	13 (20.6)
II	1 (1.6)
III	49 (77.8)
IV	0
Total number of resected lymph nodes	35.6±14.4 (6–104)
Proximal margin (cm)	4.1±1.8 (1.8–8)

Nine (11.1%) of 81 patients had more than two comorbidities. Data are mean ± SD or number (%). BMI, body mass index; ASA, American Society of Anesthesiologists.

laparoscopy-assisted total gastrectomy (LATG) in respect to extracorporeal reconstruction. Improvements include better cosmesis, earlier bowel movements, less pain, and shorter hospital stays (5). However, regarding LTG, many surgeons still perform LATG because of the high technical demand of intracorporeal reconstruction. Therefore, various types of intracorporeal esophagojejunostomy after LTG were reported. We first introduced the use of intracorporeal anastomosis after LTG in 2007.

The major methods of intracorporeal mechanical esophagojejunostomy reported have two approaches, Conventional circular stapler-anvil approach and linear stapler approach. Esophagojejunostomy performed with circular staples in laparotomy is easy and safe because of a sufficient field of operation. The key to the circular stapler-anvil approach is completing the purse-string suture and inserting the anvil into the esophagus. To reduce the difficulty of the purse-string suture (16), Endostich® (Autosuture, Tyco Healthcare, Mansfield, MA, USA) or Endo-PSI (II) (Hope Electronics, Chiba, Japan) were used. We utilized an orally inserted anvil to simplify the procedure of inserting the anvil into the esophagus (17), followed by various modifications (17-19). However, the following short comings could not be avoided; high cost, possibility of bacterial contamination in the abdominal cavity, and injury to the esophageal mucosa. Therefore, this procedure has only been adopted in a handful of specialized medical centers (20,21).

The linear stapler approach in side-to-side anastomosis was first introduced by Uyama *et al.* (22), then modified by Matsui *et al.* (23). Due to the absence of purse-string sutures, it is simpler to perform and causes less injury to the esophagus and bigger anastomotic stoma. Nevertheless, the distal esophagus needs extensive mobilization, the Roux limb is required to reduce the tension at the anastomosis site, and the surgical margin is limited as a longer esophageal stump should be reserved.

Intracorporeal hand sewn end to side esophagojejunostomy can overcome the limitations caused by the mechanical methods (24). We first applied this method of intracorporeal anastomosis after LTG in 2012, based on laparoscopic experience gained from laparoscopy gastric and pancreatic surgery, and other laparoscopic operations (14). The suturing process can be clearly observed under laparoscopy to ensure the reliability of anastomosis. In contrast with mechanical reconstruction, hand sewn esophagojejunostomy does not require excessive mobilization of the esophagus and Roux limb and causes less tissue injury at the anastomosis site. Furthermore, negative margins can be confirmed using intraoperative frozen sections before suturing begins. This method does not require a long esophageal stump to ensure the R0 resection. We can then expand the removal length appropriately. Moreover the conversion rate to laparotomy is reduced.

In our study, hand sewn esophagojejunostomy after LTG shows acceptable surgical outcomes, compared with corporeal mechanical esophagojejunostomy. However, using intracorporeal hand-sewn sutures is a complex procedure and specific skills are needed which can only be acquired after a fairly long surgical learning curve. As So and Park said (24), intracorporeal hand-sewn esophagojejunostomy in TLTG is not an unconventional technique, but if surgeons perform the technique with intracorporeal hand-sewn suturing, it could become a classic procedure as routine and effective as open total gastrectomy is today or even better.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by Zhejiang University's Ethics Committee. and written informed consent was obtained from all patients.

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Simultaneous laparoscopic distal gastrectomy (uncut Roux-en-Y anastomosis), right hemi-colectomy and radical rectectomy (Dixon) in a synchronous triple primary stomach, colon and rectal cancers patient

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Background: Gastric and colorectal cancers are both one of the most common tumors worldwide, while the morbidity of multiple synchronous primary tumors are really rare, and triple synchronous primary cancers are considered has a lower incidence. In this report, we demonstrate a rare case of synchronous triple primary cancers involving gastric, colon and rectal, and the laparoscopic operation procedure of the patient.

Methods: A 49-year-old male diagnosed with synchronous triple primary gastric, colon and rectal cancer, underwent simultaneous laparoscopic distal gastrectomy (uncut Roux-en-Y anastomosis, D2), right hemi-colectomy and radical rectectomy (Dixon).

Results: The operation lasts 305 min with about 300 mL blood lost. The patient discharged from hospital on the 12th day without any complication.

Conclusions: Laparoscopic surgery is a safe and feasible way in synchronous gastrointestinal triple primary cancers. Nevertheless, because of the rare incidence, many details and specific condition should be considered during the peri-operative period of this multiple synchronous cancers patient.

Keywords: Synchronous triple primary cancers; laparoscopic surgery; uncut Roux-en-Y reconstruction; right hemi-colectomy; radical rectectomy

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Introduction

Gastric cancer and colorectal cancer are common malignancies, while synchronous gastric cancer, primary colon and primary rectal cancel are extremely rare. Here we report a rare case of synchronous triple primary tumors involving gastric, colon and rectal in a 49-year-old male. Uncut Roux-en-Y anastomosis is relatively difficult procedures during distal gastrectomy, and laparoscopic radical right hemicolectomy as well as radical rectectomy (Dixon) are common procedures in colorectal surgery, while carrying out the three laparoscopic operations simultaneously has not been reported yet and the procedure is relatively complicated. Now we will describe our surgical techniques.

Methods

Ethical approval and patient consent

The present study was approved by the Ethics Committee of the First Affiliated Hospital of Nanjing Medical University (Nanjing, Jiangsu, China). Written informed consent was obtained from the present subject prior to enrollment in the present study.

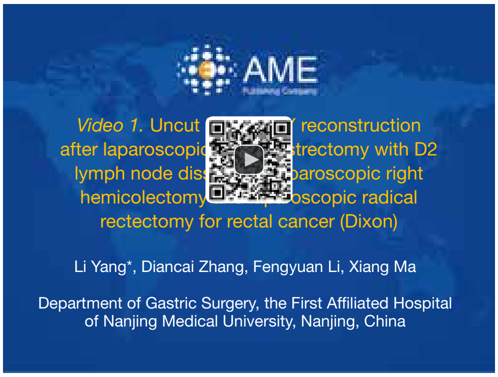

Figure 1 Uncut Roux-en-Y reconstruction after laparoscopic distal gastrectomy with D2 lymph node dissection, laparoscopic right hemicolectomy and laparoscopic radical rectectomy for rectal cancer (Dixon) (1).
Available online: http://www.asvide.com/articles/986

Patient selection and workup

In the video (*Figure 1*), the patient is a 49-year-old man who was diagnosed with synchronous triple primary cancers involving gastric, colon and rectal by gastroscopy, colonoscopy and pathological examination (*Figure 2*). The tumor stages were evaluated to be cT1N0M0 for stomach, cT4N0M0 for colon and cT2N0M0 for rectal by CT scan pre-operation (*Figure 3*). Uncut Roux-en-Y anastomosis after laparoscopic distal gastrectomy with D2 lymph node dissection, laparoscopic right hemicolectomy and laparoscopic radical rectectomy for rectal cancer were intended to be carried out.

Procedure

After successful anesthesia, the patient was placed horizontal position with legs apart. At the beginning of this operation, five trocars are required. Firstly, the 10-mm trocar was placed above the umbilicus and a 30-degree laparoscope was inserted. Then other four trocars were installed under direct sight: two 5-mm trocars into the right upper and right lower abdomen, and two 12-mm trocars into the right

Figure 2 Gastroscopy and colonoscopy.

Figure 3 CT scan.

upper and left lower abdomen.

Firstly, the peritoneal cavity and pelvic cavity were explored to rule out underlying metastasis or invasion.

Laparoscopic distal gastrectomy with D2 lymph nodes dissection procedure: after D2 lymph nodes dissection, duodenum was divided 2 cm away from pylorus using 60 mm linear stapler. The distal stomach was divided by two firings of a linear stapler, and the resected specimen was put in a plastic bag. In the same time, the jejunum 20 cm away from the Traitz ligament was labeled by silk thread.

Laparoscopic right hemicolectomy: we chose the McBurney's point incision and lower abdomen middle incision to put in another two trocars, one 5-mm, and one 12-mm under direct vision. Then we exposed and separated the superior mesenteric vein and the ileocolic vascular, then ligated the ileocolic vascular at the root. Next we entered Toldt's fascia to expose and prevent damage to the right gonadal vessels and ureter. Lymph nodes alone the superior mesenteric artery should be dissected and the horizontal and descending part of the duodenum should be exposed. After that we start resecting 2/3 left great omentum of the transverse colon. Ultimately, we detached the right colon and the hepatic flexure completely from the lateral peritoneal attachment.

Laparoscopic radical rectectomy: we dissected mesentery along with the right iliac artery surface up to the bifurcation, and separate mesentery along the abdominal aorta to expose inferior mesenteric artery. And then we separated the mesentery along Toldt fascia surface to the opposite side to expose and protect the left ureter. Next the sigmoid mesentery was separated at the root and lateral ligament of the rectum were divided. According to the total mesorectal excision principle, the rectum was freed along Denonvilliers fascia until at a distance of 3 cm from the distal margin of the carcinoma and divided the rectum.

Specimen extraction and anastomosis: the gastric specimen was then taken out from the abdomen through the trocar about 5 cm in size around the umbilicus. Taking out the right hemicolon through the incision around the umbilicus, divided and removed it, then an ileotransversostomy was performed by the linear stapler and strengthened by suturing. Put back the colon and took out the rectum, freed the sigmoid colon mesentery and divided the sigmoid colon about 10 cm above the tumor. The stapler head was extracorporeal placed and repositioned into the abdomen. After that, the jejunum was took out from the same incision by pulling the labeled thread and then a Braun anastomosis was performed in the proximal 10 cm and the distal 50 cm away from the Treitz ligament. Next, the afferent loop was occluded 10 cm far from the jejunojejunostomy place with linear stapler (uncut). After that, put back the small intestine into the peritoneal cavity and reestablish pneumoperitoneum. Sigmoidorectostomy was performed by stapler through anus. The last step was performing laparoscopic gastrojejunostomy at a point 2 cm distance to the blocking place.

Results

The whole operation took about 305 min with bleeding of about 300 mL. The postoperative pathologic finding showed an early gastric myxoadenocarcinoma (T1bN0M0, stage IA), colon adenocarcinoma (T4aN0M0, stage IIB), and rectal adenocarcinoma (T2N0M0, stage I). The patient discharged from hospital on the 12th day without any complication.

Discussion

Multiple primary malignant neoplasms are two or more malignancies in an individual without any relationship between the tumors. Synchronous tumors are defined as ≥2 primary tumors occurring within 6 months after diagnosing the first primary tumor. If the time interval was more than 6 months, the tumors were considered to be metachronous (2).

Both gastric and colorectal cancers are common tumor worldwide, while the morbidity of multiple synchronous primary tumors are really rare, which has been reported to vary from 0.7% to 11.7% (3). And triple synchronous primary cancers are considered has a rarer incidence. A previous study indicated that the incidence of multiple synchronous primary cancers in China is about 3.13% (4), which is similar to foreign countries. In all gastric cancer patients, Lee *et al.* reported that the frequency of synchronous malignant tumors is about 3.4% in 3,291 cases (5).

With the improvement of medical examination technology, more multiple synchronous primary cancers patient can be diagnosed. Nevertheless, diagnose error and misdiagnosis rate are still quite high. Therefore, when diagnosing a cancer patient, firstly, we should take synchronous primary cancers into consideration. Secondly, we should be caution when differentiating diagnosis of synchronous primary cancers from metastatic cancer, because their therapies are totally different.

Currently, there is no guideline for the treatment of multiple synchronous primary cancers. The most common treatment is surgery associated with adjuvant treatment (6). In resectable multiple synchronous primary cancers, radical surgery with or without chemotherapy is the preferred treatment (7,8). In the present synchronous triple primary stomach, colon and rectal cancers patient, we have several questions. For example, how to choose the way of operation, open or laparoscopic? If we choose laparoscopic operation on this patient, how we select the position of trocars so that we can carry out the procedure favorably and smoothly. Meanwhile, which is the optimal resection order in the present synchronous triple primary stomach, colon and rectal cancers patient? And which is the best reconstruction way for laparoscopic distal gastrectomy in this patient? Considering the relative early cStages of the three primary tumors in the present patient, we selected laparoscopic surgery and the exactly process of the operation was described detailed in the procedure part. According to our operation plan, the procedures were completed successfully, and lymph nodes dissection was sufficient, with no metastases in total 68 lymph nodes. Besides that, we made use of the essential single umbilical incision which was used to take out specimens to perform ileotransversostomy, jejunojejunostomy and occlude the afferent loop. Then laparoscopic sigmoidorectostomy and gastrojejunostomy were performed after reestablishing pneumoperitoneum. This minimally invasive operation brought the patient quickly recovery. In this case, we chose uncut Roux-en-Y reconstruction after laparoscopic distal gastrectomy with D2 lymph node dissection, because it is reported that uncut Roux-en-Y technique, would preserve unidirectional intestinal myoelectrical activity and diminish Roux Stasis Syndrome (9,10). And nine months follow-up post-operation indicates that the patient recovers well without any symptoms of Roux Stasis Syndrome.

Uncut Roux-en-Y anastomosis after laparoscopic distal gastrectomy with D2 lymph nodes dissection is a relatively complicated operation. Performing the three laparoscopic operations in one patient simultaneously is more difficult. Therefore, the laparoscopic surgery therapy for multiple primary malignant neoplasms should be performed by surgeons who are rich in experiences of laparoscopy surgical techniques.

Conclusions

In resectable multiple synchronous primary cancers, radical surgery is the preferred treatment, but weather choose the laparoscopic surgery and how to design the resection order is depending on the primary tumors' stages and surgeons' experience. More attempts should be done on the laparoscopic resection of multiple synchronous cancers.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by the Ethics Committee of the First Affiliated Hospital of Nanjing Medical University (Nanjing, Jiangsu, China). Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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B-II reconstruction with Braun's anastomosis after totally laparoscopic distal gastrectomy with D2 lymph node dissection for advanced gastric cancer

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Background: B-II reconstruction is a mature way in radical operation of gastric cancer. It can confirm the negative margin in advanced gastric cancer. And it makes the digestive juices flow more freely and prevents delayed gastric emptying with Braun's anastomosis.

Methods: We choose a 59-year-old man with moderately differentiated adenocarcinoma of gastric antrum who was diagnosed by gastroscopy and histological test and conform to the treatment standard of totally laparoscopic distal gastrectomy (TLDG) with D2 lymph node dissection and B-II reconstruction and Braun's anastomosis.

Results: The total length of operation was 190 min. The entire bleeding was 40 mL. The patient ate liquid diet on the 3rd day and discharged from hospital with the wound class-A healing on the 7th day.

Conclusions: TLDG with B-II reconstruction and Braun's anastomosis using laparoscopic linear staplers reduces gastrointestinal function disorder and minimals the surgical incision, is a safe and feasible surgical method.

Keywords: Totally laparoscopic distal gastrectomy (TLDG); B-II reconstruction; Braun's anastomosis; minimal invasiveness

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Introduction

B-II reconstruction with Braun's anastomosis after totally laparoscopic distal gastrectomy (TLDG) with D2 lymph node is a difficult but mature surgical method. It needs operator superior skills. Here we describe the technique.

Methods

Patient

The patient is a 59-year-old man in the present video (*Figure 1*). He was diagnosed moderately differentiated adenocarcinoma of gastric antrum by gastroscopy and histological test and the tumor stage was assessed to be cT3N0–1M0 by CT scan preparation (*Figure 2*). It is suitable to perform B-II reconstruction with Braun's anastomosis after TLDG with D2 lymph node dissection for those advanced gastric cancer patients. The study obtained the informed consent from the patient.

Surgical procedure

After general anesthesia, the patient was placed horizontal position with 20° head-up tilt. Legs were apart 30–45 degrees for the place of camera operator. The surgeon was positioned on the left side of the patient and the first assistant on the right side.

The 30° camera trocar-hole was inserted above the umbilicus using 12-mm trocar. Two trocar-holes were inserted on the left for the operator with a 12-mm trocar

Figure 1 Totally laparoscopic distal gastrectomy (1). Available online: http://www.asvide.com/articles/1221

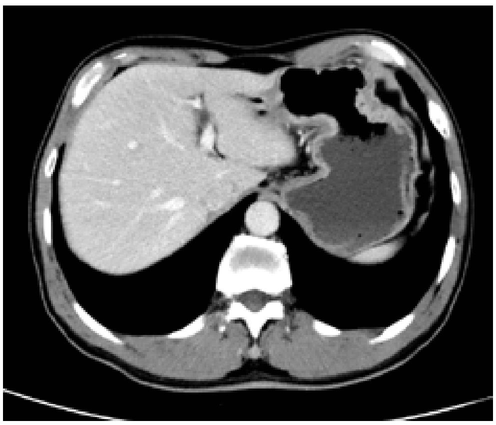

Figure 2 Abdominal CT scan.

and a 5-mm trocar.

The other two trocar-holes then were inserted into the right with two 5-mm trocars for the first assistant.

After D2 lymph nodes dissection, duodenal transection was performed with a linear stapler. The stomach was resected by two firings of a linear stapler, and the resected specimen was placed in a plastic bag. Following these procedures, B-II reconstruction with Braun's anastomosis was processed with endoscopic linear stapling devices. The gastrojejunostomy was performed at a point 20 cm distal to the Teritz ligament. The stomas were reconstructed on the dorsal sides of the residual stomach. And Braun anastomosis was performed 15 cm distal to the gastrojejunostomy.

Finally, the 12-mm trocar-hole above the umbilicus was extended to 4 cm around the umbilicus, the specimen was then extracted from the abdomen through the incision (*Figure 3*).

Figure 3 Incision around the umbilicus.

Results

The total length of operation was 190 min, and the entire bleeding is 40 mL. The pathology outcome after the surgery show it the moderately differentiated adenocarcinoma staging T2N0M0 with 0/34 lymph nodes positive. The patient ate liquid diet on the 3rd day and discharged from hospital with the wound class-A healing on the 7th day, without any significant complications.

Discussion

B-II is an operation in which the greater curvature of the stomach is connected to the first part of the jejunum in end-to-side anastomosis. This often follows resection of the lower part of the stomach. After the reconstruction, food goes through stomach and directly into upper jejunum. It allows to dissect more gastric tissue without the problem causing by a high level of tension at anastomosis and makes sure margin negativity, thus allowing the reconstruction after gastrectomy. However, this technique causes more dissectional and physiological changes, therefore, a higher chance of complications such as abdominal internal hernia, afferent loop obstruction, duodenal stump leakage, anastomosis and afferent loop obstruction, alkaline reflux gastritis, remnant gastric cancer (RGC), postoperative gastroparesis syndrome (2). Braun's anastomosis can effectively diminish obstruction, twist, protrusion and edema, and allow food go through easier. Moreover, with diminishing reflux and reducing irritation to gastric mucosa at the same time, it can effectively reduce complications above (3). And we reconstructed the gastrojejunostomy on the dorsal sides of the residual stomach to form natural fold so that the regurgitation can be reduced.

Totally laparoscopic gastrectomy (TLG) (4) has been proved to be safe and effective. It has so many advantages associated with TLG. In TLG, the whole anastomotic procedure can be clearly viewed, so such tension and injuries can be obviated, especially in an obese patient (5). However, the disadvantages of TLG include that it is difficult in intraoperative localization of the tumor, and additional costs for using many linear stapler cartridges. We overcame this problem by having endoscopy before the day of the operation again in order to confirm the exact location of the tumor and we marked the location of the tumor with nano carbon on the gastric wall (6).

Conclusions

In conclusion, TLDG with intracorporeal B-II reconstruction with Braun's anastomosis using laparoscopic linear staplers was found to be safe and feasible. We consider that our operation may represent a good choice for reconstructions after laparoscopic distal gastrectomy.

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Footnote

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Informed Consent: Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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Delta-shaped Billroth-I anastomosis in totally laparoscopic distal gastrectomy with D2 lymph node dissection for gastric cancer

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Contributions: (I) Conception and design: All authors; (II) Administrative support: None; (III) Provision of study materials or patients: J Zhang; (IV) Collection and assembly of data: W Wei, AK Zhu, G Yin; (V) Data analysis and interpretation: J Zhang, RC Ying; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: It is attractive to complete laparoscopic reconstruction of digestive tract as a part of totally laparoscopic distal gastrectomy for patients of distal gastric cancer with its obvious advantage of minimal invasiveness. Delta-shaped Billroth-I anastomosis provides a feasible option for these patients, as we herein describe.

Methods: A 61-year-old woman who was diagnosed with early gastric cancer (type III) of 1.0 cm in diameter at the gastric angle by gastroscopy underwent totally laparoscopic distal gastrectomy with D2 lymph node dissection and delta-shaped Billroth-I anastomosis.

Results: The operation lasted for about 120 min with blood loss of about 50 mL. The patient recovered well and was discharged from hospital on postoperative day 11.

Conclusions: Delta-shaped Billroth-I anastomosis by laparoscopic linear staplers is a safe procedure of alimentary reconstruction for totally laparoscopic distal gastrectomy and preferred for patients with early gastric cancer at gastric angle.

Keywords: Totally laparoscopic distal gastrectomy; delta-shaped Billroth-I anastomosis; minimal invasiveness

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Introduction

Gastroduodenostomy (Billroth-I anastomosis), a preferable method of gastrointestinal tract reconstruction for distal gastrectomy, is usually applied in open surgery. We herein describe our experience of finishing it under laparoscopy, which is widely accepted as delta-shaped Billroth-I anastomosis.

Methods

Patient selection and workup

Laparoscopic delta-shaped Billroth-I anastomosis is recommended for the selected patients with small-diameter early-stage gastric cancer at gastric angle. The present video (*Figure 1*) by my surgical team (*Figure 2*) recorded the operation of a 61-year-old woman with body mass index of 23.5 kg/m^2. She suffered from upper abdominal pain for 2 months and then underwent gastroscopy, by which a superficial ulcer of approximately 1 cm in diameter at gastric angle was discovered. Endoscopic ultrasound showed that the lesion was confined to the submucosa and suspected malignancy. The diagnosis of poorly-to-moderately differentiated adenocarcinoma was confirmed by later biopsy and histological test. There is no positive finding in physical exam, assay of serum tumor markers, chest X-ray and abdominal CT. The tumor stage was assessed to be cT1N0M0. She underwent delta-shaped Billroth-I anastomosis after laparoscopic distal gastrectomy

Figure 1 Delta-shaped Billroth-I anastomosis following laparoscopic distal gastrectomy was performed in a 61-year-old woman who was found to have a malignant superficial ulcer of about 1.0 cm in diameter confined to the submucosa layer at gastric angle by gastroscopy (1).
Available online: http://www.asvide.com/articles/980

with D2 lymph node dissection. The work was approved by the ethnical committee of our hospital, and the patient was informed before surgery.

Gastroscopy during the operation

Since the lesion only invaded the submucosa of gastric wall and was invisible on the serosa layer by laparoscopy, gastroscopy was performed to confirm its exact location during the operation.

Postoperative management

Prophylactic antibiotic treatment was given for 48 hours after surgery. A liquid diet was allowed on postoperative day 4 and continued for 3 days, followed by semi-liquids, till she was discharged on postoperative day 11.

Results

It took about 120 min to finish the operation with blood loss of about 50 mL. The pathology report was that poorly-to-moderately differentiated adenocarcinoma of 1.0 cm × 1.2 cm at the lesser curvature of stomach invaded submucosa and metastasized to 1 of 31 paragastric lymph nodes. The tumor stage was pT1N1M0. The patient recovered well and was prescribed chemotherapeutic regimens of XELOX. She had been well-tolerated for three courses of chemotherapy.

Discussion

Billroth-I anastomosis following distal gastrectomy has the physiological advantage of allowing food to pass through the duodenum. So it has been widely used as a standard reconstruction method. The anastomosis is usually completed by hand-sewing or circular stapling, either of which, however, is hard to be duplicated in laparoscopic surgery. The demand of designing an easy-to-use method eventually generates the new method of intracorporeal gastroduodenostomy, namely delta-shaped Billroth-I anastomosis, in which only endoscopic linear staplers are used (2).

The anastomosis is created between the posterior walls of the stomach and the duodenal bulb. The duodenum is first transected near the pylorus, with the duodenum bulb of 2–3 cm long left, by linear stapling from the posterior to the anterior wall. The stomach is transected by one or two linear staplers as usual, from the greater to the lesser curvature. Gastroscopy is recommended to ensure the margins of the resected distal stomach not too close to the tumor before the duodenum and stomach are transected. Conversely, if the remnant stomach is too small or if the duodenal bulb is too short, the anastomosis may be under unfavorable tension, and consequently at high risk of anastomotic leakage. Therefore, the patients who undergo the surgery should be carefully selected to meet the following criteria: early-stage gastric cancer, small size of tumor, and preferably tumor at gastric angle.

After the distal stomach is removed, small incisions, each of which is merely to allow inserting one limb of a 60 mm linear stapler, are made at the cutting edge of gastric wall near the greater curvature and at the cutting edge of duodenal posterior wall, respectively. If the incisions are too long, they may be too hard to close later on. The posterior walls of the stomach and the duodenum are approximated and anastomosed with a linear stapler. The stapling line is then inspected through the common stab incision for any defects. In the end, the common stab incision is closed at the direction vertical to the cutting edge of stomach by a linear stapler. The procedure has evolved by extending the last stapling line to the anterior wall of duodenal bulb, that is, transecting duodenal bulb again (3). The initial cutting edge of duodenal bulb is completely resected, which eliminates the intersection of duodenal cutting edge and theoretically lowers the risk of anastomosis-related complication. The anastomosis appears as an inverted T-shape.

Figure 2 Surgical team (from left to right). Front: Jian-Liang Sun (Anesthesiologist), Jian Zhang (Surgeon), Rong-Chao Ying (Technical consultant), Guang Yin (First assistant). Behind: Wei Wei (Second assistant & Camera operator), Yuan-Yuan Niu (Scrub nurse), Jing Zhang (Scout nurse), A-Kao Zhu (Second assistant & Camera operator).

Conclusions

The delta-shaped Billroth-I anastomosis is a safe and feasible laparoscopic reconstruction method for early-stage distal gastric cancer. It has the advantage of minimal invasiveness, good operative views and short operative time. Satisfactory outcomes are guaranteed if we know its technical details.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The work was approved by the ethnical committee of our hospital. Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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Laparoscopic proximal gastrectomy for upper third early gastric cancer

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Abstract: Laparoscopic proximal gastrectomy is theoretically superior to total gastrectomy in the treatment of upper third early gastric cancer, as the former is less invasive and better preserves function. Three major issues have limited the more widespread use of proximal gastrectomy: its oncologic safety, functional benefits, and risk of reflux esophagitis. Many recent studies suggest that the oncologic safety of laparoscopic proximal and total gastrectomy is similar, with proximal gastrectomy resulting in improved functional outcomes. To date, however, no standard reconstruction method has been developed to effectively prevent reflux esophagitis after proximal gastrectomy. Our recent retrospective study found that no patient who underwent laparoscopic proximal gastrectomy with double tract reconstruction experienced severe reflux esophagitis and that this method was superior to laparoscopic total gastrectomy in preventing anemia and vitamin B12 deficiency. This result led to the design of a randomized controlled trial, the Korean Laparoendoscopic Gastrointestinal Surgery Study (KLASS) 05 (ClinicalTrials.gov; identifier: NCT02892643), which is currently comparing laparoscopic proximal gastrectomy with double tract reconstruction with laparoscopic total gastrectomy. This trial may help surgeons choose the optimal surgical approach and strategy for patients with proximal early gastric cancer.

Keywords: Proximal gastrectomy; gastric cancer; laparoscopy; double tract reconstruction

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Introduction

The rates of early gastric cancer and of upper third gastric cancer have increased over time (1). Proximal gastrectomy for upper third early gastric cancer theoretically allows the storage, digestion, and absorption of food and prevents anemia. The oncologic safety of proximal gastrectomy for upper third early gastric cancer is considered comparable to that of total gastrectomy. However, the widespread adoption of proximal gastrectomy has been limited by the high rates of reflux esophagitis and associated anastomotic stenosis, with 16.2–61.5% of patients reported to experience at least one of these complications after proximal gastrectomy (2). Its minimal invasiveness and function preservation make laparoscopic proximal gastrectomy theoretically superior to open proximal gastrectomy, open total gastrectomy, and laparoscopic total gastrectomy in the treatment of patients with upper third early gastric cancer.

Studies comparing clinical outcomes of laparoscopic proximal gastrectomy followed by esophagogastrostomy with laparoscopic total gastrectomy in patients with upper third early gastric cancer found that the former group had a higher rate of reflux esophagitis (3,4). Therefore, a

Figure 1 Laparoscopic proximal gastrectomy with double tract reconstruction (5).
Available online: http://www.asvide.com/articles/1482

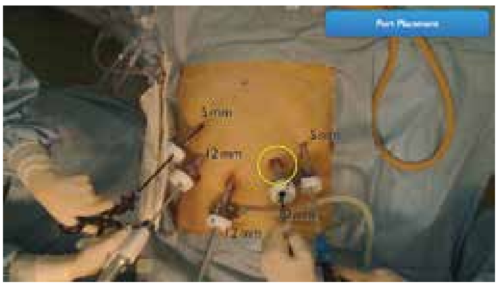

Figure 2 Port placement for laparoscopic proximal gastrectomy with double tract reconstruction.

procedure that included laparoscopic proximal gastrectomy followed by double tract reconstruction has been developed to reduce the risks of reflux esophagitis.

Patient selection and workup

All patients are evaluated by gastroscopy and computed tomography preoperatively. Patients are indicated for laparoscopic proximal gastrectomy if they have a single lesion located in the proximal stomach (upper one third) and confined to the mucosa or submucosa (cT1a or T1b); if there is no evidence of metastatic enlarged lymph nodes (LNs) in LN areas 4d, 5, 6, and, 10 and of distant metastases; and if the lesion is beyond the absolute indications for endoscopic submucosal dissection.

Preoperative preparation

Endoscopic clipping at the proximal and distal sides of the lesion is recommended to determine the resection line of the stomach.

Figure 3 Left gastroepiploic vessel ligation.

Procedure (*Figure 1*)

Laparoscopic proximal gastrectomy

The patient is placed in the reverse Trendelenburg position under general anesthesia. The operator and laparoscopist stand on the right side of the patient, and the first assistant on the left side. Five working ports are created: a 12 mm umbilical port; 5 mm right and left ports along the mid-axillary line below the costal margin; and 12 mm right and left ports along the mid-clavicular line 2 cm above the umbilicus (*Figure 2*). A combined suture technique is used to lift the falciform ligament and the left lobe of the liver. The operator starts partial omentectomy from the middle of the transverse colon, about 4 cm from the gastroepiploic vessel arcade, continuing toward the spleen. The left gastroepiploic artery and vein are ligated at their roots using hemoclips, but at positions distal to the splenic branch to prevent infarct of the lower pole of the spleen (*Figure 3*). The short gastric artery and veins are ligated and cut as much as possible (*Figure 4*), a procedure that includes dissection of LN stations 4sb and 4sa. The omentectomy is continued toward the right side of the patient, up to the transitional zone of LN stations 4d and 6, taking care to preserve the right gastroepiploic artery and vein. The peritoneum is detached along the upper border of the pancreas to mobilize the distal stomach. On the lesser curvature of the stomach, the operator identifies the boundary between LNs 3a (located along the branches of the left gastric artery) and 3b (located along the second

Figure 4 Short gastric vessel ligation.

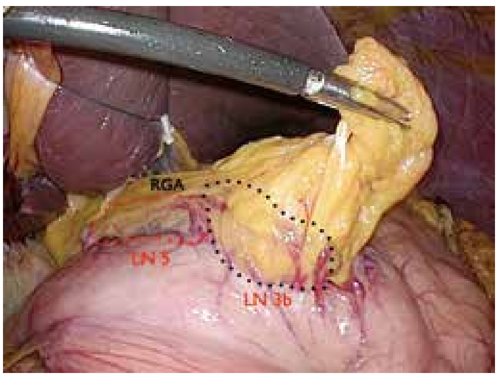

Figure 5 Lymph node station 3b.

branch and distal part of the right gastric artery). LN 3a should be dissected, while LN 3b should be preserved (*Figure 5*). The pyloric and hepatic branches are usually preserved to prevent delayed gastric emptying. The stomach is transected at this time or later, depending on tumor location. If the tumor is located in the cardia, the stomach should be transected before the celiac axis LNs are dissected, thereby exposing the operative field for LN dissection. If the tumor is located in the high body, however, extracorporeal transection may be possible after palpating the preoperative endoscopic clip. LNs 7, 8a, and 9 are dissected, during which the coronary vein and left gastric artery are ligated and cut (*Figure 6*). The operator continues to dissect LN 11p along the splenic artery and vein up to the splenic hilum, including LN 11d at the distal splenic artery. The esophagogastric junction is exposed, and LNs 1 and 2 are dissected. If the tumor has invaded the esophagus, as in Siewert type II gastroesophageal junction cancer, lower

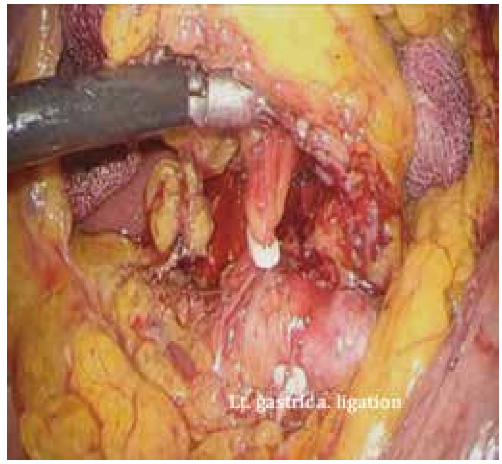

Figure 6 Left gastric artery ligation.

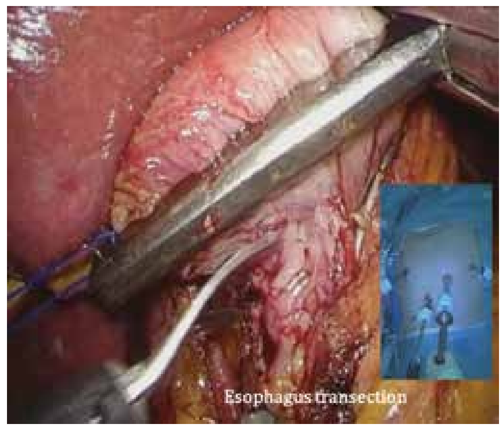

Figure 7 Esophageal transection.

mediastinal LN dissection should be performed. The distal esophagus is transected using linear staplers or proximal (LapJack; Eterne, Seoul, Korea) and distal (Endo-bulldog; B. Braun Melsungen AG, Melsungen, Germany) laparoscopic purse-string clamps, which are applied to prevent spillage from the stomach (*Figure 7*). If circular staples are used, purse-string sutures are made using a straight needle with prolene 2-0. LN 2 and any remaining LNs in area 4sa are dissected in a downstream manner. A 4 cm mini-laparotomy is made by extending the left 12 mm trocar site, followed by extraction of the resected specimen if the stomach had already been transected. Alternatively, the upper and middle parts of the stomach are obtained, followed by checking the distal resection margin with clips and transection of the stomach with linear staplers (*Figure 8*).

Figure 8 Transection of the distal stomach.

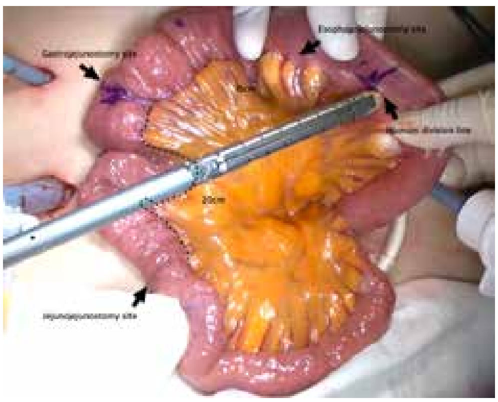

Figure 9 Markings showing the sites for esophagojejunostomy, gastrojejunostomy, and jejunojejunostomy.

Reconstructions

Direct esophagogastrostomy

Although easy to perform, direct esophagogastrostomy may induce severe esophageal reflux in some patients. Adjunct procedures to enhance the safety of direct esophagogastrostomy include antireflux procedures, overlap anastomosis, and preservation of the lower esophageal sphincter (6-8).

Jejunal interposition

Jejunal interposition is relatively complex compared with direct esophagogastrostomy or double tract reconstruction. This procedure requires the construction of a pedicle

Figure 10 Jejunojejunostomy.

of the jejunal limb and three anastomoses including an esophagojejunostomy, a jejunogastrostomy, and a jejunojejunostomy (9-11).

Double tract reconstruction

After transection of the stomach, a single stitch is made on the fusion stapler line of the remnant stomach and the latter is put back into the abdominal cavity. The anvil of the circular stapler is introduced into the abdominal cavity through mini-laparotomy, followed by pneumoperitoneum. Using a laparoscopic anvil clamp, the operator inserts the anvil head into the esophageal stump intracorporeally and ties the purse-string sutures (12). Subsequently, the jejunum is pulled out via the mini-laparotomy and the operator marks the sites of esophagojejunostomy, gastrojejunostomy, and jejunojejunostomy (*Figure 9*). The order of the anastomoses depends on the surgeon's preference. Using linear staplers, the jejunum is transected, and a side-to-side jejunojejunostomy is created 20 cm distal from the gastrojejunostomy (*Figure 10*). The jejunojejunal mesenteric defect is closed to prevent internal herniation of the small bowel. A side-to-side gastrojejunostomy 15 cm distal to the esophagojejunostomy is made in an extracorporeal manner using a linear stapler. The linear stapler is inserted into the posterior wall of the stomach and the Roux limb (*Figure 11*). A circular stapler is subsequently inserted into the Roux limb, and an end-to-side esophagojejunostomy is made intracorporeally (*Figure 12*). The jejunal stump is closed with a linear stapler, completing all three anastomoses (*Figures 13-15*).

Figure 11 Gastrojejunostomy.

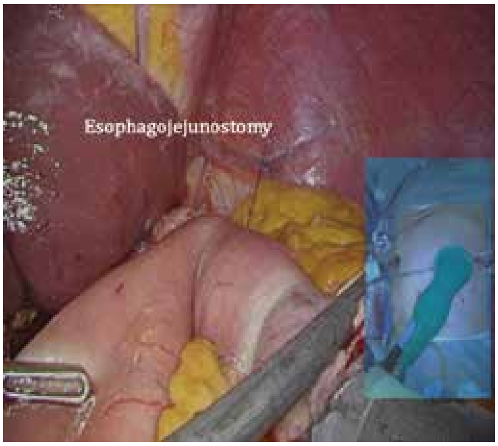

Figure 12 Esophagojejunostomy.

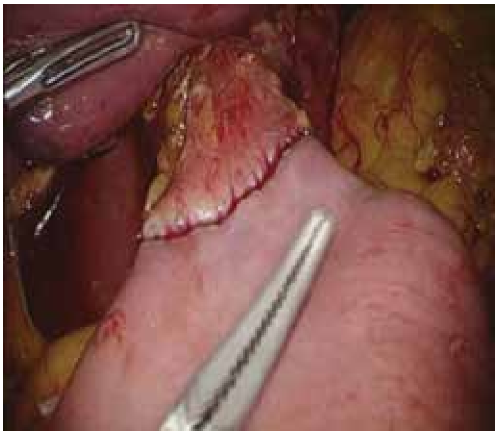

Figure 13 Completion of esophagojejunostomy.

Figure 14 Completion of gastrojejunostomy.

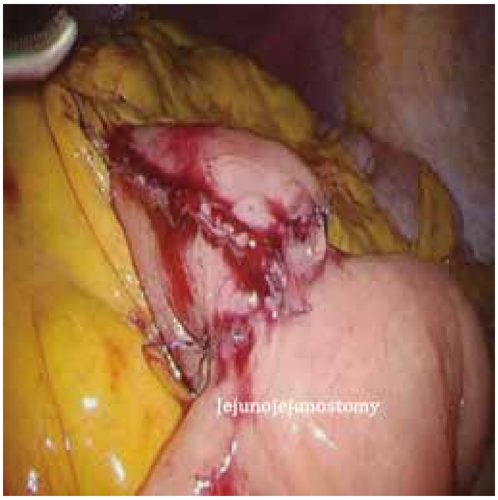

Figure 15 Completion of jejunojejunostomy.

Role of team members

Each surgical team consists of an operator, a first assistant, and a laparoscopist. If reduced or single port laparoscopic proximal gastrectomy is feasible, the first assistant or laparoscopist may be replaced by a scope holder.

Postoperative management

Patients are allowed sips of water, a semi-liquid diet, and a soft blended diet on postoperative days 2, 3, and 4, respectively, followed by removal of the J-P drain. Patients are usually discharged from the hospital on postoperative day 5 or 6, unless they experience fever, abdominal pain, or abnormal laboratory test results.

Tips, tricks, and pitfalls

The 2014 Japanese Gastric Cancer Treatment Guidelines (ver. 4) recommend that patients with proximal tumors undergo proximal gastrectomy when more than half the distal stomach can be preserved (13). Transection of the stomach at the junction of LNs 3a and 3b can result in preservation of more than half the distal stomach.

The Korean Laparoendoscopic Gastrointestinal Surgery Study (KLASS) 05: phase III multicenter prospective randomized clinical trial of laparoscopic proximal gastrectomy with double tract reconstruction and laparoscopic total gastrectomy for upper early gastric cancer.

Although laparoscopic proximal gastrectomy with double tract reconstruction was reported to be superior to laparoscopic total gastrectomy in patients with upper third early gastric cancer, these findings were based on retrospective results. To our knowledge, no prospective randomized controlled trial has compared these outcomes. We therefore designed KLASS-05, a randomized clinical trial comparing laparoscopic proximal gastrectomy plus double tract reconstruction with laparoscopic total gastrectomy alone. The results of KLASS-05 may help surgeons determine the optimal surgical strategy for patients with proximal early gastric cancer.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Uncut Roux-en-Y reconstruction after totally laparoscopic distal gastrectomy with D2 lymph node dissection for early stage gastric cancer

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Contributions: (I) Conception and design: All authors; (II) Administrative support: None; (III) Provision of study materials or patients: H Huang; (IV) Collection and assembly of data: Z Long; (V) Data analysis and interpretation: H Huang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: Roux Stasis Syndrome is a well-known complication after Roux-en-Y reconstruction. Uncut Roux-en-Y technique, would preserve unidirectional intestinal myoelectrical activity and diminish Roux Stasis Syndrome.

Methods: A 61 years old woman with moderately differentiated adenocarcinoma of antrum who was diagnosed by gastroscopy and histological test, underwent totally laparoscopic distal gastrectomy (TLDG) with D2 lymph node dissection and uncut Roux-en-Y reconstruction (URYR).

Results: The length of operation was 190 min with bleeding of about 40 mL. The patient recovers well postoperation and discharged from hospital on the 7th day.

Conclusions: TLDG with intracorporeal uncut Roux-en-Y gastrojejunostomies using laparoscopic linear staplers was safe and feasible with minimal invasiveness.

Keywords: Totally laparoscopic distal gastrectomy (TLDG); uncut Roux-en-Y reconstruction (URYR); minimal invasiveness

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Introduction

Intracorporeal uncut Roux-en-Y anastomosis is the most difficult procedure during distal gastrectomy. We successfully performed totally laparoscopic distal gastrectomy (TLDG) uncut Roux-en-Y gastrojejunostomies. Here we describe our technique.

Methods

Patient selection and workup

Early stage gastric cancer patients are fit for totally laparoscopic uncut Roux-en-Y gastrojejunostomy after distal gastrectomy. In the present video (*Figure 1*), the patient is a 61 years old woman who was diagnosed moderately differentiated adenocarcinoma of antrum by gastroscopy and histological test (*Figure 2*). The tumor stage was assessed to be cT1N0M0 by CT scan preoperation and EUS (*Figures 3*,*4*).

Pre-operative preparation

Before the day of the operation, endoscopy was performed again in order to confirm the exact location of the tumorand we marked the location of the tumor with nano carbon on the gastric wall.

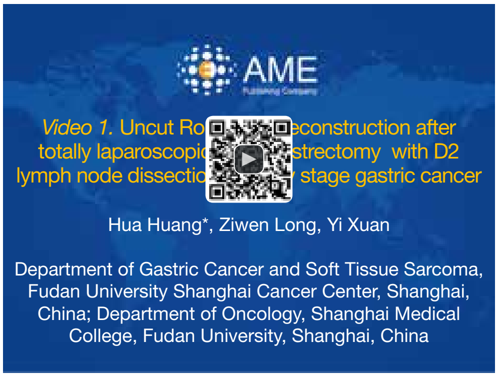

Figure 1 Uncut Roux-en-Y reconstruction after totally laparoscopic distal gastrectomy with D2 lymph node dissection for early stage gastric cancer (1).
Available online: http://www.asvide.com/articles/752

Figure 2 Gastroscopy.

Figure 3 Abdominal CT scan.

Figure 4 Endoscopic ultrasonography.

Equipment preference card

Olympus OVT-s190. EC60A: Ethicon, Cincinnati, OH, USA. NK ATS45NK: linear cutter without a knife; Ethicon, Cincinnati, OH, USA.

Procedure

Under general anesthesia, the patient was placed horizontal position with legs apart. A 20° head-up tilt was applied. The surgeon was positioned on the left side of the patient, with the camera operator between the legs and the first assistant on the right side of the patient. An 12-mm trocar for a 30° camera was inserted below the umbilicus, the other four trocars then were inserted: three 12-mm trocars into the right and left midabdomen and left upper abdomen, and one 5-mm trocar into the right. After D2 lymph nodes dissection, duodenal transection was performed with a linear stapler (Ethicon Endo-Surgery, Cincinnati, OH, USA). The stomach was resected by two firings of a linear stapler, and the resected specimen was placed in a plastic bag. The specimen was then extracted from the abdomen through the trocar about 4 cm in size around the umbilicus (*Figure 5*).

In intracorporeal reconstruction, gastrojejunostomy was performed at a point 40 cm distal to the Teritz ligament. The enterotomy for insertion of the linear stapler was made on the afferent loop. A Braun anastomosis was performed using a linear stapler 20 cm distal to the gastrojejunostomy. In-continuity stapling with a blue cartridge on a no-knife linear stapler (Ethicon EndSurgery, Cincinnati, OH, USA) was performed on the afferent loop below 10 cm of the gastrojejunostomy.

Figure 5 Surgical incision.

Post-operative management

Antibiotic prophylaxis for 3 days post-operative. Drink liquid diet from 3 days post-operative.

Tips, tricks and pitfalls

In intracorporeal gastrojejunostomy must be performed through the right-lower trocar.

In intracorporeal gastrojejunostomy, the enterotomy for insertion of the linear stapler must be made on the afferent loop. If be made on the efferent loop, can cause stricture of the efferent loop when closing the common entry hole.

Results

It took about 190 min to finish the whole operation with bleeding of about 40 mL. The pathology outcome after the surgery show it the moderately differentiated adenocarcinoma staging T1N0M0 with 0/36 lymph nodes positive. The patient recovered well postoperation and discharged from hospital without any significant complication on the 7th day.

Discussion

The Roux-en-Y gastrojejunostomy is currently considered a valid reconstruction method after distal gastrectomy for gastric cancer (2,3). Roux Stasis Syndrome is a well-known complication after Roux-en-Y reconstruction (4). This syndrome is due to motor incoordination in the intestinal folds, originating from ectopic pacemakers, because the intestine is isolated from its natural pacemakers located in the duodenum, which produces a reflux towards the gastric stump (5). Uncut Roux-en-Y technique, would preserve unidirectional intestinal myoelectrical activity and diminish Roux Stasis Syndrome (6).

Totally laparoscopic gastrectomy (TLG) has been proved to be safe and effective (7). It has so many advantages associated with TLG. In TLG, the whole anastomotic procedure can be clearly viewed, so such tension and injuries can be obviated, especially in an obese patient (8). However, the disadvantages of TLG include it is difficult in intraoperative localization of the tumor, and additional costs for using many linear stapler cartridges. Early gastric cancer is not visible or palpable from outside of the stomach, which makes the localization of the tumor very difficult during TLG. We overcame this problem by having endoscopy before the day of the operation again in order to confirm the exact location of the tumor and we marked the location of the tumor with nano carbon on the gastric wall. Most important one is intracorporeal uncut Roux-en-Y anastomosis is the most difficult procedure during distal gastrectomy. It should be on the base of rich experiences of laparoscopy surgical techniques. It had better be performed by the experienced surgeon.

Conclusions

In conclusion, TLDG with intracorporeal uncut Roux-en-Y anastomosis using laparoscopic linear staplers was found to be safe and feasible. We consider that our operation may represent the best option for reconstructions after laparoscopic distal gastrectomy.

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Ethical Statement: The study was approved by the institutional ethical committee. Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Clinical research of totally laparoscopic modified Roux-en-Y reconstruction

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Background: To evaluate the clinical efficacy of improved Roux-en-Y reconstruction after Totally laparoscopic total gastrectomy (LTG) for gastric cancer.

Methods: Clinical data of 36 patients who underwent totally laparoscopic total gastrectomy with intracorporeal Roux-en-Y reconstruction for gastric cancer with complete follow-up data between January 2014 and December 2014 in the Second Hospital of Jilin University. Patients were divided into modified Roux-en-Y group (MRY 20 cases), classic Roux-en-Y group (CRY 16 cases) according to reconstructive methods.

Results: All cases were successfully completed, without conversion to laparotomy. There were no significant differences in lymph nodes harvest, time to flatus, hospital stay and postoperative complications between the two groups. However, the MRY group had shorter mean operative time [(260.9±21.2) *vs.* (287.9±19.0) min, P=0.000], shorter mean reconstruction duration [(32.4±9.2) *vs.* (45.4±13.2) min, P=0.001] and less intraoperative bleeding [(50.9±23.5 *vs.* (67.0±20.5) mL, P=0.000]. The dissection of the mesentery of the jejunum and the jejunum resection were not needed in the MRY group.

Conclusions: The Modified Roux-en-Y reconstruction (MRY) is feasible and safe. It can short the mean operative time, simplify the surgical procedures.

Keywords: Totally laparoscopic surgery; intracorporeal anastomosis; gastric cancer

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Introduction

For more than 20 years, laparoscopic gastric cancer surgery progressed worldwide (1,2), which totally laparoscopic gastric surgery and gastrointestinal tract reconstruction is one of the most complex procedure. The operation team with a higher level of minimally invasive techniques should be needed. Types of laparoscopic gastrointestinal tract reconstruction after total gastrectomy are various, mainly includes the application of the circular anastomosis and the linear anastomosis (3). The most common used for laparoscopic digestive tract reconstruction after total gastrectomy is Roux-en-Y anastomosis, which is nearly the same procedure as the open surgery to dissect a loop of intestine with blood arch. It's important to simplify this procedure because the small intestine mesentery dissected totally laparoscopically is inconvenient. Based on the traditional Roux-en-Y anastomosis modified, without small intestinal mesentery dissection, the Roux-en-Y anastomosis can be completely performed. Comparing the classic and modified Roux-en-Y anastomosis, a simple technique should be valued for

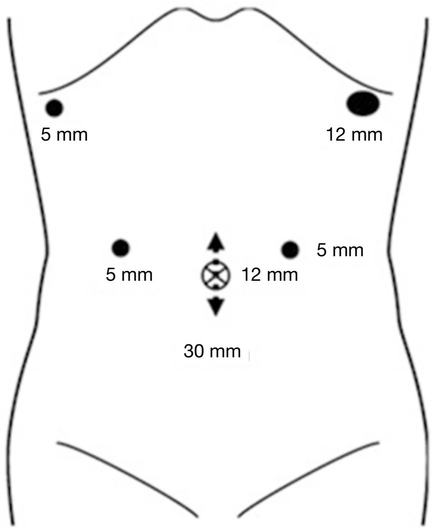

Figure 1 Location of the five trocars. The infraumbilical trocar is used for the insertion of a laparoscope. Two trocars are added to the right and left abdomen, respectively. The infraumbilical trocar is extended to 3–5 cm for the specimen retrieved.

the totally laparoscopic gastrointestinal tract reconstruction after total gastrectomy.

Methods

Patients

We retrospectively reviewed the medical records of 36 patients who underwent totally laparoscopic total gastrectomy (TLTG) with Roux-en-Y reconstruction in the second hospital of Jilin University between January 2014 and December 2014. There were 21 males and 15 females. The indication of TLTG included the patients with gastric adenocarcinoma located on the upper, upper to middle, or entire stomach, who were tested by endoscopy and abdominal CT scan. All operations were performed by one team of surgeon. All of the patients provided written informed consent to participate in the study. This study is also approved by the Ethics Committee of the Second Hospital of Jilin University.

Surgical technique

Under general anesthesia, the patient was placed in the supine position split with legs and the camera operator standing between. The chief surgeon was positioned on the left side of the patient and the first assistant on the right side of the patient during stomach mobilization and lymph nodes dissection. Five trocars were inserted as showed in *Figure 1*. After stomach mobilization and lymph nodes dissection, the esophagus and duodenal should be transected with an endoscopic linear. The resected specimen were placed in a plastic specimen bag and retrieved through the umbilical trocar extended incision (*Figure 1*). Then the pneumoperitoneum was re-established by suturing the umbilical incision to the size of the trocar, the surgeon and the first assistant switched their positions for the later gastrointestinal tract reconstruction as needed.

Figure 2 Laparoscopic classic Roux-en-Y reconstruction, dissection of the small bowel mesentery.

Laparoscopic classic Roux-en-Y reconstruction (CRY): 16 cases

First, the dissection of the mesentery was created (*Figure 2*), then the jejunum was transected 15–20 cm distal to the Treitz's ligament by using an endoscopic linear. The distal side of the jejunum (approximately 3–5 cm long) was usually removed avoiding excessive tension and lack of mesenteric blood supply. The side to side esophagojejunostomy was performed at the left side of esophagus by endoscopic linear in an ante-colic fashion (*Figure 2*). In case of false anastomosis, the fork of the linear stapler inserted into the hole of the esophagus was always guided by a nasogastric tube. The entry hole was created after a side-to-side esophagojejunostomy and closed by a continuous hand-sewn technique. At the lumen 40–50 cm distal from the esophagojejunostomy, a side-to-side jejuno-jejunostomy was performed intracorporeally,

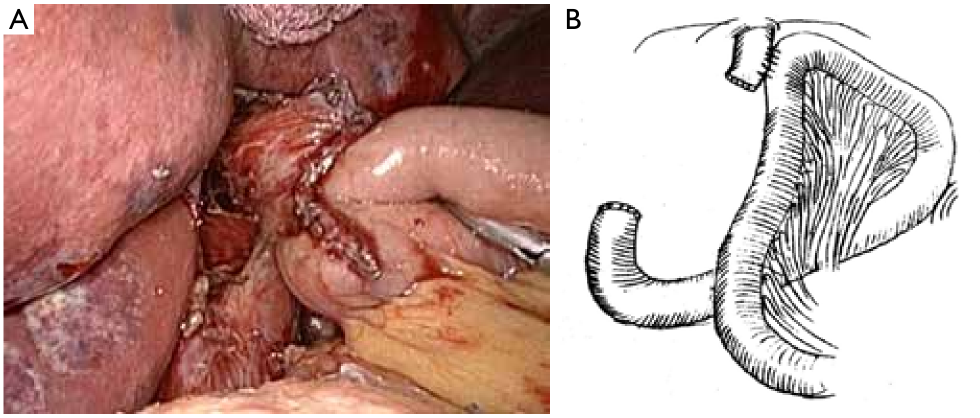

Figure 3 Laparoscopic modified Roux-en-Y reconstruction (MRY): esophagojejunostomy accomplishment. (A) Surgical image; (B) schematic diagram.

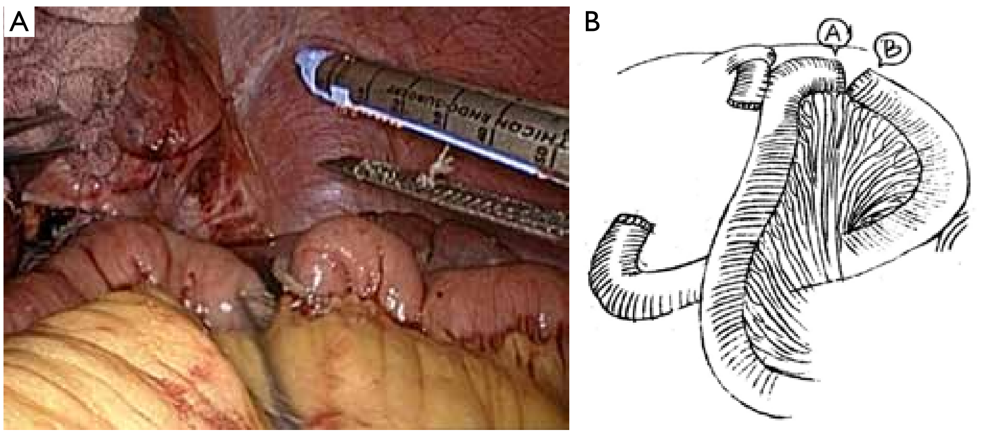

Figure 4 Laparoscopic modified Roux-en-Y reconstruction (MRY): the jejunum distal to the esophagojejunostomy 2–3 cm was intracorporeally transected, the mesentery dissection was not needed. (A) Surgical image; (B) schematic diagram.

and the entry hole was also closed by using a continuous hand-sewn technique.

Laparoscopic modified Roux-en-Y reconstruction (MRY): 20 cases

The side-to-side esophagojejunostomy was performed directly by one fork of the endoscopic stapler inserted into the jejunum 15–20 cm distal to the Treitz's ligament, another fork inserted carefully into the hole of the esophagus guided by nasogastric tube (*Figure 3*). After firing of the stapler converted the two openings into a single entry hole. The entry hole was closed by a continuous hand-sewn technique. The jejunum distal to the esophagojejunostomy 2–3 cm was intracorporeally transected and the mesenteric dissection was not needed (*Figure 4*). A side to side jejuno-jejunostomy was performed as described above (*Figure 5*).

Clinicopathological findings

All the patients information, including gender, age, body mass index (BMI), operative duration, blood loss, number of lymph nodes dissection, pathological findings, and perioperative complications was collected. All values are expressed as means ± standard deviation.

Results

All 36 patients were successfully completed totally laparoscopically, there was no conversion from laparoscopic

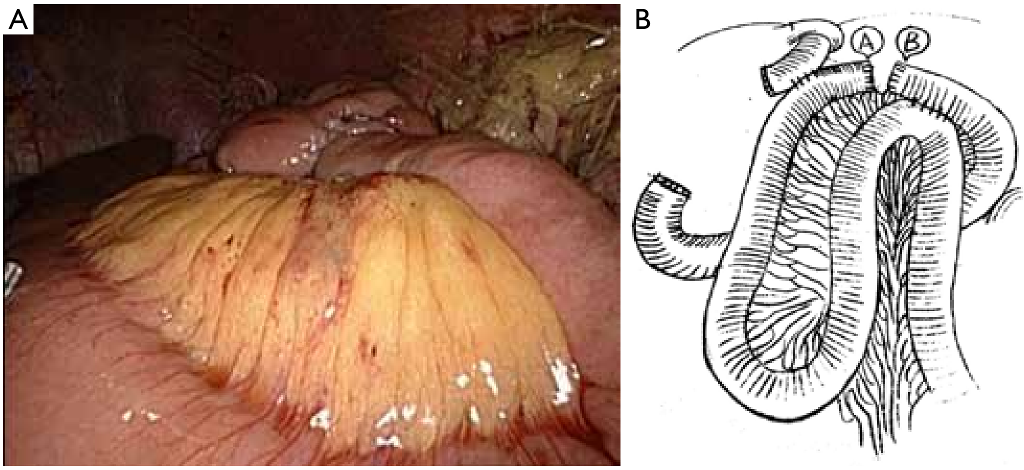

Figure 5 Laparoscopic modified Roux-en-Y reconstruction (MRY) accomplishment. (A) Surgical image; (B) schematic diagram.

Table 1 Clinicopathologic findings of patients with gastrectomy

Characteristic	MRY (n=20)	CRY (n=16)	P value
Age (years)	57.4±10.3	56.7±11.9	0.851
Male/female	10/10	10/6	0.517
BMI (kg/m^2)	22.2±2.3	21.9±4.5	0.797
History of abdominal surgery (n)	5 (25.0%)	3 (18.8%)	0.654
Tumor size (cm)	5.2±1.3	4.9±0.7	0.413
TNM stage (n)			0.189
I	2 (10.0%)	1 (6.2%)	
II	6 (30.0%)	4 (25.0%)	
III	12 (60.0%)	11 (68.8%)	

MRY, modified Roux-en-Y reconstruction; CRY, classic Roux-en-Y reconstruction.

surgery to open surgery. *Table 1* shows the clinicopathologic characteristics of the study groups. The age, sex ratio, BMI, history of abdominal surgery, tumor diameter and TNM staging did not differ between the CRY group (20 cases) and MRY group (16 cases).

The perioperative data were summarized in *Table 2*. The operative time was 260.9±21.2 mins in the MRY group and 287.9±19.0 min in the CRY group, and the blood loss was less than the CRY group (50.9±23.5 *vs.* 67.0±20.5 mL; P=0.01). The number of dissected lymph nodes did not differ between the study groups. The Roux-en-Y reconstruction time was 32.4±9.2 min in the MRY group and 45.4±13.2 min in the CRY group. The length of the mesenteric dissection and the removed intestine were 11.6±4.5 and 3.6±2.3 cm in the CRY group. The time to flatus, postoperative hospitalization and the complications did not differ between the study groups.

Discussion

Laparoscopic surgery is widely used for gastric cancer due to its minimal invasiveness. The related technique is always mastered by the experienced surgeons. Totally laparoscopic gastrectomy (TLG), however, is not widely accepted because of its technical difficulty in comparison with laparoscopic assisted gastrectomy (LAG). In particular, the intracorporeal gastrointestinal tract reconstruction after total gastrectomy for gastric cancer is thought to be particularly difficult (4,5). Currently, various methods of intracorporeal gastrointestinal tract reconstruction are normally used and the Roux-en-Y reconstruction accepted widely, which is a method of side-to-side EJ (esophagojejunal) anastomosis using a linear stapler. To overcome the difficulties of intracorporeal esophagojejunostomy and simplify the process, we tried to develop a novel method described here. In this study, the short-time effect did not differ between the MRY group and CRT group.

In 1999, Uyama *et al.* (6) first reported laparoscopic side-to-side anastomosis by the endo linear cutters. As most surgeon preformed, however, the jejunum and the esophagus were transected, the mesentery was dissected

Table 2 perioperative data

Characteristic	MRY (n=20)	CRY (n=20)	P value
Operative time (min)	260.9±21.2	287.9±19.0	0.000
Blood loss (mL)	50.9±23.5	67.0±20.5	0.000
Reconstruction time (min)	32.4±9.2	45.4±13.2	0.001
No. of dissected lymph nodes	33.4±6.5	34.3±8.2	0.715
Length of mesentery dissection (cm)	0	11.6±4.5	0.000
Length of removed intestine (cm)	0	3.6±2.3	0.000
Flatus time (days)	2.8±1.5	3.0±0.9	0.642
Postoperative hospital stay (days)	7.3±4.5	8.1±6.5	0.666
Postoperative complications (n)	3 (15.0)	4 (28.6)	0.783
Ileus	1	1	
Anastomotic leakage	0	1	
Gastrointestinal bleeding	1	1	
Duodenal fistula	0	0	
Incision infection	0	1	
Alkaline reflux gastritis	1	0	

MRY, modified Roux-en-Y reconstruction; CRY, classic Roux-en-Y reconstruction

before the esophagojejunal anastomosis. In recent years, with the development of the laparoscopic instruments and skills, various of the gastrointestinal tract reconstruction after laparoscopic total gastrectomy performed by the experienced surgeons. Noh *et al.* (7) reported a laparoscopic purse-string suture in the distal esophagus and inserting an anvil, but laparoscopic endo linear anastomosis accepted more widely, such as Billoth I delta anastomosis and Roux-en-Y uncut anastomosis (3,8,9). Roux-en-Y anastomosis is usually used after total gastrectomy, various of modified Roux-en-Y anastomosis appeared in the recent year. At the beginning, the mini-incision was prepared by the surgeon for the reconstruction, but it was complicated as the larger incision, blur surgical vision and more blood for the fat patients, so the recent studies suggested that intracorporeal anastomosis is more benefit than extracorporeal anastomosis. In 2009, Okabe *et al.* (10) reported a new technique to fulfill the intracorporeal linear-stapled esophagojejunal anastomosis, which can be performed safely and easily. The entire procedure was performed totally under laparoscopy, the method could be applied easily to obese patients. They also made some improvement: linear stapled esophagojejunostomy in the left side cause of sufficient free work space, insertion of an endoscopic linear fork into the true lumen of the esophagus guided by nasogastric tube. Inaba *et al.* (11) also previously reported the intracorporeal esophagojejunostomy by functional end-to-end anastomosis using an endoscopic linear stapler. In 2013, Shim and his teammates (12) summarized various types of anastomosis after LTG and evaluated the postoperative surgical outcomes according to their four types of anastomosis. Each study described the mesentery should be dissected and the jejunum should be transected for the Roux-en Y anastomosis (13). As far as we know, this is the first report that mesenteric does not need to be dissected for the Roux-en Y anastomosis after LTG.

At the beginning of the study, we performed this modified Roux-en Y anastomosis for the open surgery after the total gastrectomy. We started to perform the intracorporeal anastomosis after the learning curve completed and the laparoscopic techniques developed. This modified Roux-en Y anastomosis has several advantages: (I) shorten the reconstruction time to shorten the operation time; (II) the dissection of the mesentery of the jejunum and the jejunum resection were not needed; (III) no stitches were made to close the dissected mesentery. As compared with the classic Rou-en-Y anastomosis, the modified group is associated with the same short-term clinical outcomes. With all these modifications, our new procedure could become one of the simple, economic, feasible and safe procedures for intracorporeal gastrointestinal tract reconstruction after LTG.

However, further clinical and randomized controlled trials are needed to evaluate its long-term effects. This study was limited by its small patient population. To launch this new method, an experienced laparoscopic work team should be necessary.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: All of the patients provided written informed consent to participate in the study. This study is also approved by the Ethics Committee of the Second Hospital of Jilin University.

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Morphological and functional reconstruction of the esophago-gastric junction with a double-flap technique after laparoscopic proximal gastrectomy

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Contributions: (I) Conception and design: S Nunobe; (II) Administrative support: N Hiki; (III) Provision of study materials or patients: S Nunobe, N Hiki; (IV) Collection and assembly of data: S Nunobe, M Hayami; (V) Data analysis and interpretation: M Hayami; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: Esophagogastrostomy is frequently used as a reconstructive method following proximal gastrectomy, and although a safe and straightforward procedure, it may sometimes be accompanied by gastric reflux. Consequently, a standard method for reconstruction after proximal gastrectomy has yet to be established.

Methods: Esophagogastrostomy with a double-door valve was performed after laparoscopic proximal gastrectomy on 50 patients in the Department of Gastroenterological Surgery at the Cancer Institute Ariake Hospital, Tokyo, Japan, from January 2013 to December 2014. This new anastomotic procedure designed to reproduce the esophago-gastric junction (EGJ) consists of two parts: (I) a hand-sewing technique to render the anastomosis soft and flexible; and (II) a double-door valve to prevent the regurgitation of gastric content.

Results: The average operation time and estimated blood loss during LAPG using the described double-door technique was 388.9±10.8 min and 89.4±15.3 mL, respectively. None of the patients required conversion to open surgery, and no anastomotic leakage occurred in this study. Only one patient (2%) developed postoperative reflux-esophagitis exceeding grade B by the Los Angeles Classification, while two patients (4%) who developed stenosis of the esophagogastric anastomosis needed endoscopic balloon dilatation of an anastomotic stricture, 3 and 8 months after surgery, respectively.

Conclusions: The double-flap technique after laparoscopic proximal gastrectomy was safely and feasibly performed although long operation time. Future studies are now warranted to evaluate long-term quality of life following this procedure.

Keywords: Laparoscopic proximal gastrectomy; reflux-preventing; esophagogastrostomy; valvuloplasty

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Introduction

Proximal gastrectomy for gastric cancer at the upper stomach or the esophagogastric junction (EGJ) is a popular procedure for function-preserving gastrectomy. Various attempts have been made to prevent regurgitation during esophagogastric reconstructions after proximal gastrectomy including jejunal interposition, the double-tract method, and esophagogastrostomy.

Esophagogastrostomy is frequently used for reconstructions following proximal gastrectomy because of its simplicity. However, while this procedure is safe and straightforward, it is sometimes accompanied by severe reflux of the gastric contents or bile acid. Several

Table 1 Characteristics of patients undergoing laparoscopic proximal gastrectomy (n=50)

Characteristics	n (%)
Age (years)	65.2±2.0 [30–89]
Gender (male/female)	33 (66.0)/17 (34.0)
BMI (kg/m^2)	24.0±3.3 (18.2–36.2)
ASA-PS (1/2/3)	20/14/0
Previous abdominal operation	5 (14.7)
Tumor type (adenocarcinoma/ submucosal tumor)	45 (90.0)/5 (10.0)
Tumor size (mm)	
Adenocarcinoma	29.5±13.4 [10–70]
Submucosal tumor	29.5±13.4 [10–70]

Means ± SE.

investigators have tried to prevent such regurgitation after esophagogastrostomy, which exhibited the valvular ability for anti-reflux by the intra-gastric pressure (1,2); however, none has achieved a reflux-free esophagogastric anastomosis, and a standard method of reconstruction after proximal gastrectomy has yet to be established.

Kamikawa *et al.* recently developed a reflux-free reconstruction technique involving two main parts: a hand-sewn esophagogastric anastomosis designed to be soft and flexible, and a double-door valve to prevent the regurgitation of gastric contents (in described Japanese literature). Recently Kuroda *et al.* reported the paper of the technique applied to the laparoscopic procedure (3). For the present study, we applied this new anastomotic technique for cases requiring laparoscopic proximal gastrectomy (LAPG) with totally intracorporeal anastomosis, and herein present this novel reflux-preventing technique with video.

Patient selection and workup

Esophagogastrostomy using a double-door valve after LAPG was performed on 50 patients [45 patients with epithelial neoplasms including 43 gastric cancer and 2 carcinoids, and 5 patients with gastric submucosal tumor (SMT)] treated by the Department of Gastroenterological Surgery at the Cancer Institute Ariake Hospital, Tokyo, Japan, from January 2013 to December 2014 (*Table 1*). This valvuloplasty method involving a small incision at the upper abdominal wall was introduced at our institute in 2009 for the treatment of gastric cancer and is only carried out by experienced surgeons. All gastric cancers and carcinoids in this study were classified histologically as adenocarcinomas or neuroendocrine tumors that had invaded only the mucosa or submucosa of the stomach without lymph node metastasis (cT1, cN0). Gastric SMTs were diagnosed as gastrointestinal tumors of 2 cm or more in size.

LAPG was indicated if the tumor was located in the upper third of the stomach or if gastric SMT was detected at the EGJ. We evaluated tumor location and the depth of tumor invasion on the basis of endoscopy results, an upper gastrointestinal series, and endoscopic ultrasonography. Distant metastases were evaluated by abdominal ultrasonography and computed tomography. Patients treated by this procedure had early gastric cancer with extra indication of endoscopic resection, such as patients with submucosal cancer or mucosal cancer that was histologically confirmed as a poorly differentiated adenocarcinoma of 2 cm or more in size. Some patients with gastric SMT at the EGJ such as those with tumors <2 cm in size were treated by laparoscopic local resection with preservation of cardiac function.

Pre-operative preparation

(I) Lesion locations were preoperatively confirmed by endoscopic marking and an upper gastrointestinal series. A negative biopsy was collected at this time to enhance stump safety. Due to the particular difficulty in confirming the location of a lesion in early gastric cancer, the laparoscopic surgery was combined with tattoo marking. Marking was also performed on the oral side in cases where the lesion had spread to the esophageal side.

(II) LAPG is a technique prone to gastric cancer remnants not being detected, thus lesions on the pyloric side of the remnant stomach were carefully scrutinized.

Equipment preference card

For lymph node dissection, ultrasonic coagulating scissors was preferentially used. During the present procedure, staplers were used only for the division for the stomach and esophagus, however, the anastomosis was made by hand-sewn procedure to keep the softness of the anastomosis site.

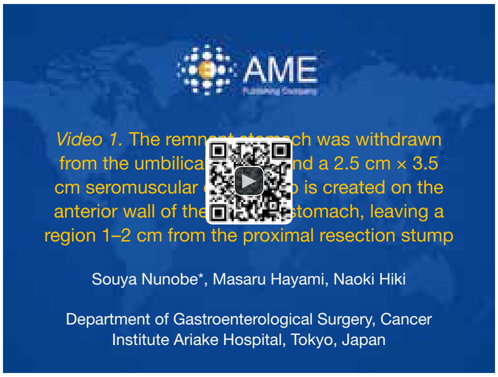

Figure 1 The remnant stomach was withdrawn from the umbilical incision and a 2.5 cm × 3.5 cm seromuscular double-flap is created on the anterior wall of the remnant stomach, leaving a region 1–2 cm from the proximal resection stump (5). Anastomosis is performed under laparoscopic guidance thereafter at the lower edge of the dissected surface. Continuous sutures are applied through all layers of the posterior esophageal wall and the mucosa of the remnant stomach flap detachment surface. On the anterior wall, the esophagus and gastric wall at the lower end of the flap detachment surface is anastomosed layer-by-layer using interrupted sutures. To finish, the flap is positioned so that it covers the anastomosis site in a Y-shape, with the midline first anchored so that the flap covers the widest possible area.
Available online: http://www.asvide.com/articles/1351

Procedure

Anesthesia and position

Epidural anesthesia was combined with general anesthesia for the patients in this study. The position of the body was the same as that used during routine laparoscopic surgery; the patient was placed in the supine position with legs apart and resting on levitators. Five ports on a reverse trapezoid were used; however, because pyloric lymph node dissection was not necessary, the port to the bottom right of the patient was best placed closer to the medial cranial side to better enable dissection of the upper edge of the pancreas and around the cardiac orifice, particularly on the left side.

Lymph node dissection

The range of lymph node dissection was determined in accordance with the "Japanese Gastric Cancer Treatment Guidelines (May 2015 revision "For Doctors", ver. 4)", thus lymph node dissection ranges were stipulated for each procedure. A dissection range of D1+: No. 1, 2, 3a, 4sa, 4sb, 7, 8a, 9, 11p is considered valid for LAPG in the case of early gastric cancer (4). Carcinoid tumors were also treated as for epithelial neoplasms, according to the strategy for early gastric cancers. Lymph flow along the posterior gastric artery was considered particularly important in upper gastric cancer, and thus No. 11p was properly dissected along the splenic artery up to the periphery of the posterior gastric arterial root.

The hepatic branch and peripheral pyloric branches of the anterior branch of the vagus nerve were preserved, and if possible, so was the celiac branch, which is the main branch of the posterior vagal trunk.

Division of the distal side of the stomach

After lymph node dissection was complete, the stomach was divided. The dividing line on the distal side was to the oral side of the line demarcating the left and right gastroepiploic arteries and veins. As much remnant stomach as possible was left by checking the preoperatively placed endoscopic markings. The #4sb lymph node was also placed on the resection side, after which the stomach was separated from the greater curvature using a stapler device 2–3 times.

Dissection of the esophagus

In patients without esophageal invasion, dissection was performed on the esophageal side using the EGJ. In patients with esophageal invasion, dissection was performed 2 cm to the oral side of the preoperative markings. Once the portion to be separated was determined, markings were made with blue dye at the dividing position of the esophagus.

Esophagogastrostomy with double-door technique (video-guided) (Figure 1)

The remnant stomach was withdrawn from the umbilical incision and a 2.5 cm × 3.5 cm seromuscular double-flap was created on the anterior wall of the remnant stomach, leaving a region 1–2 cm from the proximal resection stump (*Figure 2*). This procedure was performed carefully while cautiously stopping bleeding using an electric scalpel to prevent damage to the flap. The lower edge of the dissected surface was the portion to undergo anastomosis. Afterwards, the remnant stomach was returned to the peritoneal cavity and the peritoneum was re-inflated. Anastomosis was performed under laparoscopic guidance thereafter. First, the upper end of the flap was sutured to the posterior

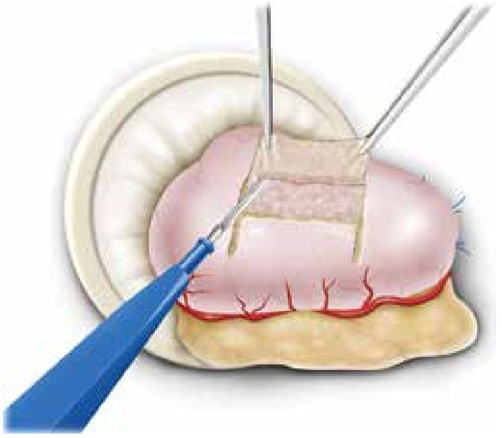

Figure 2 The remnant stomach is withdrawn from the umbilical incision and a 2.5 cm × 3.5 cm seromuscular double-flap is created on the anterior wall of the remnant stomach.

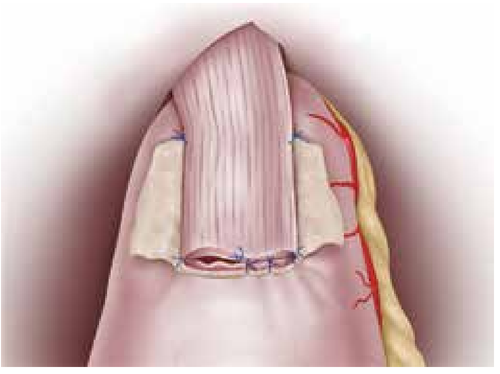

Figure 3 Esophago-gastrostomy is created at the lower board of the flap. In doing so, the lower end of the esophagus is ultimately embedded within the stomach wall over a distance of 3–4 cm.

wall of the esophagus, usually with four stitches. The flap was then fixed 5 cm to the oral side of the portion of the esophagus intended for dissection while pulling up the esophagus stump. In doing so, the lower end of the esophagus was ultimately embedded within the stomach wall over a distance of 3–4 cm. Once the esophagus and stomach were secured, subsequent anastomosis became easier. After esophageal stump dissection, 3–4 interrupted stitches were additionally sutured to prevent misalignment of the membrane of the posterior wall of the esophagus and the outer membrano-muscular layer. This step allowed subsequent full-thickness posterior wall anastomosis to be performed safely without missing the outer membrano-

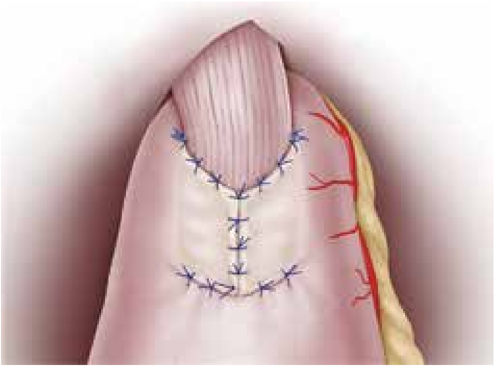

Figure 4 To finish, the flap is positioned so that it covered the anastomosis site in a Y-shape.

muscular layer of the esophagus. Because there is usually a difference in diameter between the esophageal mucosa and gastric anastomosis site, as wide an anastomosis as possible was made to match the diameter of the stomach.

Continuous sutures were applied through all layers of the posterior esophageal wall and the mucosa of the remnant stomach flap detachment surface. Recently, 4-0 barbed sutures have been also used to achieve simultaneously pulling and locking. On the anterior wall, the esophagus and gastric wall at the lower end of the flap detachment surface was anastomosed layer-by-layer using interrupted sutures (*Figure 3*). Intraluminal anastomosis was also performed safely and easily here by using 4-0 barbed sutures. Once the esophageal-stomach anastomosis was complete, the lumen was endoscopically examined for tucks or other problems. To finish, the flap was positioned so that it covered the anastomosis site in a Y-shape, with the midline first anchored so that the flap covered the widest possible area (*Figure 4*). Using interrupted stitches and 4-0 barbed sutures, the flap was then secured successively to the left "collar" portion. After securing the right "collar", the lower end was fixed. The anastomosis site could be widely covered with the flap by suturing the lower end as caudally as possible.

Drain insertion

A closed suction drain with a small diameter was placed below the left diaphragm via the upper right port and via the dorsal side of the anastomosis. This provided information on pancreatic juice leakage at the upper edge of the pancreas and suture failure.

Table 2 Surgical outcomes of patients undergoing laparoscopic proximal gastrectomy (n=50)

Variable	
Operation time (min)	388.9±10.8 [244–590]
Estimated blood loss (mL)	89.4±15.3 [10–670]
Combined cholecystectomy	3 (6.0%)
Conversion to open surgery	0 (0%)
R0 resection (%)	50 (100%)
Morbidity (CD ≥2)	1 (2.0%)
Anastomotic leakage	0 (0%)
Pancreatic fistula	1 (2.0%)
Mortality, n (%)	0 (0%)
Postoperative hospital stay (days)	10.7±4.4 [7–31]

Means ± SE.

Table 3 Postoperative endoscopic findings at 12-month in the patients undergoing proximal gastrectomy

Findings	LPG (n=50)
Reflux esophagitis (LA ≥ grade B)	1 (2.0%)
Anastomotic stricture (CD ≥ grade IIIa)	2 (4.0%)

Role of team members

The double-flap technique by the intra-corporeal hand-sewn technique would be difficult to perform for the team which was familiar with the laparoscopic suturing technique. So the team should regularly use the technique for the other laparoscopic surgery. And during operation, we often use the endoscopy for the confirmation of the location of tumor site and EGJ to keep the adequate tumor margin. So the doctor worked outside should constantly prepare the endoscopy. During the procedure, the assistant should offer the good field of vision around EGJ for the success for the procedure. Especially, the traction of the stomach to the caudal side and the traction of the liver are important. It is also important to decide the types of the thread and the length of the stitch at the each scene for the preparation by the scrub nurse.

Post-operative management

Table 2 summaries the operative and the post-operative data. The average operation time and estimated blood loss during the described LAPG with double-door technique was 388.9±10.8 min and 89.4±15.3 mL, respectively. No patients required conversion to open surgery, and R0 resection was achieved in all cases.

With regard to post-operative complications, pancreatic fistula and intra-abdominal bleeding occurred in the same one patient (2%), and a second patient (2%) received a perforated small intestine due to an intra-operative forceps injury (*Table 2*). No anastomotic leakage occurred in this study, but two patients (4%) who developed stenosis of their esophagogastric anastomosis needed endoscopic balloon dilatation of an anastomotic stricture, 3 and 8 months after surgery, respectively (*Table 3*). The strictures after surgery had healed by 4 and 6 times of endoscopic balloon dilatation, respectively. Only one patient (2%) developed post-operative reflux-esophagitis of more than grade B based on the Los Angeles Classification, and it was successfully treated by administering a proton pump inhibitor to the patient. There was no mortality in the present study.

The endoscopic findings after surgery revealed no esophageal reflux and the anastomosis mimicked normal EGJ formation (*Figure 5A,B*).

The present procedure was safe with few post-operative complication, so it was unnecessary for the specific post-operative management. However, we should pay the attention for the stenosis of the anastomosis during the mid-term after operation.

Tips, tricks and pitfalls

The present method originally developed by Kamikawa *et al.* for cases of conventional open proximal gastrectomy has the benefit of strong reflex prevention in the relevant Japanese literature. In this technique, the backflow valve is embedded between the submucosal layer and the seromuscular flap of the stomach, thus preventing backflow when compressed by resistance from intragastric pressure to the side and the flap from the anterior side. We also successfully applied this reconstruction method during total laparoscopic procedures because hand stitching in the profound place near the hiatus is quite difficult for the open procedure while laparoscopic suturing is relative easy in terms of access at this site. Only one patient in the present study developed reflux to the degree of grade B after surgery, and it improved immediately following administration of a proton pump inhibitor. Severe reflux

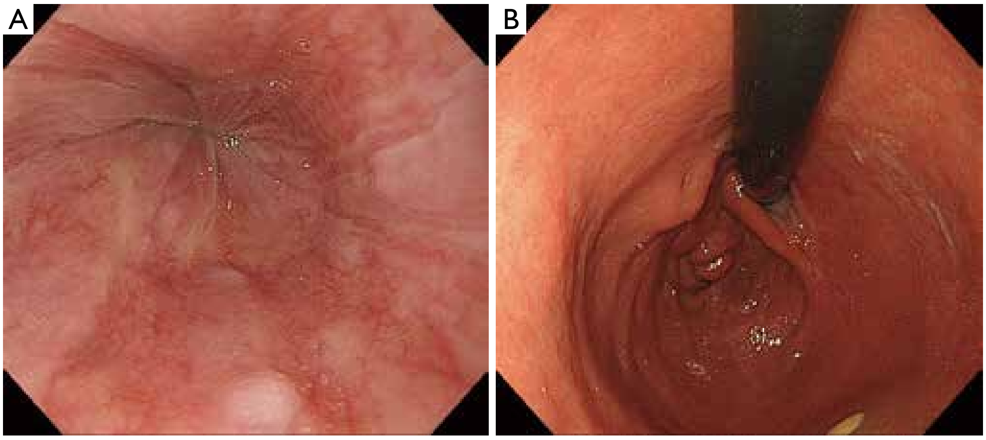

Figure 5 The endoscopic findings after surgery show no esophageal reflux and the mimic normal formation of esophago-gastric junction.

would also be unusual with the present method even in cases undergoing proximal gastrectomy with reconstruction by simple esophagogastrostomy, in which severe esophageal reflux is generally more frequent. Indeed, in such patients, the essential technical component of the present procedure for preventing reflux would be to intentionally fix the lower esophagus between the submucosal layer and the seromuscular flap of the stomach.

Moreover, because the posterior wall of this anastomosis site is composed only of mucosa, there was little constriction during swallowing following the procedure, indicating that the balance between swallowing and antireflux was struck with this post-proximal gastrectomy method of reconstruction. In terms of morphology, the shape of anastomosis was close to that of the original cardiac orifice, which allowed functional and morphological reconstruction of the cardiac orifice. In the present study, two cases developed stricture in the delayed period after surgery, requiring balloon dilatations. Thus, the constructed anastomosis should be made as wide as possible during the procedure to allow the backflow valve to function as intended (i.e., preventing stricture) when compressed by the intragastric pressure from behind the side and the flap on the anterior side.

Another major feature of the present study was the rarity of suture failure because the anastomosis site was covered with a flap, making this procedure extremely safe. While essentially a repetition of simple motions, this procedure is deceptively complex, and the surgeon should be particularly experienced in using a suturing technique under laparoscopy to construct the anastomosis. In addition, without flexibility in hand stitching, the benefits of this procedure could not be reproduced. Reconstruction should therefore be performed patiently without using a stapler after waiting for improvement in the postoperative course, the suturing technique under laparoscopy should be got especially with be particular about the minimally invasive procedure.

There were also limitations to the esophageal dissection carried out as part of the studied procedure. In Japan, the esophagus can be dissected for several centimeters with this procedure using a transhiatal approach (in which case the field of view needs to be ensured via transhiatal left thoracotomy); however, no cases of thoracoscopy have yet been encountered for the present procedure. Nonetheless, indications for esophageal cancer and their utility have already been reported, so we await results involving thoracoscopy (6).

This reconstruction method excelled in striking a balance between swallowing and reflux prevention in a morphologically and functionally successful reformation of the EGJ. Future studies of the procedure should evaluate long-term quality of life.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: Institutional Review Committee has approved the study (No. 2016-1024). Informed consents were obtained by each patient before surgery.

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Postoperative complications of radical dissection for gastric cancer

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Complications of radical gastric resection including complications of stomach resection and lymph node resection related complications. Since the surgical technology and surgical instruments have been improved, the rate of common surgical complications such as anastomotic bleeding, duodenal stump caryoclasis, anastomotic rupture or fistula, postoperative obstruction decreased. Meanwhile the clinical general surgeons are more familiar with the diagnosis and treatment so they pay more attention and are more skillful to handle. Relatively some of the rare complications after radical dissection are more likely to be ignored by clinicians causing misdiagnosis and more difficult to deal with. Therefore it is of great importance to understand rare complications of gastric radical surgery.

Postoperative delayed massive hemorrhage

Early postoperative bleeding of gastric radical resection mainly includes anastomotic bleeding, hemorrhage of abdominal cavity which often occurs within 48 hours after surgery, both may be associated with operating defects during the operation. Most of the early postoperative hemorrhage can be controlled by endoscopy and other conservative treatment. Even for a few arterial bleeding in the abdominal cavity the mentioned treatments are invalid, the exploration surgery has fine prognosis. Gastric postoperative delayed hemorrhage is different from early postoperative intraperitoneal or anastomotic bleeding. The former is a kind of fatal haemorrhage due to the rupture of celiac artery or its branches that often occurs more than 1 week after surgery. The bleeding is always dreadful, accompanied by severe abdominal pain and instable blood circulation. Almost all of the bleedings are arterial, basically all fatal, and the rebleeding afterwards is inescapable.

Our experiences think that pancreatic leakage and abdominal infection are major causes of gastric postoperative delayed hemorrhage, because the intestinal and pancreatic corrosions damage the vascular system of the operation area. Pseudoaneurysm is another important reason for the delayed bleeding. Vascular adventitia can be damaged when performing the VLND. Then the high blood pressure or persistent infection or splenic artery's long-term immersion by the corrosive liquid, pseudoaneurysm can be formed. And the infection of operation area is the major cause of aneurysm rupture and hemorrhage. Common hepatic artery and splenic artery are two vessels most likely to bleed postoperatively. It might be associated with their location and the intestinal and pancreatic corrosions.

Endovascular interventional therapy is a safe, simple, reliable and optimal therapy for delayed hemorrhage of celiac arteries. For the patients with arterial aneurysm, it is the prior method. Theoretically, bleeding faster than 0.5 mL/min can be displayed with arteriography, but there are still 25% angiographies find no hemorrhage. Because sometimes blood clot jams the developer, or the bleeding itself is interrupted, or clotting factors cause vasospasm and then stop the bleeding temporarily. Angiography can increase the positive rate for suspected bleeding when there are active bleedings. For those bleedings that cannot be detected by selective angiography, super selective angiography can clearly find out the cause and bleeding location. If there is no angiographic finding of hemorrhage, it could be difficult to find the bleeding during the operation because of the low blood pressure caused by bleeding and anesthesia. On the one hand, the embolism can create surgical opportunity and on the other hand it can help find bleeding site and help target and vessels, avoiding unnecessary emergency operation. If surgical treatment is applied, due to the long surgical time, the infection, tissue adhesion, exudation and edema make the bleeding vessels inaccessible. Furthermore, peri-pancreatic inflammation, infected, brittle tissue and vessels often lead to unsuccessful suture. Stanching using the forceps blindly can often damage the celiac trunk or hepatic artery and lead to diffuse abdominal infection. So, the timing of surgical exploration should be carefully decided and reoperation brings high morbidity and mortality.

After the interventional embolization of the main branches of the celiac trunk, the hepatic function could be changed and serious biliary complications such as cholangitis, liver abscess, and liver failure would occur. The safety of liver function can not be guaranteed. Before the embolization, the angiography of superior mesenteric artery should be performed in order to ensure whether pancreaticoduodenal artery has mutation. Our experiences suggest that because of the anastomosis, the hepatic function can fluctuate in a short period after the embolization of common hepatic artery or celiac trunk and then recover in a period, but after a period of time will return to normal. Using the vascular stent graft on the one hand will increase the success rate of interventional treatment, on the other hand, it will greatly reduce the damage of liver function caused by celiac trunk embolism.

Postoperative delayed bleeding has a high mortality rate. Although radical dissection of advanced gastric cancer does not lead to postoperative delayed bleeding, it is crucial to prevent the occurrence of complications. For patients with fistula or significantly increased amylase in the drainage fluid, unblocked drainage should be ensured. Timely ultrasonic puncture is a critical factor to ensure the non-bleeding. Interventional embolization can be used as the preferred method to treat delayed bleeding of gastric surgery. Fix the bleeding cause after stopping the bleeding. If CT or ultrasound finds of abdominal effusion or infection, puncture and drainage can be performed to reduce the possibility of repeated hemorrhage. For those who have long-term fever or high WBC after gastric cancer surgery, we should guard against the abdominal infection by early diagnosis and treatment, including ultrasonic examination, complete drainage and antibiotics, prevent the intra-abdominal hemorrhage caused by abdominal infection.

Postoperative infection of peritoneal effusion

Because of the vascularizing dissection during standard radical gastric surgery, the surgical wound is massive, leading to the infiltration or lymph leakage, so there would be an amount of abdominal drainage. The liquid is clean and the amount gradually reduces.

If the drainage tube is not expedited or the abdominal effusion is plentiful and limited, the peritoneal effusion infection may appear. The clinical manifestation could be continuous or repeating fever after surgery or the up-and-down WBC level. Patients may have abdominal pain, abdominal distension, and slow borborygmus recovery and sometimes the borborygmus could be weak or disappear. After excluding complications that probably cause the fever such as anastomotic leakage, infections of deep venous catheter, respiratory tract, and urinary tract, infection of peritoneal effusion should be considered if accompanied with poor drainage or changed characteristics of the drainage. Abdominal ultrasonography can tell the amount and location of the effusion. A small amount of fluid can be controlled by antibiotics. Ultrasound-guiding puncture or catheter drainage is feasible if the amount is massive. Do the bacterial culture and drug sensitivity test in order to select the sensitive antibiotics for the infection.

Postoperative pancreatitis

The standard radical operation of gastric carcinoma needs to strip off the pancreatic capsule and vascularize the superior gastroduodenal artery, the common hepatic artery and the celiac trunk. Superior border of pancreatic lymph tissue also needs to be stripped. Stripping pancreatic capsule injuring the pancreatic tissue, or the blood supply of the pancreas influenced by vascularizing and the vessel ligation, could cause pancreatitis. In the standard gastric radical surgery, the patient's pancreatic amylase in serum and drainage liquid will increase 3 days after surgery. But they will gradually decrease back to normal level after that. Patient's pancreatitis is usually mild and there are very few cases of severe necrotizing pancreatitis. Moreover, use of somatostatin and trypsin inhibitor postoperatively controls the further development of pancreatitis which can be covered by untypical clinical manifestation such as postoperative incision pain, surgical fever. When pancreas is damaged after the operation, we should observe the situation of amylase in the drainage liquid and get ready to perform ultrasound-guiding puncture.

Postoperative chylous ascites

Chylocyst usually locates between the right angle of diaphragm and the aorta, at the level of first and second lumbar vertebra. Lumbar trunk and chylocyst could be accidentally injured during the dissection of No. 16, 14 and 8p lymph nodes or cardiac tissue. We recommend that all soft tissue or cord-like tissues should be ligatured while resecting them.

As far as we know that the postoperative chylous ascites occurs within 2–3 days after operation and it shows increasing abdominal drainage liquid, which could be 500–1,000 mL or more than 1,500 mL but generally no more than 2,000 mL. Chyle test is positive. Such patients generally have no obvious discomfort but early removal of drainage tube may cause abdominal distension. Different from chylothorax, chyloperitoneum is usually not fatal. Major treatment is conservative. Keep the drainage unobstructed. Give sufficient liquid supply including the colloid supply and electrolyte balance according to the amount of drainage liquid. Generally within a week, the liquid would gradually reduce.

Postoperative cholecystitis and cholecystic gangrene

Cholecystitis and cholecystic gangrene are special complications caused by dissection of No. 12 lymph nodes, and vascularization of hepatoduodenal ligament. Almost all gallbladder arteries stem from the branch of common hepatic arteries and arrive to the gallbladder through the gallbladder triangle. If cystic artery is injured during the No. 12 lymph node dissection, cholecystic gangrene usually occurs. Other causes include vagotomy, postoperative fasting induced gallbladder emptying disorder, cholestasis and gallbladder pressure rise. In general, the postoperative cholecystic gangrene occurs within 3–5 days after operation accompanied by symptoms of peritonitis. Patients show persistent fever or postoperative hypothermia and fever, right upper abdominal pain, intense abdominal muscle, tenderness and rebound tenderness, followed by increased heart rate, WBC rise and so on. Clinically, those manifestations are sometimes very similar to the duodenal stump fistula. Once we suspect the cholecystic gangrene, emergency abdominal ultrasound examination must be performed to find out the situation of the gallbladder, and the specific location and the amount of right upper abdominal effusion. Emergency laparoscopic cholecystectomy could be performed. Ultrasound-guiding puncture or catheter drainage is also applicable. Other treatments include using broad-spectrum antibiotic to control the infection.

Postoperative cholecystitis and cholestasis: due to extensively vascularizing the 12 groups of lymph nodes, blood supply and nerve innervation of the gallbladder are damaged more or less, causing gallbladder emptying disorder. In a period of time after surgery, the patients may show cholecystitis signs like right upper abdominal pain and intense abdominal muscle. Ultrasound examination may reveal the signs of enlarged gallbladder and cholestasis. Cholecystectomy is needed when it is severe.

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Laparoscopic surgery for gastric cancer in patients with high body mass index

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Abstract: Laparoscopic gastrectomy has gained much popularity in the treatment of gastric cancer in China. But it is more difficult to perform than open gastrectomy. In recent years, the prevalence of obesity is rapidly increasing and the application of laparoscopic surgery for these patients still exists controversial. The major obstacle of its application is mainly associated with its higher risk of complication, technical difficulties, longer operative time and higher conversion rates. The surgical difficulties mainly come from the accumulated visceral fat tissue that may induce bleeding, increase the difficulty of lymph nodes dissection and prolong the operative time. However, with the development of laparoscopic techniques and the increasing experience of surgeons, many skilled surgeons could perform the surgery well and accumulate some experience. The safety and feasibility of laparoscopic surgery for obese patients become acceptable to more and more surgeons. Considering of the surgical difficulties, mastering the surgical skills of laparoscopic surgery of obese patients is critical for performing the surgery successfully. Thus, in our present study, we will introduce some experience to overcome these surgical difficulties and shorten the learning curve.

Keywords: Laparoscopic surgery; gastric cancer; high body mass index (high BMI)

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Introduction

Laparoscopic gastrectomy has gradually matured from the exploratory stage, many Chinese clinical center have formed their unique style. The operation process is smooth and highly skillful, and surgeons have measures to deal with intraoperative complications timely. After nearly 5 years of clinical practice, our current laparoscopic surgery team is stable and accumulates some of our own understanding and experience. In recent years, the prevalence of obesity is rapidly increasing and it becomes a serious health problem worldwide. Patients who are obese are initially a relative contraindication for laparoscopic surgery, mainly because of its higher risk of complication, technical difficulties, longer operative time and higher conversion rates (1-3). However, with the development of laparoscopic techniques and the increasement of surgeons' experience, the safety and feasibility were verified in several studies and the laparoscopic surgery become acceptable for obese patients (4,5). The patients in our hospital are usually obese and with relatively advanced stage. Thus, for laparoscopic gastrectomy in patients with higher body mass index (BMI), we gained some clinical experience as reference to share. Patients with higher BMI are usually divided into two types: subcutaneous obesity and visceral obesity. The surgical difficulties mainly come from the accumulated visceral fat tissue, which may induce bleeding, increase the difficulty of lymph nodes dissection and prolong the operative time. On the other hand, previous studies also showed that visceral fat is a significant factor of complication (6,7). Thus, we will

Figure 1 Dissociation greater omentum (8).
Available online: http://www.asvide.com/articles/1198

Figure 2 Breaking right gastroepiploic vein (9).
Available online: http://www.asvide.com/articles/1199

mainly focus on visceral obesity patients and introduced some surgical skills and precautions in our present study.

Patients position and the trocar placement

For patients with lower BMI, the body position has less effect on operation. However, for patients with higher BMI, body position is particularly important for exposure of surgical field. In this case, it is our experience that the patient is placed in the supine position with both legs abducted and tilted to the reverse Trendelenburg position (tilted angle >20°). Since the position of pancreas in obesity patient is usually high, insufficient tilted angle is not enough to perform the dissection of the lymph nodes in suprapancreatic area. When we perform the splenic hilar lymphadenectomy, the body position should tilt to the right side.

When the trocar is placed, the distance between each Trocar should be as wide as possible. The observation hole should be placed possibly low and the main operating hole should be placed near the midline as much as possible.

Dissociation greater omentum

Greater omentum of obese patients is rich and thick, and adhesion and anatomic abnormalities usually occur. Therefore surgeons should dissociate greater omentum of obese patients more carefully, and violent traction is not allowed to avoid bleeding. In addition, surgeons should also avoid damaging transverse colon because it is often wrapped with greater omentum. We recommend that dissociation starts near splenic flexure and then enters omental bursa, which is a breakthrough point for dissociation. We think our recommendation can avoid vice-damage and repetitive operations. The anatomic landmark is gastric wall (*Figure 1*).

Breaking right gastroepiploic vein

Anatomical position of middle colic vein is fixed, of which anatomic variation rarely occurs. Therefore middle colic vein is the anatomic landmark of lymph node dissection. Firstly, surgeons should find inferior margin of pancreas. And then surgeons should continue dissociating to the lateral aspect to show head of pancreas and to release duodenum absolutely. We advise that surgeons should not break right gastroepiploic vein at its root. The capillaries of obese patients are abundant, and therefore bleeding always occurs when breaking vessels by hemoclip. If bleeding occurs, surgeons could use another hemoclip at vessel root. On the contrary, if surgeons break right gastroepiploic vein at its root and then bleeding occur, hemostasis is hard. Right gastroepiploic artery processing is conventional (*Figure 2*).

Dissection of lymph node of superior border of the pancreas

Surgeons should place dissociated greater omentum between stomach and liver. Assistants should not hold it too lowly to avoid vision blocked by slipped greater omentum and stomach. Find splenic artery, and dissect No. 11p lymph nodes. Then reveal left side of left gastric artery, and reveal further left gastric vein along hepatic common artery. Before break left gastric vein, we advise that surgeons firstly dissect lymphoid and adipose tissue behind blood vessels.

Figure 3 Dissection of lymph node of superior border of the pancreas (10).
Available online: http://www.asvide.com/articles/1200

Figure 4 The dissection of No. 1 and No. 3 lymph node groups (11).
Available online: http://www.asvide.com/articles/1201

This is because that hemoclip may disturb the next step of dissection of lymph node. In addition, we also advise that surgeons should not break left gastric vein at its root (*Figure 3*).

The dissection of No. 1 and No. 3 lymph node groups

The lesser omenta of the obese patients usually also be thick, which always warp extensive stomach wall of the lesser curvature. We suggest to dissect the No. 1 and No. 3 lymph node by two steps. Firstly, dissect the posterior lobe of lesser curvature from behind. And then dissect the anterior lobe from the front. Thus, the No. 1 and No. 3 lymph node groups can be resected entirely with few omentum left (*Figure 4*).

Figure 5 The ligation of left gastroepiploic vessels (12).
Available online: http://www.asvide.com/articles/1202

The ligation of left gastroepiploic vessels

The common methods we suggested are moving the greater omentum to the lower abdomen with turning the patient position to left side lifted, so that the left upper quadrant can be exposed distinctly. Mobilize the greater omentum from the transverse colon until to the root of left gastroepiploic vessels. Then, ligate the left gastroepiploic artery and vein. Therefore, the greater omentum could be removed easily and avoid damaging the short gastric vessels by mistake (*Figure 5*).

Removal of the specimen

The specimens of the obese would usually be of larger volume, and hard to take out from the abdomen especially when total laparoscopic surgery performed. In this condition, our suggestion is catching and taking the stomach out firstly, then taking out the greater omentum. Thus, the incision for removing the specimen could be as small as possible.

Key points

(I) Carefully dissecting along the space between different layers;
(II) Operating patiently and making more use of the slower cutting model of ultrasonic scalpel;
(III) Leaving some distance from the root of vessels when ligating;
(IV) Continually draw lessons from the experiences.

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Footnote

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Notes on laparoscopic gastrointestinal surgery—current status from clinical studies of minimally invasive surgery for gastric cancer

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Abstract: To establish high-quality evidence of laparoscopic gastrectomy (LAG) in the field of gastric cancer treatments, large-scale, prospective randomized controlled trials have been performed in Japan, Korea and China. Furthermore, as advanced laparoscopic techniques have been developed, prospective clinical studies are being performed with regard to laparoscopy-assisted total gastrectomy and robotic gastrectomy. This review summarizes the current status of minimally invasive surgeries for gastric cancer based on the latest ongoing clinical trials.

Keywords: Laparoscopic gastrectomy (LAG); randomized clinical trials; advanced gastric cancer

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Introduction

Since laparoscopy-assisted distal gastrectomy (LADG) with lymph node dissection for early gastric cancer (EGC) was developed in 1991 in Japan, this procedure has been widely accepted (1,2). Initially, major efforts were made to improve the technical safety and improve the standardization of laparoscopic gastrectomy (LAG) (3-7). In order to improve the laparoscopic technique, the Japan Society for Endoscopic Surgery (JSES) established the Committee for the Endoscopic Surgical Skill Qualification System in 2001 (8,9). It is considered that establishment of the system is one of the reasons why quality of laparoscopic surgery is guaranteed so far in Japan.

Although advances in techniques and improvement of instruments have led to the standardization of LAG with lymph node dissection among experienced surgeons, surgeons should valuate as to whether the laparoscopic approach to gastric cancer is adequate and beneficial for cancer treatment. Therefore, large-scale, prospective studies are needed to answer several clinical questions. Here we review the current status of the latest studies.

Ongoing clinical studies of LAG for gastric cancer

To provide answers to the clinical questions, prospective clinical studies are ongoing. These contain multicenter prospective randomized trials and a large-scaled prospective cohort study.

LADG for gastric cancer

So far, most of these studies were limited by having a small sample size-, and a short-term follow-up period (10). Therefore, a retrospective, multicenter study was conducted to know whether LAG for EGC is a safe procedure or not in terms of short- and long-term outcomes (11). According to some retrospective studies with large samples, LAG for EGC is considered to be feasible treatment in terms of technical and oncological aspects. With regard to prospective studies, a randomized controlled study (JCOG0912) was performed to confirm the non-inferiority of relapse-free survival of LADG to ODG in patients with the same inclusion criteria used in the phase II study (JCOG0703) (12). Regarding short-term outcome, there were no significant differences between two groups in terms of intra-operative adverse events (G3-4) and in-hospital, non-hematological adverse events (G3-4) (13).The authors concluded that LADG performed by the credentialed surgeons was safe as ODG for cStage I cancer. A large-scale, multicenter randomized trial (KLASS01) regarding the safety of LADG for cStage I cancer from Korea has mentioned that this procedure confers the benefit of a lower occurrence of wound complications compared with conventional ODG (14). Therefore, LADG is safe in terms of short-term outcomes, at least for patients with cStage I cancer. Regarding the non-inferiority of LADG in terms of long-term outcome, the result should be anticipated from each country.

In order to feedback for surgeons the real-time clinical data, a nationwide surgical patient registration system named the National Clinical Database (NCD) was initiated from 2011 in Japan. Recently, retrospective- and prospective-cohort studies have been conducted to clarify a risk model of LAG using the NCD (15). These results based on mega-data will be expected to cover the fields of exclusive criteria in our prospective RCT for LAG, such as age (elderly patients), and high BMI.

The extent of lymph node dissection in advanced gastric cancer (AGC) remains controversial. In Asian countries, D2 lymph node dissection is routinely carried out in AGC, the main advantages of D2 lymph node dissection being considered to include prolonged survival and improved staging accuracy (16,17). Recent retrospective studies and meta-analysis comparing laparoscopic D2 gastrectomy and open D2 gastrectomy for AGC demonstrated that the laparoscopic procedure may be feasible (18-20). A phase III trial to confirm the non-inferiority of this procedure to open gastrectomy in terms of long-term outcomes is ongoing. In East Asia, large-scale, multicenter RCTs are currently ongoing in Japan (UMIN000003420) (21), Korea (KLASS 02: NCT01456598) (22) and China (CLASS 01: NCT01609309) (23). Regarding to short-term outcomes from the Korean and Chinese trials, favorable outcomes in LADG as well as ODG for AGC have been demonstrated. These data may contribute to make a decision of indication for LAG.

LATG for gastric cancer

There are a lot of concerns of LATG because of its technical difficulty, particularly for esophagojejunostomy (24-26). So far, no RCT data on LATG are available, because the standardization of techniques for esophagojejunal anastomosis has proved difficult even for experienced surgeons. Recently, a multicenter, non-randomized confirmatory study of LATG with lymph nodal dissection for clinical stage I gastric cancer (JCOG1401) was carried out in terms of technical safety-, and short-term surgical outcomes (registered number, UMIN 000017155). In Korea, a feasibility study of LATG in EGC (KLASS03) was performed, and patient enrollment has already finished (NCT01584336). The primary endpoint of the KLASS03 study was to evaluate the incidence of postoperative morbidity and mortality. These studies will lead to the confirmation of the technical safety of LATG for EGC. On the other hand, several issues related to the technical and oncological feasibility still exist regarding LATG for AGC. For standardization of these procedures, it will be needed to expand the indication of LATG step by step at this moment.

Robotic gastrectomy for gastric cancer

Although a number of robotic systems is rapidly increasing, several issues remain to be solved regarding clinical indication, short- and long-term outcomes, cost-effectiveness, and stress of surgeons (27-29). Recently, prospective cohort study of robotic gastrectomy for gastric cancer conducted (registered number, UMIN000015388). These results will be expected to inform decisions on the future direction of robotic gastrectomy for gastric cancer.

Future perspective

Since the first LADG for gastric cancer was introduced, many surgeons have made efforts to improve the technical and oncological safety of LAG. With a view to standardizing LAG, multicenter clinical studies have also been launched to establish high-quality evidence from Japan, Korea and China. The fruitful data from these studies are expected to decide future directions for the use of LAG for gastric cancer. International cooperation and sharing of information on current issues regarding LAG for gastric cancer will be required.

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Laparoscopic extended right hemicolectomy with D3 lymphadenectomy

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Abstract: Laparoscopic extended right hemicolectomy with D3 lymphadenectomy is the most challenging surgery among all colon procedures. This surgery involves an extensive scope and a number of important organs. In this article, we aim to share our experience in laparoscopic extended right hemicolectomy with D3 lymphadenectomy from three aspects, including surgical position, trocar positions and surgical procedures.

Keywords: Right colonic neoplasm; laparoscopy; surgical skills

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Introduction

Laparoscopic extended right hemicolectomy with D3 lymphadenectomy has been recognized as the most challenging surgery among all colon procedures. This surgery involves an extensive scope and a number of important organs, where a clear understanding of the superior mesenteric vein (SMV) anatomy is needed to complete the thorough dissection. It is not only demanding for the surgeon, but also associated with a high requirement for the cooperation by the assistant and camera-holder. The slightest mistake may result in failure to achieve complete mesocolic excision (CME) and D3 lymphadenectomy, or even damage to the ureter, duodenum and other vital organs, or worse, superior mesenteric arteriovenous damage directly leading to fatal bleeding. We have accumulated the experience of experts from multiple centers across the country, and summed up with some of our own experience in this study to share with you.

Position

The patient is first placed supine with legs apart. For those with a small statue, both hands should be placed close to the body. Postural changes are required for a few times according to surgical needs (see below). The basic principle is to avoid the interference of the small intestine with the operative field by adjusting the position.

Operator positions

Positioning: in our center, the surgeon stands to the left of the patient; the primary assistant stands to the right, while the camera-holder stands between the patient's legs (*Figure 1*). This positioning will facilitate the exposure and freeing of the pancreatic head, duodenal C curves and the hepatocolic ligament. However, due to the perpendicular relationship between the ultrasonic scalpel and SMV, it is more difficult to dissect the lymph nodes on its surface. A pair of dissecting forceps in the left hand can be used to aid (*Figure 2*). The other positioning is that the surgeon standing in the middle between the patient's legs (*Figure 3*), which has just the opposite strengths and weaknesses compared to the above (*Figure 4*). I recommend that beginners can take the second positioning during lymph node dissection, and then change to the left side standing position for dissection of the pancreatic head and duodenum; at last, you can stand between the patient's legs to continue dissecting the middle colonic vessels. Once you are skilled, the two positioning modes make no difference to the outcome of surgery.

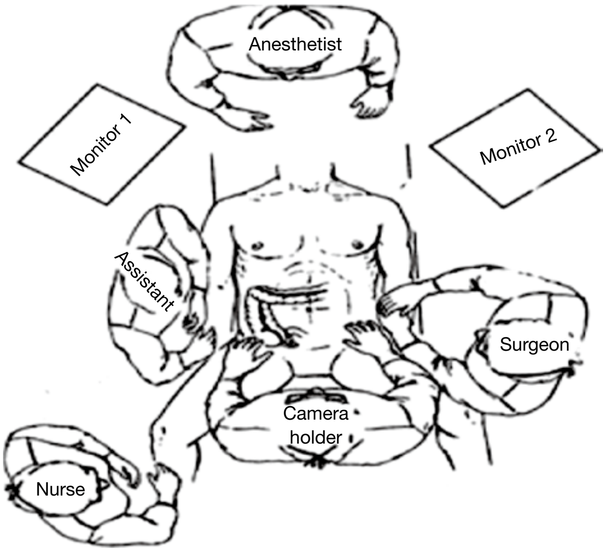

Figure 1 Standing position 1: surgeon stand to the left of the patient.

Figure 2 Operation technique when standing to the left of the patient.

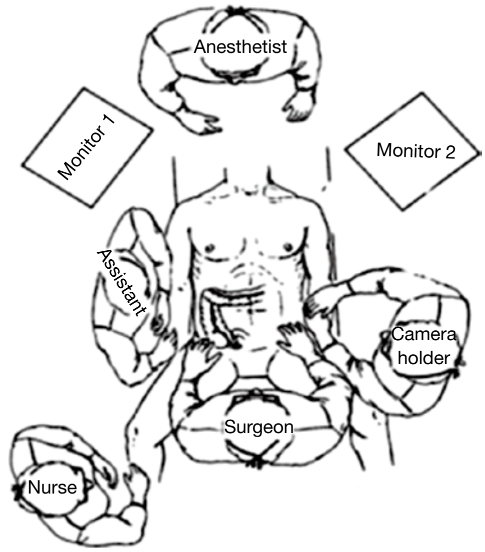

Figure 3 Standing position 2: surgeon stand in the middle between the patient's legs.

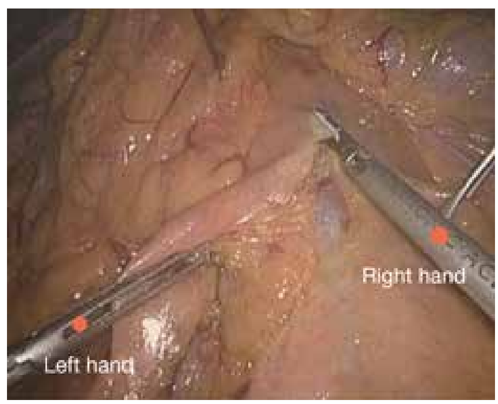

Figure 4 Operation technique when standing in the middle between the patient's legs.

Trocar positions

At present, the traditional five-port method is used.

Observation port

The location depends on the overall vision of the surgery. A rule of thumb is that the farther away from the surgical field, the better exposure of the whole picture is, but caution should still be given to close meticulous operation. If it is placed too close to the operative field, it will increase the difficulty of seeing the whole area, thus increasing the difficulty of operations by surgeons and assistants as well as the risk of injuring adjacent organs. Along the learning curve, we once made the observation port below the umbilicus and two fingers below the umbilicus, ignoring the patient's body size. As a result, patients with a short abdomen were easy to operate, but for those with a longer abdomen, the camera had to be placed towards the left hand of the surgeon for observing the ileocecal part, interfering with the operation by the surgeon. They even needed to suspend the surgery just to adjust the position of the camera holder. After practice over a long time, we decided to choose the junction of the line connecting both McBurney's points and the lower abdomen white line (about

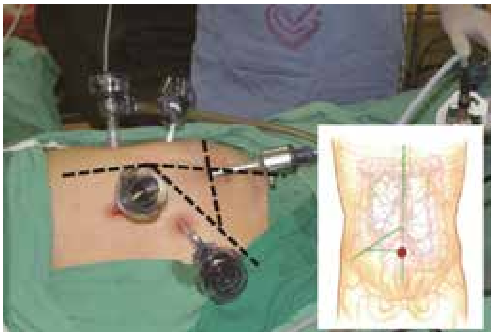

Figure 5 Trocar position of observation port.

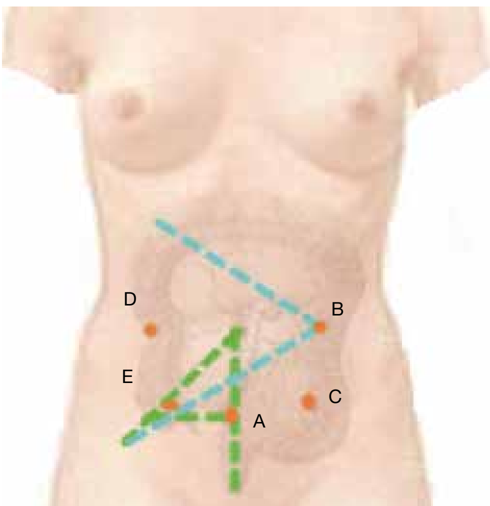

Figure 6 Port locations.

4 cm below the umbilicus) as the observation port (*Figure 5*). In this way, the camera holder does not need to adjust his/her position for complete observation of the field of the right colon, which has less interference on the surgeon. For elderly and female patients, given the loose skin of the lower abdomen, subcutaneous fat thickness, peritoneum relaxation and urachus remains, even if a towel clamp is used to pick up the skin around the puncture point, a deep vertical length is often needed to successfully break through the peritoneum during needle puncture for pneumoperitoneum. Sometimes the entire needle needs to be inserted, and even so, there will be no strong peritoneal breakthrough feel. Inadvertently, there may be puncture outside the peritoneum. In this case, inflation may lead to widespread extraperitoneal emphysema, leading to open surgery. There used to be some cases with increased CO_2 partial pressure, resulting in termination of surgery. Our experience is that in the case of exceptionally thick abdominal fat, we will separate the subcutaneous tissue through the white line under direct vision, and clamp the white line with curved forceps during the puncture, which will lead to a higher success rate than pulling the skin using a tower clip. After the puncture needle enters into the abdominal wall, it is directed to the umbilical part. Due to the relatively fixed position of the umbilical peritoneum, it is easier to puncture successfully. After successful pneumoperitoneum, a 10 mm trocar is vertically inserted. Before connecting continued air supply, it is recommended to insert the laparoscopic instrument first to identify whether the trocar has caused any injury in the abdominal cavity, and adjust the optimal position of the trocar by observing the side hole at the end of the trocar. In principle, the shorter the abdominal segment of a trocar, the less interference it will cause to the abdominal operation. It is recommended to make a single stitch on the abdominal wall to fix the trocar so that the movement of the camera will not bring the trocar away and consequently affect the surgery.

Working port

This is made at the conjunction between the left clavicular midline and the line connecting the hepatic flexure to the midpoint of the ileocecal part (B in *Figure 6*). This position makes it comfortable for both operations at the ileocecal region and the hepatic flexure. An auxiliary port is made 5 cm below the right subclavian midline, along the middle point at the line between bilateral anterior superior iliac spines and the umbilicus. The assistant port is basically opposite to the surgeon, located in the right abdomen. Each port should be at least four fingers away from each other to reduce mutual interference.

Surgical approach

The procedure is approached from inside to outside and from bottom up (*Figure 7*). In other words, lymph nodes No. 3 on SMV are first treated and the vessels ligated, and the right mesocolon is freed outwards in a fanned shape. After that, the right part of the greater omentum is resected. Finally, the right paracolic sulcus is freed from up to down to meet the starting point. All operations for malignant tumors should follow the principle of non-tumor below. As for transverse colon tumors at or close to the hepatic flexure, D3 extended radical mastectomy is recommended (see the appendix).

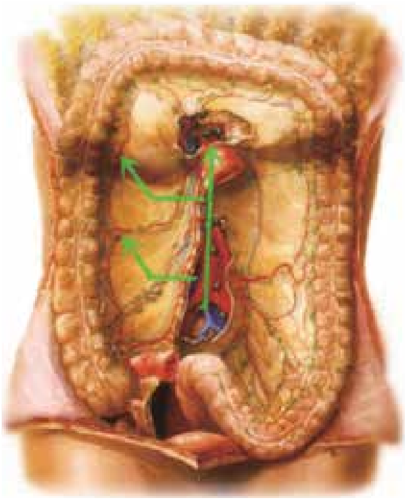

Figure 7 Retrograde procedure with the middle approach.

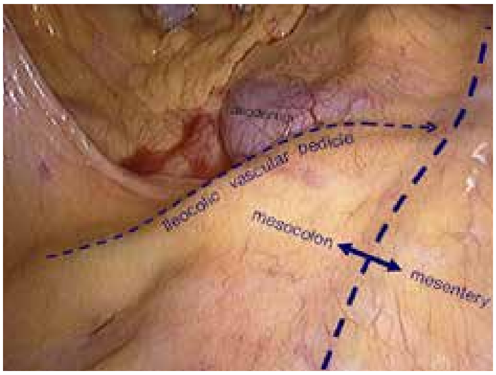

Figure 8 The positions of mesocolon, ileocolic vascular and duodenum.

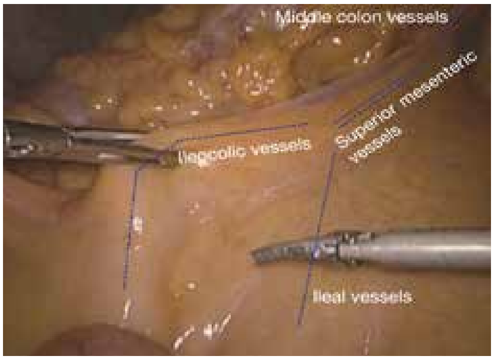

Figure 9 The anatomy when the transverse mesocolon and ileocolic vessels are clamped.

Surgical procedures

We intentionally divide the surgery into the following 11 steps.

Step 1: abdominal exploration

The abdomen is explored from distant to proximal ends, with focus on the liver. If necessary, laparoscopic ultrasound probe can be used to identify the presence of any possible liver metastases, and frozen pathology can be employed to diagnose liver metastases. Finally, the primary lesion is explored.

Step 2: identifying anatomical projection

The operating table is adjusted so that the patient is tilted backwards with legs higher than the head. In this position, the small intestine gathers at the lower left quadrant, reducing interference to the operative field. The camera holder keeps the camera at 30° forward and downward, overlooking the upper abdomen from a far distance to expose the transverse colon and omentum so that the assistant and the surgeon can flip the omentum onto the top of the transverse colon to expose the surgical field, including the blood vessels in the colon, inferior mesenteric veins, projection of ileocolic vessels, horizontal part of the duodenum and so on (*Figure 8*).

The assistant uses his/her left hand to drag the transverse mesocolon to the head site. (The optimal clamped site is the mesangial avascular zone around the right branch of the middle colon vessels, so that the omentum can be blocked and the middle colon vessels can be pulled to maintain tension between the middle colon vessels and the superior mesenteric vessels). The right hand is used to clamp the ileocolic vessels, and pull, flatten and pick them towards the right bottom direction so that the ileocolic vessels—superior mesenteric vessels—middle colon vessels form a plane like a piece of canvas, in which a compact tension is maintained (*Figure 9*).

Step 3: looking for Toldt's clearance, ligating the ileocolic artery (ICA/ICV) and dissecting lymph nodes No. 203

The conjunction between ileocolic vessels and SMV is exposed via step 1 (*Figure 10*). The ileocecal mesentery is cut with an ultrasonic scalpel from the distal to proximal

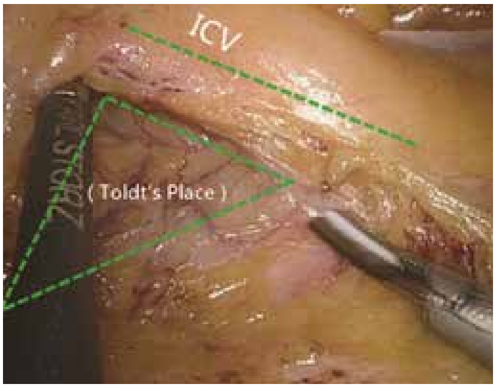

Figure 10 The conjunction between ileocolic vessels and SMV. SMV, superior mesenteric vein.

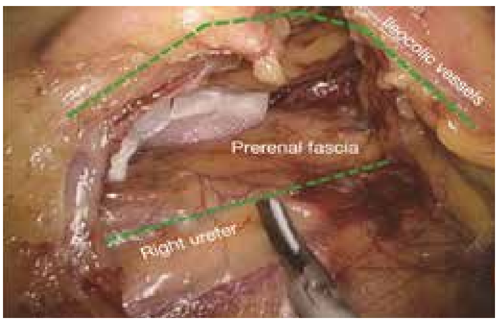

Figure 11 Adjust the vision to keep the ureter at a horizontal position.

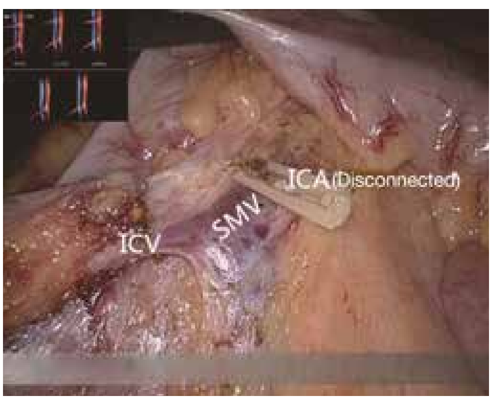

Figure 12 Cut off from the root of ICV and ICA. ICA, ileocolic artery.

end to enter the loose Toldt's space (located between the right prerenal fascia and the ascending colic mesentery). Upon entering the correct Toldt's space, the camera holder gradually adjusts the vision with the ureter at a horizontal position (*Figure 11*). During lymph node dissection and vascular separation, the vision can be adjusted with the SMV at the neutral position (6 to 12 o'clock). The assistant maintains stable traction, or insert the clamp in the left hand into the Toldt's space to pick it up to further expose the gap ("mischief"). The surgeon follows the principle of priority on a plane, first bluntly separates towards the lateral paracolic sulcus and properly extends upwards and downwards while ensuring the intactness of the ascending mesocolon and anterior fascia of the right kidney. For some skinny patients, the right ureter and reproductive vessels may be visible but should not be separated, unless it is needed to confirm the presence of side injury. With continued separation along the Toldt's plane towards the ICV and SMV angles, the ICV and ICA are skeletonized one after another (in which it is important to note if the relationship between ICV and ICA is variated, see upper right part of *Figure 8*), until the they enter SMV. The No. 203 lymph adipose tissue at the arteriovenous root of the colon is dissected and the SMV end needs to be completely revealed until the right wall of the SMA is visible. The roots of ICV and ICA are cut off with a biological clamp (*Figure 12*).

Step 4: expanding Toldt's clearance

After cutting the ICA/ICV, the Toldt's gap is revealed more fully, so that the mesangial ascending colon is gradually separated from the renal front fascia, duodenum, head of the pancreas and other tissue. The camera holder maintains the vision at right ureter horizontal position, adjusts along with the surgeon's operation and gradually transfers it to the pancreas horizontal position. The fiber angle can be adjusted to facilitate the surgeon's operation, but the camera body should always be remained at the retroperitoneal level. The assistant can insert clamps in both hands into the Toldt's space and pick up the mesocolon in a reverse direction. The surgeon further expands the whole Toldt's space down to the iliac artery, external to the Toldt's line (i.e., the right paracolic sulcus), and up to the outside edge of the duodenal C loop for the moment, as long as the gallbladder can be vaguely seen through the mesocolon at this point (*Figure 13*). Now one or two pieces of gauze can be placed in the Toldt's gap to stop bleeding with compression and separate vital organs such as the ureter, duodenum and head of the pancreas, to prevent injury later when separating the paracolic sulcus.

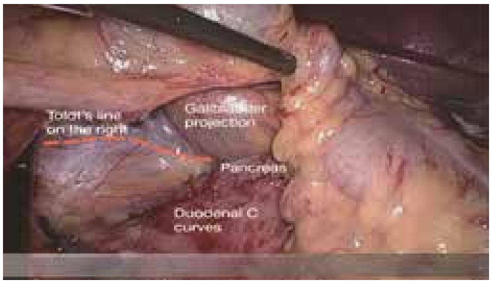

Figure 13 Organs around the right side Toldt's gap.

Figure 14 Dividing of SMV. SMV, superior mesenteric vein.

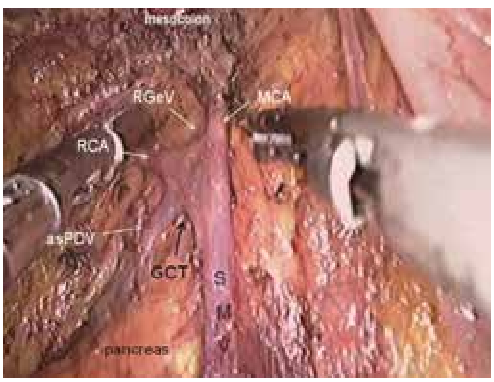

Figure 15 Branches of SMV. SMV, superior mesenteric vein.

Step 5: transecting right colonic vessels (RCV) and middle colonic vessels (MCV), and dissecting the right side

The camera holder adjusts the field of view to the SMV neutral position. The primary assistant pulls the transverse mesocolon with the left hand, and pulls the separated ascending mesocolon with a clamp in the right hand to fully expose the SMV and MCV junction area. During the surgery, holding a clamp in the right hand can help the surgeon to perform fine separation. Holding a separation clamp in the left hand is conducive to fine separation by the surgeon. When separating the SMV vascular sheath, blunt dissection can be done down to up with dissection forceps in the left hand, with the right hand holding an ultrasonic scalpel to cut the tissue in the middle of the clamp teeth (*Figure 14*). The protective tip of the ultrasonic scalpel should be placed close to vessels while the working surface away from them to avoid accidental injury. Using this method, the surgeon can separate upwards closely along the SMV anterior part until the Henle stomach and colon common joint and have it skeletonized. Meanwhile, the lymph nodes around the surgical root are dissected to expose the right colon vein and right gastroepiploic vein, as well as various SMV branches, and the root of the right colon vein is clamped and cut off. The superior mesenteric lymph nodes are dissected left to the vein at the level of the right colic artery branch where the superior mesenteric artery is originated, and the arterial root is clamped and cut off at this level.

Step 6: dissecting lymph nodes at the root of the middle colonic artery, and cutting off the right branch of the vessel

The camera holder adjusts the vision at the pancreas horizontal position. The primary assistant pulls the transverse mesocolon towards the head side, holds a clamp in left hand to pull the left side of the mesocolon, and pull its right side with a clamp in the right hand, flatten it so that the mesocolon maintains tension, revealing the roots of the transverse mesocolon. The surgeon continues to divide tissue upward along the SMV, the purpose being to find the middle colic artery and vein as well as their right and left, and to dissect the lymph nodes to the right of the vascular root. Due to the length of the transverse mesocolon, it is difficult to expose the laparoscopic surgical vision, and there are multiple starting points and variations of the middle colonic artery (*Figure 15*). In laparotomy, the arterial pulse can be felt through tactile sensation to determine the position of the vessel, and the course of the vessel is visible through light projection, and the omental bursa can also be cut to determine the relationship between the pancreas and middle colonic blood vessels. However, with the laparoscopic approach, the superior mesenteric artery is the only thing that can be relied on to predict the location of the root of middle colonic blood vessels, which are sometimes hardly distinguishable from the RCV (*Figure 16*), leading to mistaken litigation. It will be easy for surgery

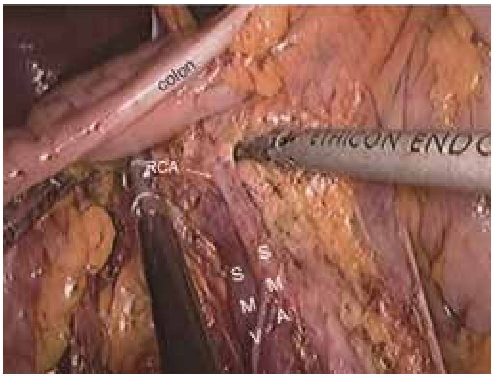

Figure 16 The middle colonic blood vessels.

Figure 17 Cut off the right branch of middle colonic blood vessel and retain the left branch.

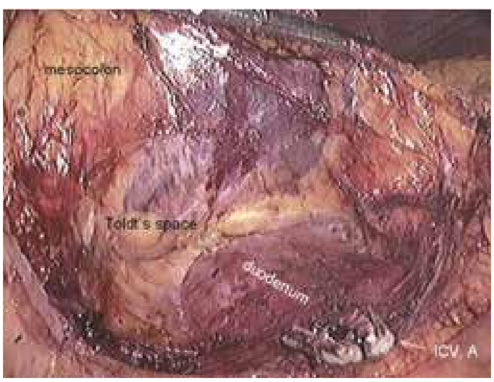

Figure 18 Organs around the right side Toldt's gap.

in skinny patients if colonic vessels can be directly seen through the mesentery, but for obese patients, particularly when lymph nodes are enlarged and fused here, it is difficult to distinguish the starting point and course of the middle colonic vessels. This is an inherent "flaw" of laparoscopic surgery! Therefore, many young doctors often stop here or just blindly separate until injury occurs, and have to perform regular dissection of the right half colon without being able to retain the left branch of the middle colonic vessels, leading to compromised blood supply to the left colon and excessive bowel resection. We usually use separate against the SMV until MCV with a separation clamp (*Figure 14*). When lymph nodes are enlarged, however, it is not easy to do so. We explore the following surgical methods. Since the duodenum and head of the pancreas are basically exposed, we usually do not hurry to separate the middle colonic vessels along the superior mesenteric artery vein. Instead, we separate the lower edge of the pancreas towards the left Treitz's ligament first. Since the ligament is loose and structurally constant, there is no interference from major blood vessels or enlarged lymph nodes. The lower edge of the pancreatic body can be easily exposed along the jejunum wall. With exposure to the pancreatic body and head of the pancreas, the location of the middle colonic vessels becomes very clear. At the same time, clear exposure of the pancreas can also help to block the superior mesenteric artery beneath, reducing the risk of injury. By this "encircling" approach with three-dimensional separation of the roots of the colon lymphatic vessels in adipose tissue, the third group of lymph nodes can be successfully dissected in the middle colonic vessels while retaining its left branch (*Figure 17*). After ligation of the left branch of the middle colic artery, the Toldt's space in the left upper quadrant can be further extended until the dark green gallbladder can be seen through the transverse mesocolon (*Figure 18*). One to two pieces of gauze can be placed in the gap to stop bleeding by compression and also as a marker of the correct layer to reduce accidental injury in the separation of the hepatocolic ligament.

Step 7: cutting off the gastrocolic ligament and hepatocolic ligament

Next, turn to the superior transverse colon area so that the transverse colon is hanging downwards to the left naturally. The camera holder uses a far vision maintaining the hepatic horizontal position or horizontal transverse colon position. The primary assistant uses both hands alternately to stretch the greater curvature to the left, to find the "avascular zone" between the left and right gastroepiploic arteries. The assistant uses a clamp in both hands to lift the gastric wall to the head side, with the left hand holding the distal wall and right hand the proximal side, and expand it to

Figure 19 Gastrocolic ligament transection.

Figure 20 Divide the hepatocolic ligament.

maintain tension. The surgeon uses the left hand to control the omentum, and identify from outside the vascular arch, the weakest point of the gastrocolic ligament to cut into the omental bursa, and then "pull while cutting" from left to right along the greater curvature of the stomach to cut off the right gastrocolic ligament (*Figure 19*). After entering the omental sac, the right transverse mesenterium is cut at the root of the pancreas. Gauze placed before can be seen, and cross from left to right the descending duodenum to the hepatocolic ligament. It is recommended to cut the hepatocolic ligament close to the hepatic edge, particularly when resecting a hepatic flexure tumor.

Step 8: freeing the hepatic flexure of the colon and ascending paracolic sulcus (i.e., Toldt's line)

Because the ascending mesocolon has been isolated by separation of Toldt's space, it is easier to free the hepatic flexure and descending paracolic sulcus.

When freeing the hepatic flexure, the camera holder should insert the camera to the right upper quadrant, with the fiber dialed at 1 to 2 o'clock position, keeping the liver in the horizontal position as much as possible. When reaching the descending paracolic sulcus, the vision can be adjusted to the horizontal position of the paracolic sulcus. The primary assistant needs to pull the hepatic flexure inwards and downwards to expose the hepatocolic ligament and right phrenicocolic ligament and maintain tension. The surgeon divides the hepatocolic ligament and right phrenicocolic ligament along the lower edge of the liver and the anterior renal fascia surface, separate the hepatic flexure and cut off the side peritoneum (*Figure 20*). For patients with hepatic flexure tumors, if the serous membrane is already involved, the anterior part of the right renal fat capsule should be cut until the thin and tough fibrous membrane covering the kidney is exposed. Because the Toldt's space posterior to the right mesocolon has been completely exposed and marked with gauze, this steps is aimed at opening the above "membranous" colon fixation device, so that the whole process can be done "in one snap" (*Figure 20*).

Step 9: cutting the ileocecal part and peritoneal return outside the ascending colon, as well as the upper and lower bout

The patient should be adjusted to a position with the head lower than the legs and tilted left. The intestine is then gathered to the left upper abdomen to facilitate exposure of the surgical field. Under direct vision of the ileocecal region, the camera holder adjusts the fiber to 10 to 11 o'clock in favor of observing the ascending paracolic sulcus. The primary assistant needs to operate in a mirror reverse way with clamps in both hands retracting the ileocecal region, revealing the ascending paracolic sulcus while maintaining tension. The surgeon cuts the lateral side of the peritoneum at the ascending ileocecal region (*Figure 21*). The ascending colon is pulled to the left side to the middle line, and the lateral peritoneum is separated along the right paracolic sulcus from the iliac fossa to the hepatic flexure, joining the upper part. So far, all the surgical dissection has been completed and "harvested". All right colon fixation ligaments are cut (*Figure 22*), and it is ready for the next step of vitro resection and anastomosis.

Step 10: resecting the right colon and creating an ileotransverse anastomosis

The pneumoperitoneum is removed and the patient

Figure 21 Divide the lateral side of the peritoneum at the ascending ileocecal region.

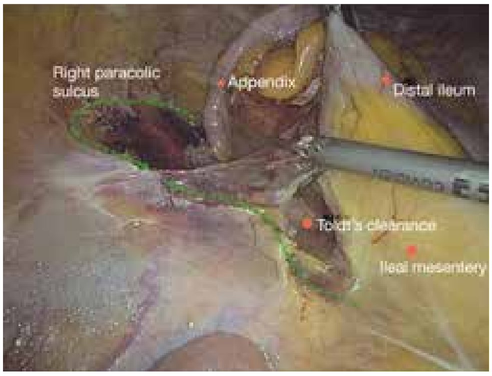

Figure 22 Cut off the right colon fixation ligaments.

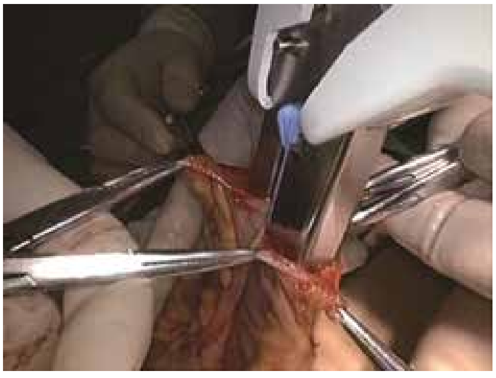

Figure 23 Ileum and colon side-to-side anastomosis.

adjusted to the supine position. A vertical incision is made through the rectus abdominis in the right upper quadrant based on tumor size, just allowing the removal of the tumor.

A plastic sleeve is placed to protect the incision so that tumor cells may not fall in it and grow. The right colon is

Figure 24 Ileum and colon side-to-side anastomosis.

dragged out of the body. It is recommended to remove the omentum first, which will be more conducive to removing the tumor. Try not to rotate the intestine to avoid reverse during anastomosis. Under direct vision, transect the transverse colon, and ensure that the bowel resection margin is >10 cm from the edge of the lesion, including all dissected D3 lymph nodes. Remove the right colon, including 10–15 cm distal ileum, the right colon where the tumor is located, colorectal mesentery and adequate bowel segments, and remove specimens. If the tumor is large, a cutter can be used to cut the intestines in the body, thus reducing the length of the abdominal incision. In our center, we often use a linear stapler for functional anastomoses between the ileum and the colon, which does not damage the vascular arcades at the bowel edge, and will not lead to anastomotic stricture. More importantly, the differences in the ileum and colon diameters do not matter. After completion of the anastomosis, it is recommended to add one to two stitches in the intestine junction 2 to relieve creeping tension of the anastomosis. Caution should be made to the risk of anastomotic bleeding. For high-risk groups, it is recommended to use the 8-shape whole layer suture to prevent anastomotic bleeding. The free edge of the transverse mesocolon and the ileal mesentery can be either closed or remained open. Finally, check the anastomotic patency and presence of torsion (*Figures 23-25*).

Step 11: washing, checking, placing and drainage

Close the small incision, re-establish pneumoperitoneum, wash the abdominal cavity with saline, and check if there is bleeding from the wound, bowel or without tension, anastomotic leak, and so on. Pay attention to place the

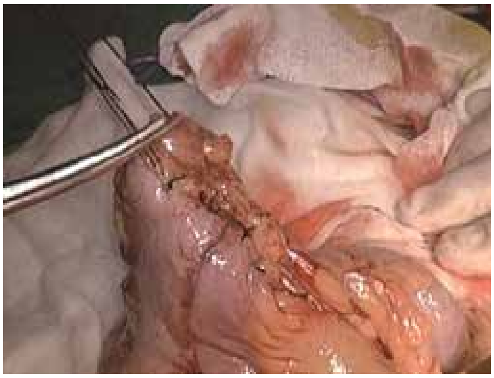

Figure 25 The 8-shape whole layer suture.

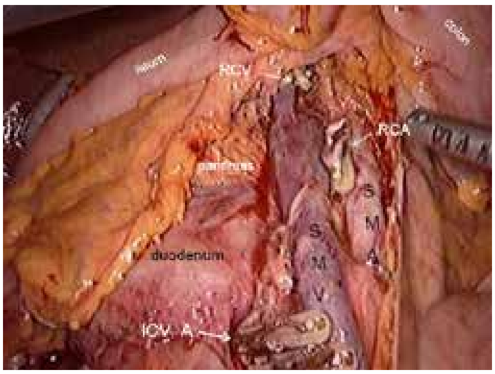

Figure 26 Washing, checking and placing.

Figure 27 Closure of abdominal incision and drainage.

intestines properly to prevent intestinal hernia. After confirming there is no active bleeding, place a drainage tube in the right paracolic sulcus led out from the pole in the right lower quadrant (*Figures 26,27*). At present, due to implementation of ERAS, if the surgery is satisfactory and there is no contamination of the surgical field, the laparoscopic drainage tube can be waived.

Summary

All laparoscopic colon surgery should follow the four key principles: identifying blood vessels, dissecting lymph nodes, going through the gap, and separating the colon. The key points in the implementation of D3 colon surgery include: non-contact operation, transection at vascular roots, main lymph node dissection, precise gap separation and adequate bowel resection. In the right laparoscopic colon surgery, we must adhere to the principle “from the center to the surrounding, from lymph nodes to vessels, and from veins to arteries”. First, transecting the draining lymph nodes of the bowel tumor segment followed by vessels helps to reduce tumor blood and lymphatic metastases during the surgical procedure due to squeezing. Intrathecal separation along the vascular sheath in operation is safe and thorough. In summary, a deep understanding of the fascial anatomy, especially the integration gap, skillful mastery of surgery, and tacit cooperation of the surgical team can make laparoscopic colorectal surgery smoother. With the integration of modern surgical equipment, high-definition cameras and development of energy platforms, laparoscopic colorectal surgery can become a pleasing art.

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Footnote

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Laparoscopic complete mesocolic excision (CME) with completely medial approach for right-hemi colon cancer

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Contributions: (I) Conception and design: M Zheng; (II) Administrative support: M Zheng; (III) Provision of study materials or patients: B Feng, J Ma; (IV) Collection and assembly of data: P Xue, H Hong, X Yan; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: Laparoscopic complete mesocolic excision (CME) has the potential to become the standard procedure of colon cancer surgery for its lower local recurrence rate and improved prognosis. Completely medial approach (CMA) is a promising access of laparoscopic CME in right hemicolectomy. A 45-year-old female patient was diagnosed as right-hemi colon cancer. Based on this case, we share the surgical strategies of laparoscopic CME with completely medial access combined with our previous study. Laparoscopic CME emphasized on en bloc resection of mesocolon without defections to the planes. Besides, further dissection is needed for cancer at the hepatic flexure, which involves subpyloric lymph nodes and of greater omentum that is within 15 cm of the tumor and along the greater curvature. The operation time was 128 min and the blood loss was 10 mL. The total number of central lymph nodes retrieved was 19. The time for passage of flatus and hospitalization were 2 and 12 days respectively. Laparoscopic CME with completely medial access is technically feasible, and should be conducted by experienced hand in right hemicolectomy.

Keywords: Right-hemi colon cancer; complete mesocolic excision (CME); completely medial approach (CMA)

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Introduction

Surgical strategies of complete mesocolic excision (CME) includes two concepts based on embryonic anatomy and surgical oncology: sharp separation of the mesocolic visceral and parietal plane; radical lymph nodes dissection and ligation colon-feeding vessels at their roots for a larger range of longitudinal enterotomy (1). The feasibility and survival benefit of CME for the patients with colon cancer has been demonstrated recent years (2-5). Lateral and medial accesses are two modes of CME procedure. Conventional laparoscopic CME utilizes lateral access. Previous study has indicated that laparoscopic CME via medial access and traditional colectomy are technically comparative (4).

Completely medial approach (CMA) and hybrid medial approach (HMA) are two different approaches for medial access proposed by our medical center. CMA involves several bottom-to-top approaches including the entrance of intermesenteric space (IMS) via transverse retrocolic space (TRCS), the dissection of the middle colic vessels (MCV), the gastrocolic trunk of Henle (Henle trunk, HT) and the inferior margin of pancreas. Previous research has demonstrated that CMA is technically feasible, and is the better choice for right hemicolectomy (6). The main goal of this article is to illustrate the surgical procedures and anatomic strategies of CMA in details based on this case.

Method

Patients with clinical stage II, III right-hemi colon cancer and whose important vessels in the surgical area are free from the invasion of tumor can be the candidate for CMA. Patients should have a well tolerability for laparoscopic

Figure 1 Laparoscopic CME with CMA for right-hemi colon cancer (7).
Available online: http://www.asvide.com/articles/1522

surgery, and without severe cardiopulmonary insufficiency. In the present video (*Figure 1*), the patient is a 45 years old woman who was diagnosed adenocarcinoma of ascending colon proximal to hepatic flexure by coloscope and histological test (*Figure 2*). The tumor stage was assessed to be cT4N1M0 by CT scan preoperation (*Figure 3*).

Surgical position

The patient was placed in supine position after the administration of general anesthesia, with both legs split and arms folded, and at a head-down left side tilt position. The surgeon stood on the left side of the patient, while the first assistant was on the right. The camera operator was positioned between two legs of the patient.

Surgical procedures

Pneumoperitoneum maintained not higher than 12 mmHg, and was built via the Veress needle. Five trocars were required in this surgery. One 10-mm trocar was placed on the upper left abdomen; the other was placed at the infraumbilical area with an inserted 30-degree laparoscope. One 5-mm trocar was on the lower left abdomen, and another two 5-mm trocars were on the upper and lower right abdomen respectively (*Figure 4*).

The surgical procedure of CMA starts at the ileocolic vessel and proceeds along superior mesenteric vein (SMV) to enter the TRCS from bottom to top. A bottom-to-top fashion is used to extend from pancreatic inferior edge. Middle colon vessels and the HT were dissected afterwards. TRCS is extended laterally to commute RRCS and

Figure 2 Coloscope.

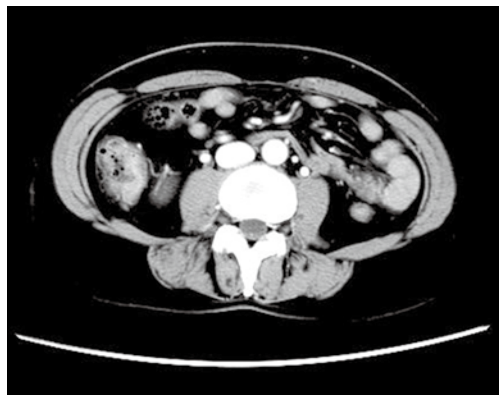

Figure 3 Abdominal CT scan.

superiorly to enter the IMS. Extending the inborn surgical plains to avoid mesocolon from defection. The surgery was conducted as follow (*Figures 4-13*).

Results

It took 128 min to finish this surgery, intraoperative bleeding was about 10 mL. Nineteen central lymph nodes were retrieved. The pathology outcome after the surgery shows it the adenocarcinoma staging T4N1M0. Besides, the time to first passing flatus and discharge were 2 and 12 days respectively.

Discussion

Anatomic strategies of CMA

Laparoscopic CME via medial access completes the dissection of surgical trunk and the ligation of central vessel to mobilize colon, involving an approach of inferior

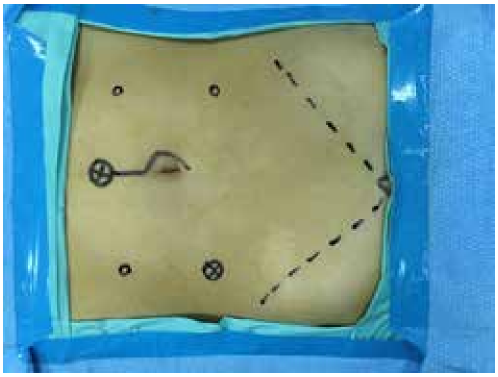

Figure 4 Trocars position.

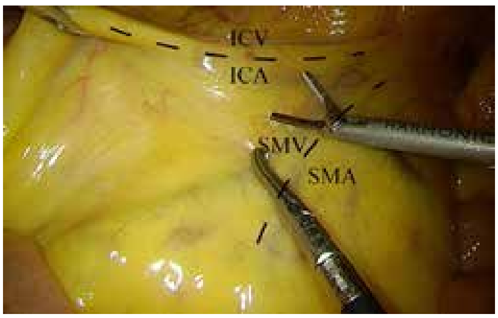

Figure 5 Initiation: the anatomic projection of ileocolic vessels (ICA and ICV) served as the initiation.

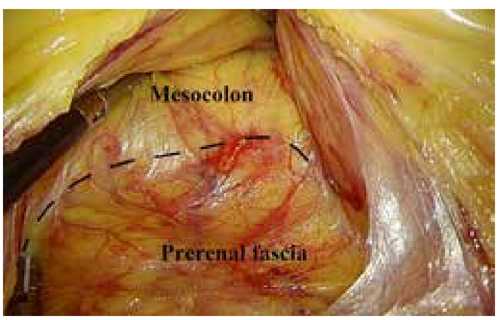

Figure 6 Identification and extension of RRCS: sharp separation of the mesocolic plane. The visceral plane of mesocolon and prerenal fascia (PRF) remains intact.

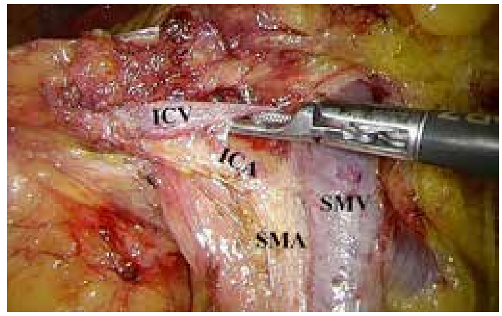

Figure 7 Identification of superior mesenteric vessels (SMV/SMA) and ileocolic vessels (ICV/ICA), lymph nodes dissection at the root of these vessels.

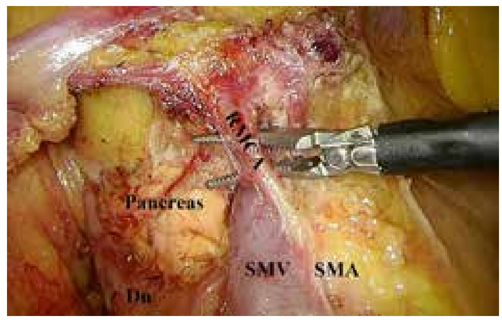

Figure 8 Identification and extension of the TRCS: TRCS is extended to commute with the RRCS. Proceed along the SMV/SMA or surgical trunk to conduct the ligation of right colic vessels (RCA/RCV) and right branch of middle colic artery (RMCA).

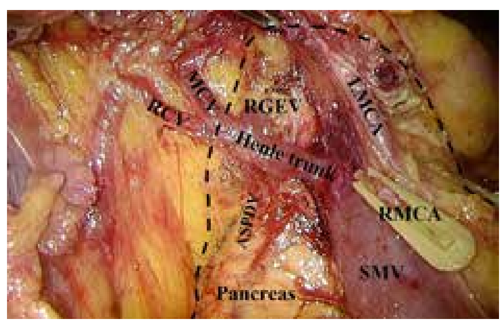

Figure 9 Ligation of Henle trunk (HT): HT's branches are of high variability. In this case, HT consists of RCV, ASPDV, RGEV and MCV.

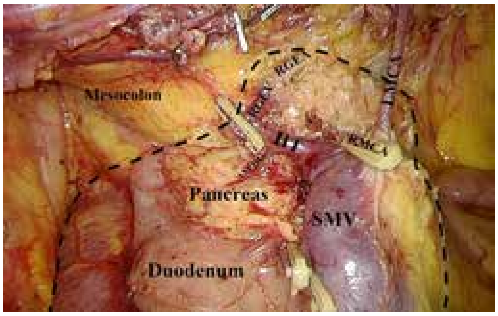

Figure 10 Extension of TRCS, section of right branch of middle colic artery (RMCA) right branch, mesocolon was excised without defections.

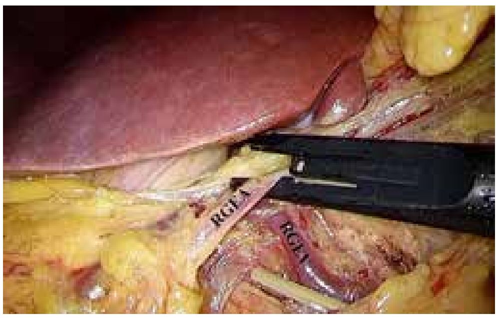

Figure 11 Identify the right gastroepiploic artery (RGEA), dissection of subpyloric lymph nodes is required for advanced colon cancer located at the hepatic flexure.

medial to superior lateral. Three avascular spaces (TRCS, RRCS and IMS), and one surgical plane consists of gut, prerenal fascia (PRF) and nearby structure is essential to the mobilization of right-hemi colon (6).

IMS is located superior to the transverse mesocolon and posterior to the greater omentum. It communicates with the TRCS via the root of the transverse mesocolon. Thus, the entrance of the IMS is necessary for the mobilization of transverse mesocolon. CMA requires a bottom-to-top approach during the mobilization, which has the advantage of fewer vessel-related complications and reducing operation time.

Difficulties and obstacles in CMA to the CME

Recognize the TRCS

The TRCS is an inborn surgical space located posterior to the transverse mesocolon and anterior to the pancreatic inferior margin. We propose two ways to identify the TRCS. First,

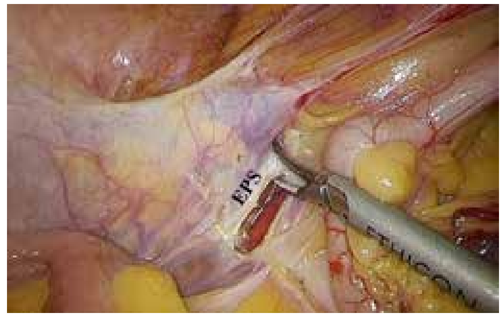

Figure 12 Extend the extraperitoneal space (EPS) to mobilize the right-hemi colon.

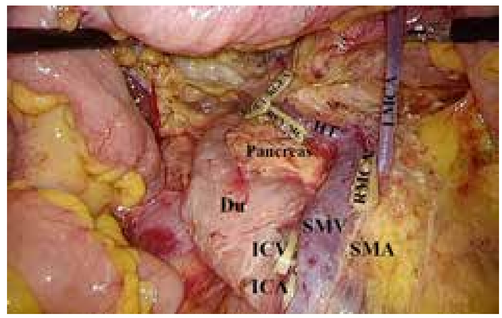

Figure 13 The surgical field after completely medial approach (CMA).

SMV can serve as a landmark for TRCS. In CMA, the range to dissect mesocolon can be clearly defined by the surface of SMV sheath, and the entrance of TRCS can be achieved after dissection. Second, TRCS can be successfully entered by superior extension of RRCS by dissecting the ventral part of the pancreas and the horizontal portion of duodenum.

"Climbing" the pancreatic inferior edge

Hemorrhage of pancreatic injuries is a potential complication of CMA. Therefore, it's vital to recognize the pancreatic inferior edge and the timing for "climbing". We regard emergence of the HT as the symbol of close to the pancreatic inferior edge. Meanwhile, the extension of the avascular space should be converted into a climbing procedure from bottom to top. Besides, it's also feasible to dissect along the left margin of right gastroepiploic vein (RGEV) get entrance to IMS.

Conclusions

Laparoscopic CME for CMA is safe, technically feasible and highly recommended for the tumor locates in the right-hemi colon. Whereas, it's also a difficult surgery that should be conducted in an experienced medical center.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Informed Consent: Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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Laparoscopy-assisted complete mesocolic excision for right-hemi colon cancer

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Abstract: There aren't any standardized ways of controlling operating, although laparoscopic-assisted right-hemi colon cancer complete mesocolic excision (LR-CME), has been widely applied used in China and abroad. Hohenberger gave a new concept that treating complete mesocolic excision (CME) as a colon cancer standard operation for the first time in 2009. And the LR-CME that based on the anatomy of the vascular and level coincide with the concept. One case, male, 69 years old. LR-CME was performed in our department. Following we will introduce correlation experiences and skills of LR-CME. It took about 110 minutes to finish the whole operation with bleeding of about 20 mL. This case recovers well postoperation without any significant complication and discharged from hospital on the 10th day.

Keywords: Ascending colon carcinoma; laparoscopy; complete mesocolic excision operation skills

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Introduction

Jacobs first describes laparoscopy-assisted right hemi colectomy (1). Clinical trials have proven laparoscopy-assisted right hemi colectomy is feasible, safe and effective. 2009, Hohenberger, of Germany, and others (2) first proposed the new concept of complete mesocolic excision (CME). Recent research has proved, CME improves the surgical quality with keeping more harvested lymph nodes (3) and better effect of oncology (4). There are two different operation ways (middle approach and lateral approach) for laparoscopy-assisted right hemi colectomy. More surgeons choose middle approach that marked by ileocolie artery and superior mesenteric vein. Some studies indicate that middle approach has obvious advantages in complication and shorten the hospitalization time (5).

Methods

Surgical indications

The tumor is located in the ileocecal junction, ascending colon, hepatic flexure of colon, the right side of the transverse colon. Operation method obtained the informed consent. Cases of exclusion criteria: (I) the diameter of tumor >8 cm; (II) with ileus or enterobrosis and accepted emergency surgery; (III) IV period tumor or tumor invading other organs were found during the preoperative or operative; (IV) others can't tolerate laparoscopic surgery.

Surgical position

Under general anesthesia, the patient was placed horizontal position with legs split. The surgeon was positioned on the left side of the patient, with the camera operator between the legs and the first assistance on the right of patient. And then place the patient at foot-high right side tilt position with starting the operation.

Surgical procedures

Incise 1cm skin in the middle point of 3–5 cm below the umbilicus. And making a 12 mm trocar as an observation hole. Building pneumoperitoneum and keeping the pressure in 12–15 mmHg. Chose a 12 mm trocar as the main operation hole under the umbilical 3 cm and left about 4 cm. Keeping three 5 mm trocars separated into the holds of under the umbilical 3 cm and right about 4 cm and the intersection points above the umbilicus 4 cm level and left and right collarbone midline.

The first step of the operation is abdominal exploration with a 30 degree camera to know whether there has any metastasis or invasion to adjacent organs and to verify the position, size and degree of external invasion. Then we cut the mesentery with ultrasound knife along the front left of superior mesenteric vein surgical trunk. Lymph nodes and adipose tissue around the roots should be dissected and the ileocolic vessel and the right colonic vessel should be ligated.

Cut avascular area in the left of the middle colic artery above the pancreatic body on the edge of the left transverse mesocolon root. Separation of the middle colic artery around to the branch in the colon, keep left to cut off the right one.

Along the ileocolic vein cut back the mesocolon, where we can enter the Toldt's fascia and extend it. If we enter the correct space, we can separate the ascending colon from retroperitoneum without bleeding. The last step of laparoscopy is to divide other ligament of ascending colon so that we can mobilize the ascending colon completely and reconstruct the digestive tract.

Results

The postoperative pathological says: colonic mucinous carcinomas have infiltrated all layer of serosa. Vascular cancer embolus can be seeing. There are two paracolic lymph nodes with metastasis, other 22 lymph nodes from colic mesentery and surgical trunk without metastasis.

Discussion

The CME proposed by Hohenberger *et al.* (2) brings a completely new concept for advanced colon cancer of normative surgery. CME was performed in 1,438 cases and proved that CME can improve 5-year survival rate after surgery and reduce relapse rate. The difference of the beginning time and the case numbers of such surgery lead to unbalance development of operation. There isn't normalizing surgery control criteria.

We support that there are three keys in Laparoscopy-assisted CME for right-hemi colon cancer: (I) first cut down the right-hemicolon feeding arteries which left to superior mesenteric vein surgical trunk and clear away 203, 213 group lymph nodes. Then dissect avascular area which in the left of middle colic artery of inferior border of body of pancreas and clear away 223 group lymph nodes; (II) identify the surgical plane and mesocolon can't be destroyed; (III) emphasizing block resection of lymph nodes and mesentery.

Conclusions

LR-CME is safe and efficient for the tumor locates in the right hemicolon.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Informed Consent: Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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Laparoscopic right hemicolectomy with transvaginal specimen extraction

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Contributions: (I) Conception and design: X Wang; (II) Administrative support: G Wang; (III) Provision of study materials or patients: Y Chen; (IV) Collection and assembly of data: Z Liu; (V) Data analysis and interpretation: G Wang, H Hu; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: This study demonstrates that laparoscopic right hemicolectomy with transvaginal specimen extraction is a feasible and safe alternative for the right colon cancer and some benign diseases. This procedure may bridge the gap between the conventional laparoscopic surgery and the incisionless surgery. Undoubtedly, large scale studies with long-term follow-up information are needed to further evaluate the safety and feasibility, which may warrant the role of this procedure as a well-established alternative for female patient with right colon diseases.

Keywords: Laparoscope; right hemicolectomy; transvaginal

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Introduction

Laparoscopic surgery is a well-established choice for the patients diagnosed with colon diseases. However, this technique inevitably needs an abdominal incision to extract the specimen and complete anastomosis, which could cause some incision-associated complications, such as infection and hernia. Besides, such an incision weakens the cosmetic effects to some extent. In order to minimize the trauma associated with the abdominal incision, natural orifice transluminal surgery (NOTES) has gain popularity among surgeons. This technique could avoid the bodily injury and decrease the incision-associated complications (1,2). Nevertheless, in the present, lack of reliable platforms and instruments and reliable methods to close the natural orifice incision, the complex procedures, high-selective operative approaches, and unclear exposure of surgical field, are obstacles to applying the NOTES (3,4).

Combining the notion of laparoscopic techniques with that of specimen extraction via natural orifice can sustain the advantages of both laparoscopic surgery and NOTES. It may bridge the gap between laparoscopy and NOTES. The vagina is regarded as a suitable route for natural orifice surgery and specimen extraction, considering the improved healing and elasticity compared to anus (5-10). Moreover, very rare studies related to laparoscopic right hemicolectomy with transvaginal specimen extraction are available. Here, we have introduced this new procedure of "laparoscopic right hemicolectomy with transvaginal specimen extraction" (11).

Patient selection and work-up

(I) The lesions are located at ascending colon and sex is female;
(II) The depth of tumor invasion is clinically less than T4;
(III) The maximal diameter of the lesion is less than 8 cm;
(IV) Body mass index (BMI) is less than 30 kg/m^2.

Pre-operative preparation

All the patients took oral laxatives in the evening the day before the surgery, and an enema was given three times in the morning on the day of surgery. During anesthetic induction, a single dose of second-generation cephalosporin's or levofloxacin was given by intravenous infusion. Such administration would be repeated if the operative time was more than three hours. All patients were given general anesthesia.

Equipment preference card

Laparoscope, regular general surgery equipment, ultrasound knife, 60 mm linear stapler, vaginal suture thread, sterile protection sleeve and uterine manipulator.

Procedure

The patient was placed in the split and left-title position with a pneumoperitoneum of 12 mmHg after the general anesthesia. The patients' arms were tucked at the side and their shoulders were securely taped to the operating table. The operator stood on the left of the patient, the first assistant stood on the right of the patient, and the second assistant stood between the legs of the patient. The laparoscopic camera was inserted through a 10 mm trocar near the belly button. The 12 mm trocar was placed slightly above the 5 cm left of umbilicus. Three 5-mm trocars were placed at the position of lower right quadrant, the insertion points of the umbilical line with the left and right midclavicular line, respectively. No metastasis, dissemination and multiple primary tumor was found in patients with cancer and the lesions were located at the ascending colon. We operated in the plane between the duodenum, head of pancreas and the mesocolon. Start to cut up the ascending mesocolon along superior mesenteric artery to the origin of ileocolic artery and vein. Dissection is continued through the Toldt space up to the lower edge of the pancreas, where the right colic artery and vein are observed and ligated. Then, the great omentum was divided carefully and the right branch of the middle colic artery and vein was ligated and dissected. Dissect the fatty tissue clearly on the wall of ileum at the planned anastomosis location. The great omentum was divided as a further step. The lymph nodes around the vessels were removed completely. Dissect the epiploic appendages clearly on the wall of transverse colon at the planned anastomosis location. The endo GIA linear stapler inserted through the 12 mm trocar transected the transverse colon. Division was continued along the Toldt space and the lateral attachments of the ascending colon with the abdominal wall were released. The endo GIA linear stapler inserted transected the terminal of the ileum. A small incision was made at the stump of the colon and ileum, respectively. Another endo GIA linear stapler was used to perform the functional end-to-end anastomosis and then enclose the stump of the transverse colon and ileum. After sterilizing the vagina with diluted povidone-iodine solution, the most visible bulging part of the posterior vagina was cut under laparoscopic guidance, the protective sleeve was inserted, and then the specimen was extracted via vagina. Warm distilled water flushed abdominal cavity. One drainage tube was placed at the side of anastomosis and the other drainage tube was placed at hepatorenal recess through the trocars in the right quadrant. The pneumoperitoneum was released and the holes of trocar were sutured. Till then, the operation had been finished. The picture of a patient's abdomen was presented (*Figures 1*,*2*).

Role of team members

It is of great importance that an experienced team consisting of a colorectal surgeon, orthopedic oncologic surgeon, spine surgeon, urologist, plastic surgeon, vascular surgeon, musculoskeletal radiologist, medical oncologist, radiation oncologist, and specialized anesthesiologist evaluate and surgically treat tumors that are large and extend to or destroy the hemipelvis or the upper half of the sacrum.

Post-operative management

Adequate pain control is necessary to maximize cardiac and respiratory function and decrease the risk of complications. Without large incision, patients feel less pain than traditional laparoscopic surgery.

As a result of surgical stress, there is an increase in renin, aldosterone, and antidiuretic hormone release and activation of the sympathetic system resulting in sequestration of fluid (third spacing) and increased volume requirements.

The resumption of a diet is critical to the recovery of the patient undergoing intestinal surgery. Before discharge, it is accepted that patients should tolerate oral analgesia, not require IV hydration, and demonstrate return of intestinal tract function.

Tips, tricks and pitfalls

Anatomy of superior mesenteric vein and Helen trunk and

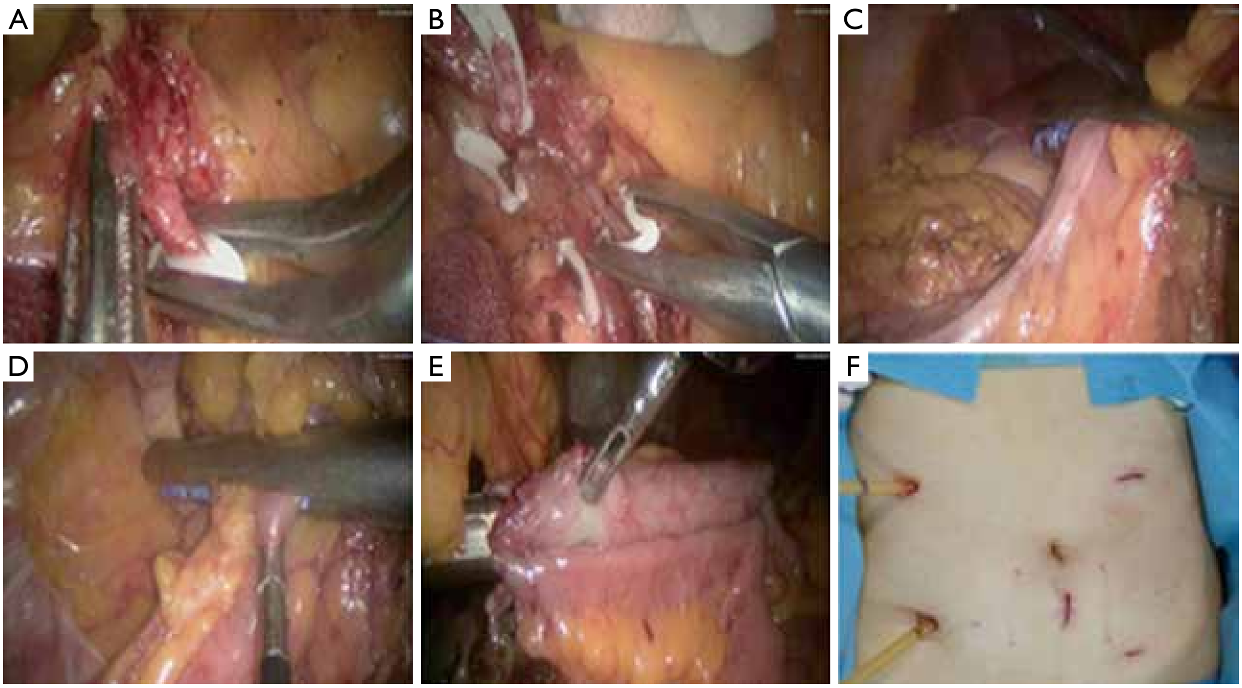

Figure 1 The procedure of resecting cancer and anastamosis. (A) The right colic artery and vein were ligated; (B) the right branch of the middle colic artery and vein was ligated; (C) the transverse colon was transected; (D) the terminal of the ileum was transected; (E) the functional end-to-end anastomosis was completed; (F) the picture of patient's abdomen.

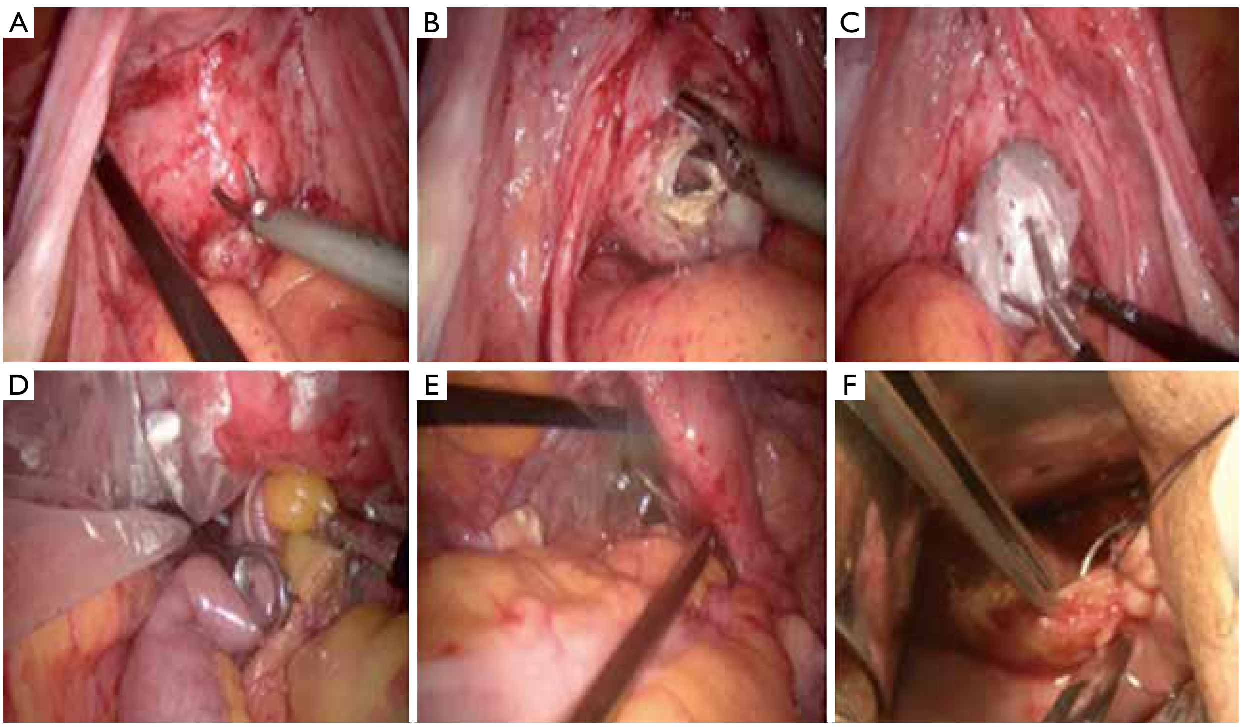

Figure 2 The specimen was extracted from vagina. (A,B) Widely expose and cut posterior vaginal fornix; (C) insert a protective sleeve into vaginal fornix; (D,E) oval clamp was inserted in to vaginal fornix and specimen was extracted via vagina; (F) continuously suture vaginal fornix.

Table 1 Characteristics of patients who received the surgeries

Characteristics	Outcome
Mean age	65
BMI (kg/m^2)	25.5
TNM	
I	2
II	–
III	–
IV	–
Adenoma	3
Tumor size (cm)	4.0
Operation time (min)	210.3
Blood loss (mL)	25.5
Open surgery	0
Complications	0
Function recover time (hr)	19.7
Lymph nodes examined	13.1
Positive margin	0

BMI, body mass index.

anterior pancreas-duodenum fascia is of vital important for right hemicolectomy. Laparoscope favors these procedures. To completely resect right hemi-colon, adequate exposure of superior mesenteric vein should be performed.

The main indications are introduced as follows: the depth of tumor invasion is T2–T3. The described procedure is suitable for early colon tumor and benign disease, and the elaborate preoperative examinations, such as CT scan and ultrasonic endoscopy, are necessary. The size of tumor is a very significant index. We recommend the maximal diameter is less than 8 centimeters. For the local advanced tumors and excessively obese patients, it is hard to extract the specimen through the vagina.

The right colic artery may also arise from the ileocolic or middle colic arteries and is absent in 2–18% of specimens. It supplies the ascending colon and hepatic flexure through its ascending and descending branches, both of them joining with neighboring vessels to contribute to the marginal artery. Thus, we should be prudent to deal with the arteries.

During our surgeries we performed functional end-to-end anastomosis (FEEA). The FEEA is a side-to-side anastomosis, and follows the excision of the ileocecal site and the ascending colon using linear staplers. There are many theories to explain why FEEA should fare better, including the wider diameter, a reduction in intraluminal pressure, and less proximal ischemia. The literature seems to suggest that the FEEA has become the most commonly preferred technique in recent times.

Here we make a description of the basic characteristics of patients who received the surgeries (*Table 1*).

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Laparoscopic complete mesocolic excision for cancer of the right colon

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Abstract: Complete mesocolic excision (CME) is a high-quality colon radical surgery, which follows fine surgical dissection and precise surgical concept. Laparoscopic CME combines the above advantages theoretically, while it is still in the early stages of application for the higher quality requirements and longer learning curve of CME. The current literatures suggested that laparoscopic CME could be achieved the same effect with the open for colon cancer. However in order to maximize patient benefits, laparoscopic CME needs more strict indications. Compared with the left colon, transverse colon, right colon resection specimens are of higher quality. So the right colon cancer is more suitable for laparoscopic CME. This article will describe the procedure of laparoscopic CME of the right colon step by step.

Keywords: Complete mesocolic excision (CME); laparoscopy; right colon cancer

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Because of minor injuries and rapid postoperative recovery, laparoscopic technique had been developed rapidly and used widely in colorectal surgery since the 1990s. Moreover, National Comprehensive Cancer Network (NCCN) had confirmed the feasibility of laparoscopic colectomy in 2008. Complete mesocolic excision (CME) is a high-quality radical surgery for colon cancer, which follows fine surgical dissection and precise surgical concept. NCCN had recommended it as a standardized surgical procedure for locally advanced colon cancer. Laparoscopic CME combines the above advantages theoretically, while it is still in the early stages of application for the higher quality requirements and longer learning curve of CME.

Laparoscopic right hemicolectomy is mainly used for cecal and ascending colon cancer. The patients were placed in supine position after the administration of general anesthesia. Using a five-port technique (*Figure 1*), the operator and camera operator stood on the left and the assistant on the other side.

The abdominal cavity was explored carefully. There were three approaches for laparoscopic colectomy: medial to lateral approach (medial approach), lateral to medial approach (lateral approach), and hybrid approach. The medial approach are thought to be due to decrease manipulation of the cancer, and reduce the vessel-related complication rate for prior division of vessels (1-3). As the initial step for the medial approach, the dissection started at ileocolic vessel (see *Figure 2*) and proceeded along superior mesenteric vein (SMV) (*Figure 3*). The ileocolic artery and vein were ligated at the root with clips (*Figure 4*), and the dissection continued upward to the right colic artery and vein, and the gastrocolic venous trunk (Henle trunk). The colic branch was transected, while the pancreatic and gastric branches were preserved. Hereafter the middle colic artery was exposed at its origin. After lymph node dissection in this region, the right branch of the middle colic artery was ligated.

Maintaining tension during exposing the potential surgical plane formed between the visceral fascia (posterior lobe of mesocolon) and the underlying parietal fascia (covering retroperitoneum, such as pancreas, duodenum, kidney, gonadal vessels, ureter, etc.) (see *Figure 5*). The mobilising range begins from the origin of transverse colon mesentery to the side peritoneum.

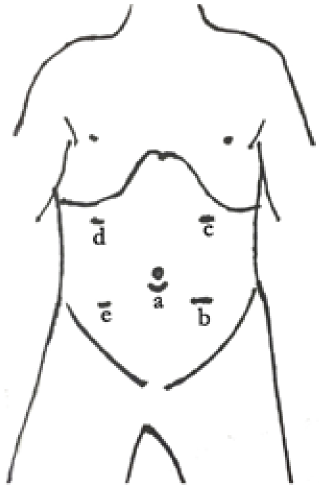

Figure 1 Skin incision of trocar placement of a 10 mm port for a camera (umbilicus) (a), a 12 mm port for a working port (below the umbilicus, left side, midclavicular line) (b) and another three 5 mm ports in each remaining quadrant (c,d,e).

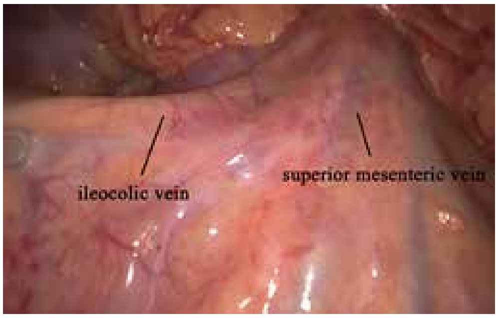

Figure 2 Using tension by retracting to confirm the vessels line.

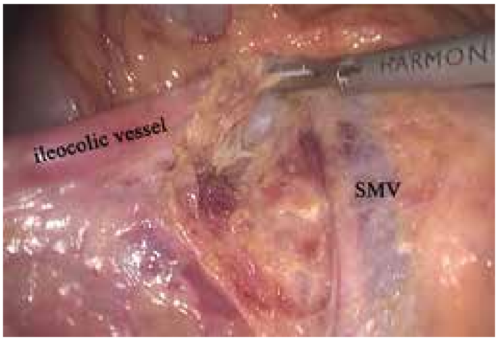

Figure 3 Exposing the superior mesenteric vein (SMV), in order to dividing the corresponding vessels at their origin from the superior mesenteric vessels.

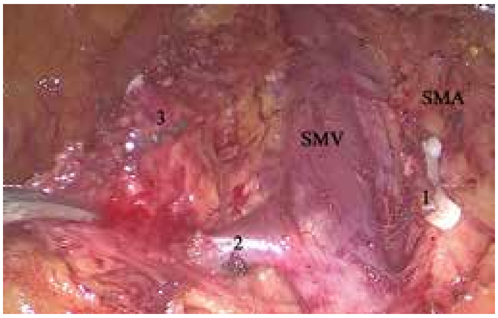

Figure 4 To expose the superior mesenteric artery (SMA), exposure of the superior mesenteric vein (SMV) at its right is necessary: root of the ileocolic artery [1]; ileocolic vein [2]; ileocolic artery [3].

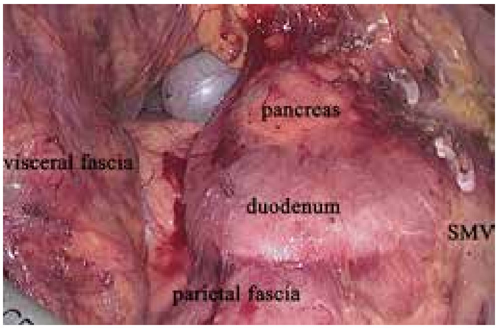

Figure 5 By a sharp dissection following an avascular surgical plane composed of visceral (covering the posterior mesocolon) and parietal (covering the retroperitoneal organs) fascia was exposed.

The entire mesocolon was preserved carefully. After removal of the specimen by enlarging the right upper quadrant incision (see *Figures 6,7*), an end-to-side ileocolic anastomosis was performed extracorporeally using stapled technique. It should be noted that the angle of anastomosis is smooth, in order to avoiding mesangial twist. After anastomosis, we need check it's no anastomotic bleeding and stenosis.

In cases of difficulty of finding the exact location of ileocolic pedicles, such as obese patients, blindly dissection will cause mesocolon rupture. For these patients, hybrid approach maybe an option. We can mobilise the ileocecal area firstly by lateral approach. The discrimination of the ileocolic pedicle from the SMV could be facilitated by prior mobilization of the ileocecal area (1) (see *Figure 8*).

Figure 6 Viewing the operative field, including whether the parietal fascia is intact, and the retroperitoneal organs such as ureter and reproductive vascular are uninjured.

Figure 7 Resected specimen of ascending colon cancer. A peritoneal window was made gently on the mesentery along the flow of the ileocolic artery to the SMV.

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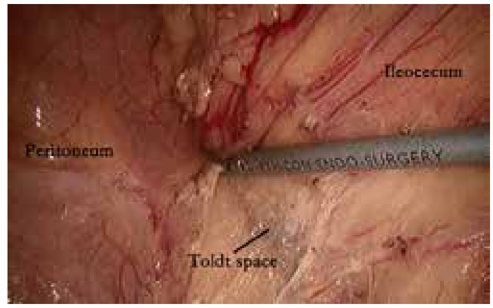

Figure 8 After the sharp incision at Toldt's line, The peritoneum lateral to the ileocecum is incised from Toldt's line applying traction and countertraction. An avascular plane in Toldt's space was developed by sharp dissection.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Laparoscopic-assisted radical left hemicolectomy

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Background: Laparoscopic-assisted radical left hemicolectomy (LRLH) is much less than other locations for its technical difficulty. There are rare reports about surgical skills of this operation. According to our rich experiences of laparoscopy surgical techniques recent years, we can proficiently master the surgical techniques and difficulties of LRLH base on the anatomy of blood vessels and the interfacial space.

Methods: A 34 years old patient who was diagnosed left colonic cancer, underwent LRLH. Combined with this case, we share the surgical technical of LRLH base on our experience.

Results: The length of operation was 80 min with bleeding of about 30 mL. The patient recovers well postoperation and discharged from hospital on the 5th day.

Conclusions: LRLH is safe and efficient for the tumor locates in the left hemicolon. Whereas, this operation is rarely difficult that should be done in the experienced center.

Keywords: Left colonic neoplasm; laparoscopy; surgical skills

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Introduction

Laparoscopic-assisted radical resection of colonic neoplasm was proved to be efficient in the past few years (1). More and more colonic surgeries are done by laparoscopy nowadays while laparoscopic-assisted radical left hemicolectomy (LRLH) is still uncommon. One of the real reasons is that the incidence of descending colonic neoplasm is very low, which was reported about 2.5% of all the colonic neoplasms (2). It can easily cause obstruction so it is not fit for laparoscopic surgery. Another is for its technical difficulties, such as complicated surgical anatomy, both superior mesenteric artery and inferior mesenteric artery lymph nodes dissection, splenic flexure mobilization etc. that needs a long term practice. To perform a LRLH, rich knowledge about anatomy, good surgical techniques and well teamwork are required. In this article and video (*Figure 1*), we would like to share the surgical techniques with you via a case of descending colonic neoplasm who underwent the LRLH. Moreover, electrocautery was used in most of the operating procedures, which might increase difficulty unless skilled enough.

Methods

Surgical indications

LRLH is suitable for the tumors locate in distal 1/3 of the transverse colon, splenic flexure, descending colon and upper sigmoid colon. Patient with severe cardiopulmonary insufficiency, obstruction or tumor bigger than 6 cm should be excluded.

In the present video, the patient is a 34 years old woman who was diagnosed moderately differentiated adenocarcinoma of splenic flexure by coloscope and histological test (*Figure 2*). The tumor stage was assessed to be cT3N1M0 by CT scan preoperation (*Figure 3*).

Figure 1 Laparoscopic-assisted radical left hemicolectomy (3). Available online: http://www.asvide.com/articles/709

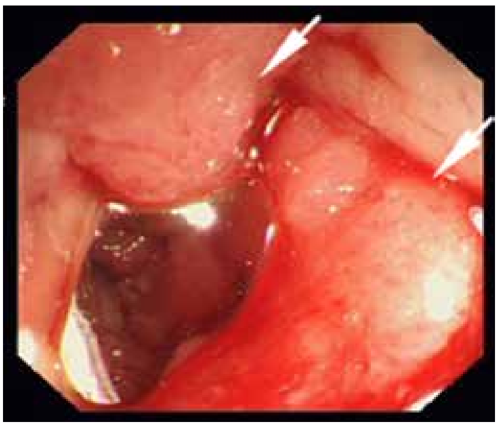

Figure 2 Coloscope.

Figure 3 Abdominal CT scan.

Surgical position

The patient is placed in a supine position after general anesthesia, with both legs split and arms folded. There are three monitors in our operation room that one is positioned above the head and others positioned behind each legs respectively. The operator stands on the right side of the patient while the fist assistance on the other side. Firstly, place the patient at a head-down right side tilt position with the camera assistance at the upper right side of the patient. And then place the patient at a feet-down right side tilt position with the camera assistance between the patient's legs.

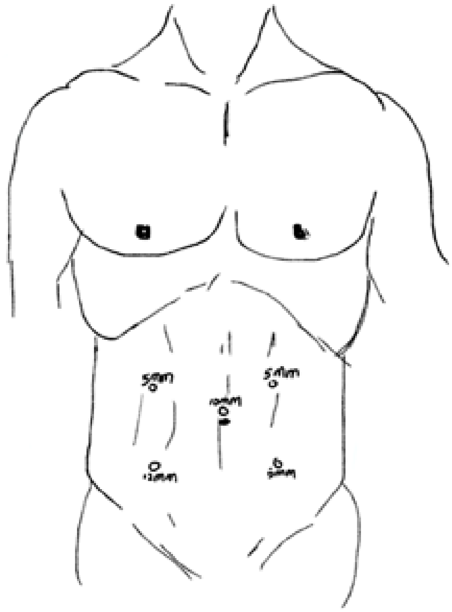

Figure 4 Trocars position.

Surgical procedures

Pneumoperitoneum was built via the Veress needle that should be maintained not to higher than 12 mmHg. In this operation, five trocars, a 12-mm, a 10-mm and three 5-mm trocars, are required. The 10-mm trocar was installed above the umbilicus firstly and a 30-degree laparoscope was inserted. Then other four trocars were installed under direct vision according to the previous position (*Figure 4*).

The first step of the operation is abdominal exploration to know whether there has any metastasis or invasion to adjacent organs. And then we cut the descending mesocolon from the inferior mesenteric artery, where we can enter the Toldt's fascia and extend it. If we enter the correct space, we can separate the descending colon from retroperitoneum up to the splenic flexure easily and even without bleeding. At the same time, lymph nodes alone inferior mesenteric artery, vein and their branch should be dissected and the vessels for descending colon should be ligated. In this

Figure 5 Surgical incision.

process, we must careful enough to protect the vessels for sigmoid colon and the rectum. For the tumor locate in the middle of descending colon in this case, we just dissected the lymph nodes alone left branch of middle colic artery and didn't ligated it. After handle with the vessels and freeing the descending colon, we can start resecting most of the great omentum of the transverse colon. The last step of laparoscopy is to divide the lienocolic ligament and the gastrocolic ligament so that we can mobilize the splenic flexure completely.

We made a left side paramedian about 5 cm in size to take out the tumor and use the anastomosis staplers the make a side-to-side anastomosis (*Figure 5*). At the end of the operation, we use the vicryl to seam the incision and the trocars holes.

Results

It took about 80 min to finish the whole operation with bleeding of about 30 mL. The pathology outcome after the surgery show it the moderately differentiated adenocarcinoma staging T3N1M0 (IIIB) with 1/12 lymph nodes positive. The patient recovers well postoperation without any significant complication and discharged from hospital on the 5th day.

Discussion

Laparoscopic-assisted radical colectomy has been proved to be safe and effective by many clinical trials (4,5). It has so many advantages like less blood loss, fast recover, shortened hospital stay, etc. that has been accepted gradually and become the standard surgical for colorectal cancer. However, for lack of patients with left colonic carcinoma and less practice, surgeons are unfamiliar with LRLH. What more, carcinoma in descending colon is easy to cause obstruction that make it unfit for laparoscopy surgery (6). In addition, left hemicolectomy requires to dissect the lymph nodes alone the superior mesenteric artery and the inferior mesenteric artery, which make the operation more difficult. The region of lymph nodes dissection should be decided according to the position of the tumor. Tumor locates in the descending colon or sigmoid colon can preserve the middle colic artery with lymph nodes dissection, while in splenic flexure or transverse colon should cut off the middle colic artery.

LRLH is really difficult for many surgeons, especially for young doctors. First attempt should be on the base of rich experiences of laparoscopy surgical techniques. It had better be under guidance of the experienced surgeon. When laparoscopy is hard to go on, we should convert to laparotomy as soon as possible.

Conclusions

LRLH is safe and efficient for the tumor locates in the left hemicolon. Whereas, this operation is rare difficult that should be done in the experienced center.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by the institutional ethical committee. Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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Superselective vascular surgery of rectum and sigmoid colon

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Preoperative preparation and exploration

Preoperative preparation

The preparation of laparoscopic surgery is similar with open surgery: (I) treat hypoproteinemia and anemia; (II) cure the electrolyte disturbances, and gastrointestinal decompression of pyloric obstruction patients; (III) soft semi-liquid diet 2 days before surgery and liquid diet 1 day before surgery; (IV) bowel preparation; (V) apply the stomach tube or nasal feeding tube preoperatively; (VI) skin preparation.

Indications

Superselective vascular surgery of rectum and sigmoid colon could be applied on diseases of rectum and sigmoid colon, benign diseases like diverticulitis and segmental Crohn's disease, unresectable polyp by colonoscope, and malignant diseases like colorectal cancer, colorectal endocrine tumors and GIST.

Contraindications

Absolute contraindications: patients with uncurable bad body condition, severe organ dysfunction and laparoscopic contraindication. Patients with severe septicopyemia, coagulopathy, gestational colon tumor, wide abdominal and lymphatic metastasis, settled tumor or tumor invasion to small intestine and wide abdominal adhesions that could not be resolved laparoscopically are also excluded. Relative contraindications: obvious bleeding trend, tumor size >6 cm, tumor with or without severe adjacent invasion, severe abdominal adhesions, severe obesity, emergent colorectal cancer surgery and cardiopulmonary dysfunction.

Surgical appliance

Conventional appliances

These appliances include camera and display system, insufflators, flushing and suction device, and video and image storage devices as well as laparoscopic instruments such as Trocar and forceps.

Special appliances

These appliances include ultrasound knife, Ligasure high-energy electric knife, unipolar electrocoagulation device, all kinds of gastrointestinal anastomosis staplers and circular staplers.

Methods of operation

Body position

The optimal body position should be improved lithotomy position. The legs are settled horizontally.

The operator stand on the right side of the patient, while first assistant on the left and the scope-holder on the operator's left side. Monitor stands near patient's feet. Another monitor would be needed at the head side when dissociating the spleen area.

Location of trocar

At present we use the 5-hole method. The scopic hole is located at the lower edge of navel and the 10–12 cm trocar as the observation hole. This spot is used in almost all laparoscopic surgeries and it brings less disturbance to the operator. For the old and fat patients, the peritoneum is relatively immobile, which makes it easier to operate and puncture. Ensure the secondary injury by the trocar after inserting the scope. Then modify the trocar to the optimal position through the hole at the end of the trocar. The shorter the celiac part of the trocar is, the more convenient the operation would be.

Use Mcburney points as the operating holes and penetrate them with 12 cm-trocars while the air pressure is 1.6–1.87 kPa. Adjust the operator's assistant operating hole according to the intraperitoneal situation. The holes for operator and assistants are basically on the left side of patient's abdomen. To avoid being interrupted by each other, the distance of each hole should be more than 5–6 cm.

With regard to female patients, a suture though the abdominal wall could be used to pull the uterus up to expose the pelvic cavity clearly.

Surgical procedure

The operating path is an inside-out and bottom-up and middle processing way. The following principles should be obeyed in tumor surgeries: (I) tumor principle—vein ligation before tumor management, avoiding pressing and touching tumor, incisal margin >10 cm away from tumor, water flushing, and incision protection; (II) rectal cancer total mesorectal excision (TME)—keeping the completeness of the mesentery to prevent the tumor cells falling off; (III) R0 resection. According to the tumor location and the intestine part that needs to be resected, the blood vessel that should be preserved varies. For the tumor located at the middle and lower part of rectum, the descending colon artery should be preserved. For the tumor in the descending colon, the superior rectal artery should be preserved. Next the mentioned two situations will be discussed.

Tumor at the middle and lower part of rectum

After abdominal expedition, generally, sigmoid colon mesentery should be debonded to make it easier for the assistant to pull up the sigmoid colon. Ligature the colon that is 10 cm from the tumor with galloon.

(I) Medial sigmoid colon dissociation

Cut open the medial sigmoid colon mesentery. The assistant uses one hand to pull the rectum to front side with bowel forceps, while the other hand pulls the mesentery, in which the superior rectal artery lays, to front and upper side. The operator at the meantime holds the posterior peritoneum of the sigmoid colon to keep the colon intense. Cut open the mesentery to the Toldt's space.

(II) Expand the Toldt's space

Then the assistant keeps the tension of the mesentery, while the operator carefully expands the Toldt's space. The completeness of left part of colon mesentery and prerenal fascia should be ensured to avoid injuring inferior mesenteric plexus and ureter and reproductive blood vessels. Left colon mesentery can be dissociated up to pancreas, and out to left colon sulcus. Key point for assistants: keep the tension of the mesentery, lift the rectum and the inferior mesenteric vascular pedicle.

(III) Expose the inferior mesenteric artery and nerves

The gray superior hypogastric plexus can be seen at the intersection of two common iliac arteries. Dissociate the mesentery along the surface of the plexus and abdominal aorta to inferior mesenteric arterial root. Perform resection of lymph node and adipose tissue of the area. Vascularize the inferior mesenteric artery or perform VLND. Then dissociate the blood vessels from proximal to distal. Pay attention to the left colon artery which lays at the inferior mesenteric arterial root. Protect it and the inferior mesenteric vein. Open the peritoneum of both sides of sigmoid colon and rectum along the Toldt's space and protect the ureter.

The assistant lifts up the rectum and bares 2–3 sigmoid colic vessels then finally bares the superior rectal artery. Protect concomitant the inferior mesenteric vein. Dissociate the sigmoid colic and descending colic mesentery and separate the Toldt's space to duodenojejunal flexure and left colic sulcus. Expose the inferior mesenteric vein by the lower side of pancreas. Separate the left Toldt's space to splenic flexure of colon and expose the space below the mesentery. Cut off the inferior mesenteric vein and then the descending colic mesentery. Resect left colic mesentery and lymphoid and adipose tissue around the inferior mesenteric artery. Choose to preserve left colic vessels or superior rectal vessels as required. Intrathecal or extrathecal lymph node resection can be selected according to the relation of lymph nodes and vessels.

Key points for operators: when performing the vascularized lymph node resection of inferior mesenteric vessels, we suggest opening the vagina vasorum with separating pliers left handed from near to distal end. Don't touch the vessels with ultrasound knife for too long and avoid heat injury. Preserving the left colic vessels may increase the tension of anastomotic stoma. So we need to dissociate the Toldt's space towards tail of pancreas and cut off descending colic mesentery by the lower side of pancreas so that the descending colon could fall down to pelvic cavity. Dissociate splenic flexure and distal transverse colon if necessary.

Key points for assistants: when the operator dissociates the inferior mesenteric artery, the assistant should change the holding spot flexibly and keep the tension neither too intense nor too loose because neither brings benefit to the surgery.

Key point for scope holder: be skillful, flexible and use multi-angle observation.

Radical prostatectomy of descending-sigmoid junction colon cancer

Dissociate the posterolateral part of descending colon, sigmoid colon and upper rectum.

(I) Descending and sigmoid colon posterolateral dissociation: draw the sigmoid colic mesentery to the right, turn the sigmoid colon around. Separate the mesentery from the back to right, then go up to the splenic flexure level.

(II) Upper rectum posterolateral dissociation: go into the loose connective tissue behind the upper rectal mesentery from sacral promontory level. Expand to postrectal spatia. Then expand the peritoneal incisions to the upper rectum level. According to the tumor's location, continue the organ expedition, separate loose connective tissue under direct vision. Keep the completeness of mesorectum. Open the subperitoneal fascia in the way of total mesorectal excision, and enter the loose connective tissue then dissociate to the lateral rectal ligaments. Protect the sacral plexus. Cut open the peritoneal reflection, separate the Denovilliers fascia. Cut off both collateral ligaments and sacral rectal ligaments to levator ani level. The mesorectum then is dissociated completely.

Bare the upper rectal bowel, and remove the resected specimen

Bare the bowel with the ultrasound knife. Cut off the bowel with Endo-GIA Stapler through the 12 mm operating hole.

Key point for operator: cooperate with the assistant to make the mesorectum intense with the left hand and use the right hand to hold the ultrasound knife to cut the mesentery. Touch the bowel with non-working surface of the knife to avoid injuring it.

Key point for assistant: it is of great importance to keep the tension of the mesentery. Grab the proximal bowel with the left forceps, and pull the mesentery to cephalic and dorsal way to make flat the mesentery.

Removal of the specimen: according to the tumor location select the transabdominal anastomosis with mini incision or peranum anastomosis. Make sure that the end of the cut-off bowel is >10 cm from the tumor. The distance of sigmoid colic cancer and upper rectal cancer to the cut-off end should be more than 5 cm while middle or lower rectal cancer more than 2 cm.

Attentions

(I) The judgment to the anatomic spaces and path selection is clearer and more accurate intraoperatively. Identification and protection of pelvic plexus is more definite. The rectal mesentery can be more completely cut off by the ultrasound knife. All of these make it accord with the TME principles. The operator must have excellent surgical experience and laparoscopic operating skills, especially the skill of vessel dissociation with ultrasound knife.

(II) Identification of inferior mesenteric artery: find the aorta abdominalis first. When the sigmoid colic mesentery is lifted by the assistant the inferior mesenteric artery can be seen to angulate with the aorta abdominalis. From this spot the inferior mesenteric artery is easier to be separated. When skeletonizing vessel, the assistant should adjust the dragging direction. Lift up the inferior mesenteric vessels then the scope holder change the angle of the scope. The assistant should drag the Inferior mesenteric vessels to the pelvic cavity to make if easier for the operator to dissociate the vessels.

(III) Identify the anatomical layers. After opening the peritoneum, go along the Toldt's space then enter the loose space between the proper fascia of rectum and parietal pelvic fascia. Separate the anterior rectum between Denonvillier fascia and seminal vesicle. Make sure the mesorectum cut off completely.

(IV) The assist by the assistants is also important. First assistant should not only help expose the operating area but also make the bowel or mesentery intense.

The scope holder should fully use the 30-degree visual angle, especially in the narrow pelvic cavity. Repeatedly adjust the visual field when dealing with the rectum.

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Key points of tumor-free operation in laparoscopic resection for colorectal cancer

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Abstract: Tumor-free operation is an important principle of oncological surgery for colorectal cancer. Laparoscopic resection of colorectal cancer should also adhere to the tumor-free operation principle. Iatrogenic dissemination of cancer cells into the abdominal cavity during the laparoscopic resection of colorectal cancer is possible and should be paid attention by the surgeons. In order to reduce the rate of peritoneal seeding, the tumor-free operation principle should be implemented throughout the whole laparoscopic procedure. The steps we should follow as a routine practice include: (I) proper management of trocars and the pneumoperitoneum; (II) no-touch and protection of the tumor; (III) protection of the incision wound; (IV) priority of the high vascular ligation; (V) *en bloc* resection of the primary tumor and regional lymph nodes; (VI) sharp resection of the tumor; (VII) complete mesocolic excision (CME) of colon cancer and total mesorectal excision (TME) of rectal cancer; (VIII) replacement of the surgical instrument and gloves after the removal of the tumor; (IX) satisfactory scrub and irrigation; and (X) selective intraperitoneal chemotherapy.

Keywords: Colorectal cancer; laparoscopic resection; tumor-free operation

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In the current age of minimally invasive surgery, laparoscopic technique has accomplished a major progress in the treatment of colorectal cancer (1-3). As with conventional open surgery, laparoscopic surgery for colorectal cancer is also required to follow the principles of tumor-free operation to reduce the risk of iatrogenic dissemination of cancer cells on the peritoneal surface. In the early 1990s, there was reports of port site recurrence up to 21% when the laparoscopic resection for colorectal cancer started initially (4). However, with the increasing maturity of laparoscopic procedure and highly emphasizing the importance of the principle of tumor-free operation, the incidence of port site metastases has significantly decreased to below 3% (5-7).

Reports of port site metastasis have stimulated clinical and basic research, attempt to explain the possible mechanisms involved in the pathogenesis of peritoneal dissemination in laparoscopic surgery for colorectal cancer (8-10). The possible mechanisms of peritoneal seeding of colorectal cancer cells in laparoscopic procedure include the following aspects: (I) the tumor penetrates the serosa, escapes from the primary tumor and spreads in the peritoneum; (II) the excessive manipulation of tumor during laparoscopic surgery; (III) tumor cells spread during lymphadenectomy in patients with lymphatic invasion or lymph node involvement; (IV) the hemorrhage during the surgery for colorectal cancers with vascular invasion. These shedding cancer cells enter the abdominal cavity, enwrapped by the fibrin and blood clots, inducing the peritoneal implantation with the effect of immunologic responses. The exploring and understanding of the mechanisms of peritoneal dissemination of colorectal cancer cells provides clues for surgeons to take essential measures to reduce the cancer cell dissemination.

In order to reduce the potential peritoneal dissemination of cancer cells, the following three principles should be obeyed by surgeons:

(I) The principle of multidisciplinary comprehensive treatment. For colorectal cancer patients with high risks of metastasis, such as primary carcinoma invading the surrounding organs (T4), lymph node involvement and positive resection margin, perioperative neoadjuvant and adjuvant chemotherapy or chemoradiotherapy should be taken into consideration.

(II) The principle of tumor-free operation. A set of effective measures of tumor-free operation performed in the open surgery can also be applied in the laparoscopic surgery.

(III) Awareness of the specificity of laparoscopic operation. Strengthen the management of pneumoperitoneum during the laparoscopic surgery.

The principle of tumor-free operation should be kept in mind by surgeons, which runs through the whole process of laparoscopic operation. The following are key points of tumor-free operation in laparoscopic resection for colorectal cancer.

Operation associated with trocars

Placement of trocars

Proper placement of trocars to minimize tissue trauma is important. A suitable size of puncture hole made with trocar helps to perform trocar fixation to prevent trocars slipping off and CO_2 leakage around trocars. Caution should be exercised during the operation to reduce the risk of bleeding.

Removal of trocars

Before the trocar removal, the gas in the trocar sheath should be exhausted first, then the trocar can be removed. In that case, it can reduce the incidence of port site recurrence caused by the "chimney effect" (the chimney effect refers to the increase in the number of tumor cells at the port sites caused by leakage of gas along the trocars) (11).

The pressure of pneumoperitoneum

Appropriate pneumoperitoneum pressure is essential in the laparoscopic operation. A carbondioxide pneumoperitoneum at 12–15 mmHg is most commonly used which provides good laparoscopic visualization and sufficient working space (12). In the premise of obtaining sufficient operation space, it's recommended to choose a relatively low pressure of pneumoperitoneum.

The principles of laparoscopic exploration

Laparoscopic exploration should follow the principle of "from far to near", and explore the tumor in the end.

The principles of tumor resection

Protection of the tumor surface

It is recommended for carcinomas with serosa invasion to isolate serous surface by using gauze or blocking glue, in an attempt to prevent the shedding of cancer cells.

No-touch technique

"No-touch" principle should be followed throughout the operation: (I) minimal or even no touch with tumor; (II) avoidance of squeezing the tumor. The following four points should be complied with to the best of the surgeons' efforts: (I) minimum frequency of tumor touch; (II) minimum duration of tumor touch; (III) latest time of tumor touch; and (IV) preferably no touch with tumor.

Use protective bags to retrieve specimen

For the specimens resected from different regions, each specimen can be placed in a protective bag, which can be taken out together when the resection of all lesions and tissues and organs involved is accomplished. For example, in the laparoscopic resection of rectal cancer combined with bilateral lateral lymph nodes, the preferential removal of lateral lymph nodes can be put into a protective bag (gloves or disposable protective bags, etc.), which can be taken out together with other resected specimens(the other side of lateral lymph nodes and the rectal cancer).

Performing high vascular ligature

Once the resection scope is determined, central ligation of main supplying vessels first may reduce the risk of hematogenous dissemination of cancer cells (13). A high main reflux vein ligation is recommended if circumstances permit. For instance, in the radical resection of rectal carcinoma, surgeons can cut off the inferior mesenteric vein first, then cut off the main artery (the inferior mesenteric artery or superior rectal artery) and finally perform tumor resection.

Regional lymph node dissection

Current principle of colorectal cancer surgery is en bloc resection of the primary tumor with regional lymph nodes and all grossly suspected or involved lesions should be removed during operation (14). The operation of single lymph node resection should be avoided as possible. As it should be, a biopsy or resection of lymph nodes outside the drainage area is acceptable.

Sharp dissection

Sharp dissection is conducive to reducing the traction and squeeze involved in handling of tumor. To carry out accurate sharp dissection needs to maintain good tension in the operation. Nevertheless, some experts suggest that sharp dissection and blunt dissection be combined in laparoscopic surgery due to its particularity, in that case, the operation will be more secure and easier to master from a technical aspect. However, in terms of the principles of oncology, sharp dissection may be more reasonable and is proposed to be performed in laparoscopic surgery.

Removing the mesocolon or mesorectum as one package

Total mesorectal excision (TME) and complete mesocolic excision (CME) have become essential principles of radical resection for colorectal cancer (15,16). The concept of membrane anatomy has been increasingly emphasized by surgeons. TME/CME prevents the shedding of cancer cells by en bloc resection of a primary tumor and mesorectum/mesocolon as one package, contributing to the improvement of outcomes (15,16).

Minimizing haemorrhage

Only by minimizing haemorrhage can surgeons obtain a clear surgical field to ensure laparoscopic operation smooth and successful. If there are free cancer cells in circulatory system or vascular involvement, haemorrhage may also result in the spillage of cancer cells into the peritoneal cavity and onto the surfaces traumatized during surgery. Therefore, to minimize haemorrhage by operating carefully and suctioning blood clots promptly and thoroughly can also help to reduce the spread of cancer cells.

Instruments cleaning and glove replacement

The instruments should be cleaned or even replaced if there's obvious contact with tumor. After the removal of tumor specimens, the gloves should be replaced and the resection margin should be washed before the intestinal reconstruction. Rinsing the tip of instruments if they touch the tumor before they are reintroduced into the abdominal cavity (13). Betadine solution is recommended since it has been confirmed to be tumoricidal by many investigators (17).

Scrub and irrigation

The procedure of scrub and irrigation

When specimen is removed out of the abdominal cavity, the resection margin and surgical field should be irrigating *in vivo* or *in vitro*. The cut edge of intestine is proposed to be scrubbed with iodophor gauze or gauze ball before the anastomosis of intestines, aiming to avoid cancer cells shedding into the anastomosis. Anastomosis site needs irrigating again when the anastomosis is completed. Besides, the abdominal auxiliary incision wound and puncture port-site should also be irrigated with iodophor and water. The careful suction of blood clots and fat blocks is also needed.

The application of irrigation fluid

There are many arguments about the application of irrigation fluid in clinical practice. In addition to cleaning effect, ideal irrigation fluid needs to be capable of destroying cancer cells. In general, double distilled water (DDW) is better than normal saline (NS). Immersion in 43 ℃ DDW is better than that in DDW at ambient temperature. Immersion in 1:2,000 chlorhexidine at ambient temperature lasting for 3 minutes is equal to that in 43 ℃ DDW lasting for 10 minutes. Therefore, irrigation with 1:2,000 chlorhexidine at ambient temperature after the removal of specimens is a relatively simple and effective method. However, there is no supply of chlorhexidine in many hospitals, as a result, chlorhexidine is replaced by diluted iodophor. Diluted iodophor is effective disinfectant confirmed by many investigators (17). The 0.5–1% diluted iodophor is widely used for disinfection of skin and instruments. It is noteworthy that the surgical area should be irrigated with sufficient NS (500–1,000 mL) after irrigation with chlorhexidine or diluted iodophor.

Incision protection

Incision protection must be done immediately after entering the abdominal cavity in open surgery. Different from open surgery, the auxiliary incision from which specimen is taken out is created in laparoscopic surgery when the tumor is resected or is about to be removed. The incision in laparoscopic surgery also needs protection in order to reduce the incidence of specimens touching incision leading to tumor cell implantation. There are many products and ways for incision protection. The incision protection sleeve with sealing cover is recommended.

Selective intraperitoneal chemotherapy

Intraperitoneal chemotherapy is not the standard treatment for colorectal cancer at present. But intraperitoneal chemotherapy, especially hyperthermic intraperitoneal chemotherapy (HIPEC), may reduce the risk of peritoneal metastasis for colorectal cancer patients with the following high risk factors: (I) serosa invasion (T3/T4); (II) mucinous carcinoma or signet ring cell cancer; (III) positive resection margins; (IV) tumor rupture; or (V) intestinal perforation. A small sample study conducted by Sammartino *et al.* indicated that HIPEC seems to achieve a good local control in preventing peritoneal dissemination without significant increase of the perioperative morbidity (18). Mitomycin, cisplatin and oxaliplatin are chemotherapeutics commonly used in HIPEC. HIPEC is carried out lasting 30–90 minutes at a temperature of 42–43 ℃ (19,20). The time of HIPEC lasting varies in different chemotherapeutic drugs.

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Footnote

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Always on the way towards precise TMEtter understanding of fascia and vascular anatomy around mesorectum

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Abstract: Even though laparoscopic surgery for colon cancer has long been established as a standard treatment, the effectiveness of laparoscopic surgery for rectal cancer in long-term results as well as in cancer clearance remains controversial. While some researches indicated similar short-term and long-term outcomes between laparoscopic and open surgery, others warned about an increased risk of positive circumferential margin and incomplete TME associated with laparoscopic surgery. However, the issue of incomplete TME is likely more related to the experience and volume of a surgeon than the technique itself. For a beginner, laparoscopic surgery certainly has a steeper learning curve than its open counterpart. To ensure a complete mesorectum resection in difficult cases, one may need hundreds of cases to perfect his skill. However, the author believes that laparoscopic surgery is promising in providing superior quality of surgery for rectal cancer, because the laparoscope gives us a direct and clearer view of the lower pelvis, especially structures around the levator hiatus, which could not always be viewed in obese patients with low rectal cancer in open surgery. Here, we introduce our experience and key anatomic landmarks for laparoscopic low anterior resection for low rectal cancer.

Keywords: Rectal cancer; laparoscopic surgery; total mesorectal excision

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The key to a complete excision of mesorectum is to dissect along the fascia propria of mesorectum which envelopes the mesorectum. However, there has been no consensus over the correct dissecting plane in the anterolateral aspect of mesorectum. Heald advocated dissecting in front of the Denovilliers fascia (DVF) and transecting it along the inner verge of neurovascular bundle. Others claim that dissection behind DVF is ok, given the anterior meserectum is not involved. Incorrect dissecting plane will lead to either incomplete mesorectum removal or damage to pelvic autonomic nerves. Here we introduce our understanding of fasica and vascular anatomy around the lower mesorectum and our way of performing low anterior resection for rectal cancer.

How we get into the right plane at the start

The most important landmark to guide the whole procedure of TME is undoubtedly the fascia propria of mesorectum, which extends cephalad into the fascia propria of mesocolon, covering the mesocolon in its posterior aspect. The best point to have a good start is before the sacral promontory. In order to get into the right plane quickly and easily, the assistant need to hold the sigmoid mesocolon with two forceps and pull it in a way that there are no folds in this part of mesocolon, and the superior rectal artery is stretched (*Figure 1A*). After cutting the peritoneum with monopolar shears, carbon dioxide will enter and fill the retro-rectal and retrocolon space automatically (*Figure 1B*). Cutting the peritoneum along the upper edge of air filled space will ensure entering into the right plane, closest to the mesorectal fascia(MRF), and prevent us from entering behind the hypogastric nerve (*Figure 2A*). Holding on to the nerve itself will gain a wider retrorectal space (*Figure 2B*).

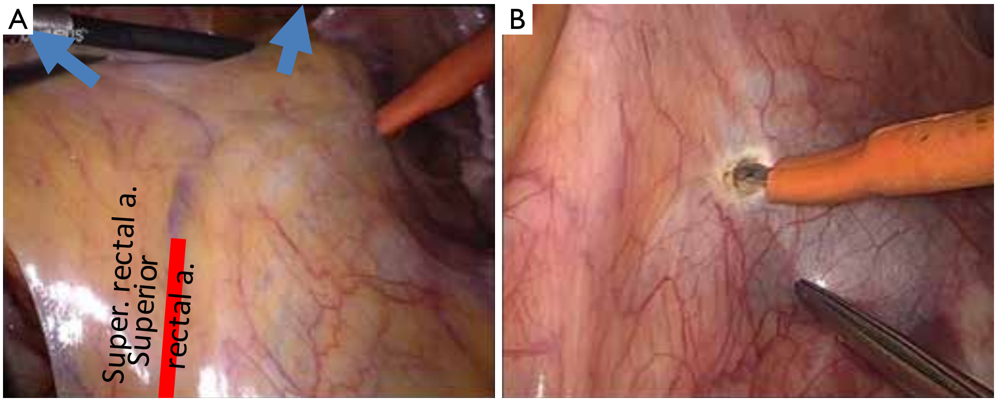

Figure 1 Retraction of mesosigmoid and the starting point. (A) Retraction on the sigmoid mesocolon; (B) tension will allow air fill retrorectal space automatically.

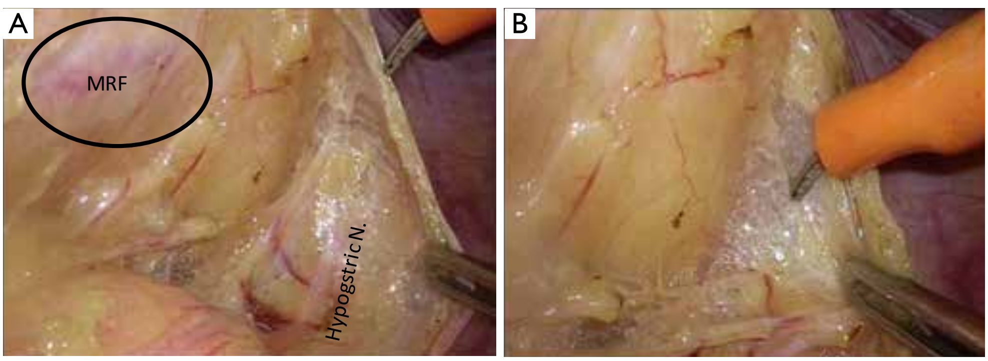

Figure 2 To identify the mesorectal fasciae. (A) Mesorectal fasica be seen as the landmark; (B) retract on the hypogastric nerve.

How to get a high ligation of SMA

After mobilization of sigmoid mesocolon in front of the sacral promontory and the left iliac fossa, the assistant takes hold of the superior rectal vessels at a higher (proximal) place, stretch and push the mesentery ventrally, thus forming an angle of no less than 45 degree between IMA and the aorta (*Figure 3A*) which facilitates approaching the origin of IMA. Cut the peritoneum up to the area between the duodenum and the origin of IMA, from where IMA can always be easily identified. It is preferable to enter the sheath of IMA before severing it, considering the close attachment of the superior hypogastric plexus to the IMA (*Figure 3B*).

After ligation of IMA 1-2 cm away from its origin, the nerves to the mesocolon are divided at a distal level to avoid injury to the hypogastric plexus, as shown in *Figure 4*.

The inferior mesenteric vein can be divided at the lower edge of the pancreas or after branching of the left colic vein. Cautions must be paid to preserve the bifurcation of left colic artery, which may serve as an alternative pathway, in case there is a discontinuation of marginal vessel at the Griffith Point at the splenic flexure.

How to mobilize the descending colon up to the splenic flexure

The best way to approach the splenic flexure is to mobilize from behind the descending mesocolon. To get a good view, the assistant need to hold the upper sigmoid colon from behind the mesocolon, and stretch the descending colon caudally. The surgeon pushes the descending mesocolon ventrally and cephalad. Dissection should be carried out in front of the Toldt's fascia. Cutting tiny vessels passing through Toldt's fascia and fascia propria followed by blunt dissection will help maintain a perfect dissecting plane (*Figure 5*).

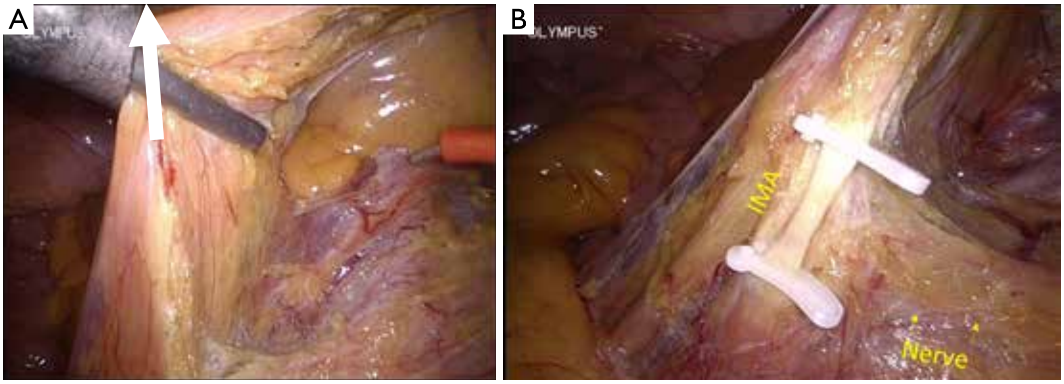

Figure 3 Ligation of inferior mesenteric artery. (A) Pull up the sigmoid mesocolon; (B) open the sheath of IMA and ligate it.

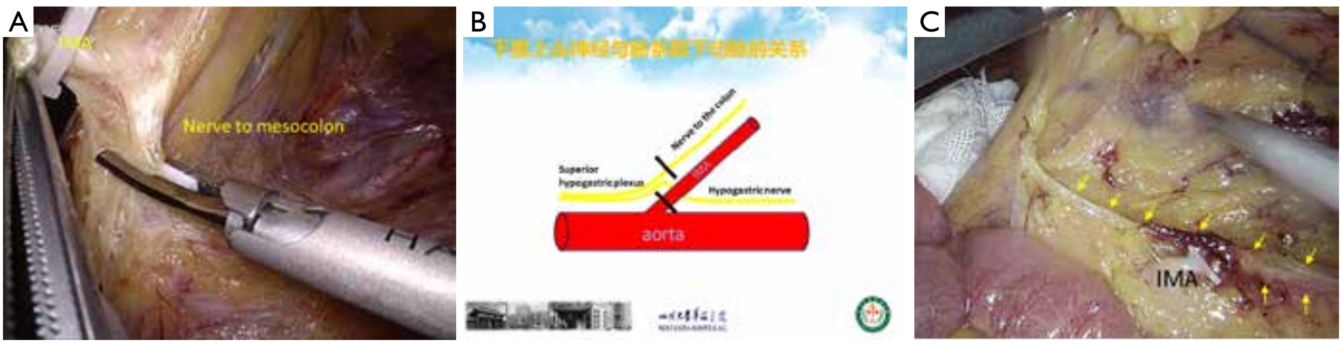

Figure 4 After dividing the IMA, nerve to the colon is divided at a distal level to preserve superior hypogastric plexus.

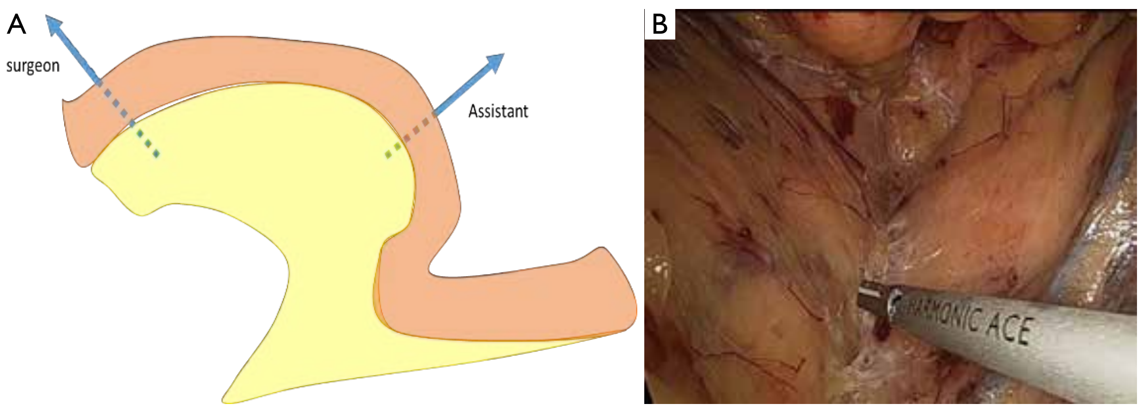

Figure 5 Mobilization of descending colon. (A) Retraction of descending and sigmoid colon; (B) dissect in front of Toldt's fascia.

How to carry on posterior dissection down into the superior levator space

Dissection in the retrorectal space is relatively easy. One must stay close to fascia propria of mesorectum to avoid injuries to the hypogastric nerve or tearing of the thin-walled presacral vein (*Figure 6A*). But when dissection comes down to the curvature between sacrum and coccyx, where one can always notice condensed fatty/connective tissue, the so called rectosacral ligament, which requires division with monopolar shear or ultrasonic shear, preferably a little bit away from the fascia propria. Staying too close at this level

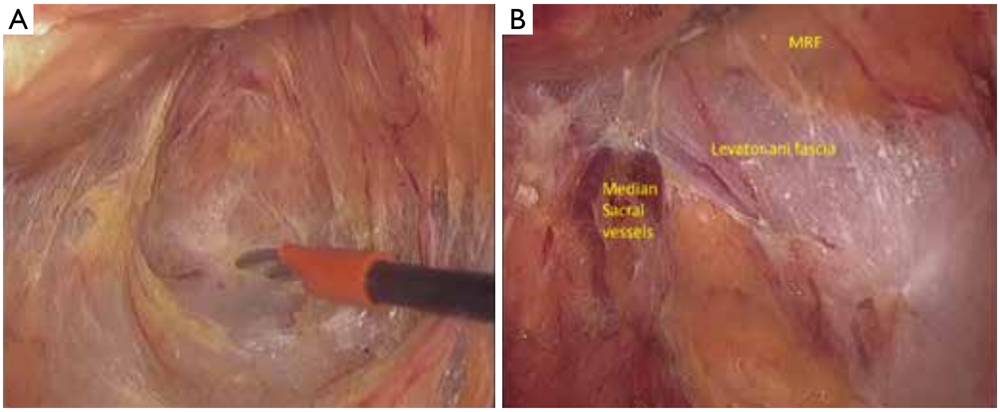

Figure 6 Retrorectal space dissection. (A) Stay close to MRF; (B) enter the supralevator space.

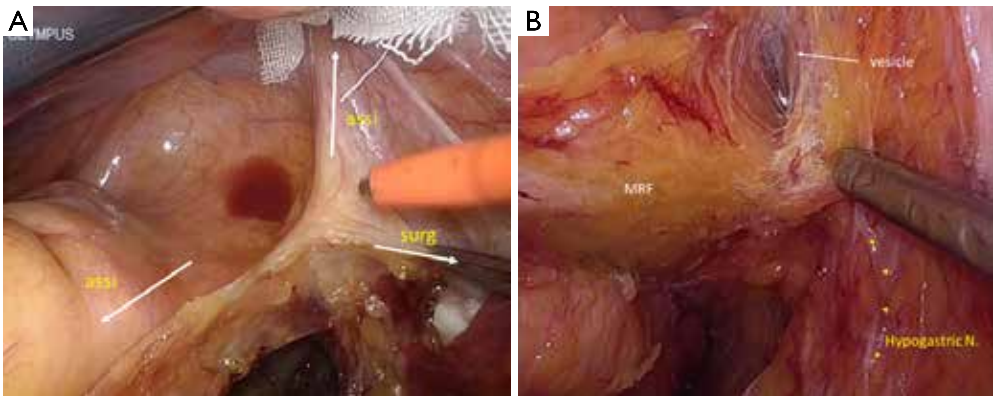

Figure 7 (A) Retraction for anterior dissection; (B) enter in front of DVF.

might lead you into the thin and loose distal mesorectum. After division of rectosacral ligament, the loose and wide supralevator space is entered, and dissection should be carried along the levator ani fascia, which constitutes the landmark of dissection in the supralevator space (*Figure 6B*).

How to enter into the right plane before Denovilliers' fascia

On the right side, the assistant applies cephalad retraction on the mesorectum and ventral retraction on the bladder in male and uterus/ broad ligament in female (*Figure 7A*). The surgeon pulls the retroperitoneum or the hypogastric nerve outwardly. Separation of mesorectum away from the hypogastric nerve is carried on under direct viewing of fascia propria and hypogastric nerve till reaching the level of seminiferous duct or corresponding level in female. Then, cutting the peritoneum a little bit away from the peritoneum reflex (following the curvature of mesoretum), followed by gentle pushing on the anterior pelvic wall will allow identification of the seminiferous duct (*Figure 7B*). Gentle blunt separation of mesorectum from the seminal vesicle will set up the correct dissecting plane in front of Denovilliers fascia (*Figure 8A*). The setting up of anterior dissection plane on the left side can be achieved in a similar way, except the upward retraction of mesorectum being applied by the surgeon himself (*Figure 8B*). We do not suggest incision of peritoneum in the midline, 1-2 cm away from the peritoneum reflex on the bladder side, as suggested by other authors. This method will not certainly develop a dissection plane in front of DVF.

Anatomy of Denovilliers fascia and tiny vessels feeding the mesorectum

DVF used to be regarded as a single layer structure in

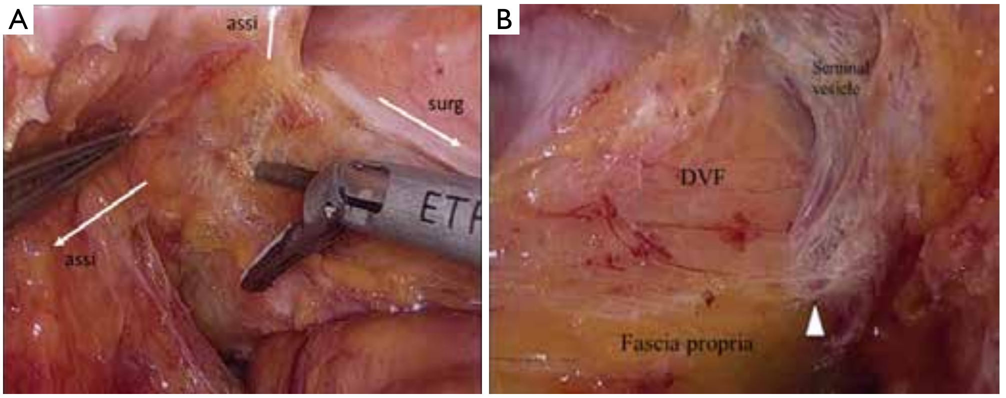

Figure 8 How to get in front of DVF. (A) Dissecting plane in front of DVF, white triangle indicates the point to start dividing of DVF; (B) retraction for anterior dissection on the left.

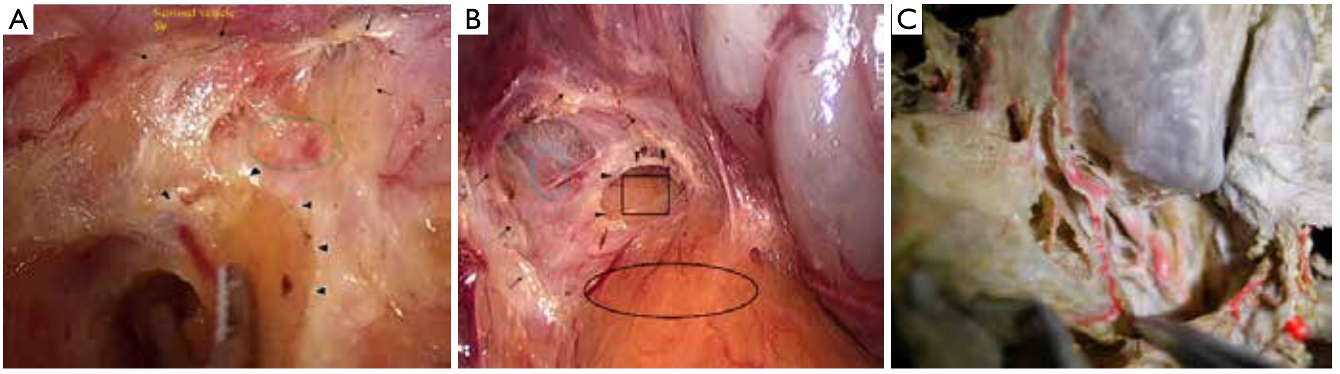

Figure 9 Lamination of DVF. (A) On the left side, the anterior layer of DVF have been divided, indicated by black arrows, posterior layer by black triangles and green circle; (B) in the midline, anterior layer indicated by black arrows, posterior layer by triangle and blue circle. Square indicates MRF, ovary indicates a much thinned layer over MRF; (C) multiple laminated DVF on the right side in corpse.

adults macroscopically. In laparoscopic surgery, however, multiple laminations of DVF can be often observed both in the midline and on two sides (*Figure 9*), thanks to the magnifying effect of high definition laparoscope.

Near the seminal vesicle junction, several tiny vessels can be always observed passing through the thicked DVF to supply the mesorectum (*Figure 10A*). On two sides of the prostate, tiny vessels from the neurovascular bundle can also be observed to pass through DVF to supply mesorectum (*Figure 10B,C*). On the most distal part, DVF becomes too thin to be observed either on the NVB side or rectal side. However tiny vessels from NVB can be seen as low as the levator hiatus is reached.

These tiny vessels, ranging from several to dozens of them in number, can also be observed in corpse with or without filling the arteries with colored resin (*Figure 11A,B*). Through these tiny vessels, the mesorectum is fastened to the upper edge of prostate and to the NVB on two sides.

How is mesorectum fastened to the pelvic plexus

With the widely use of TME and laparoscopic surgery, most surgeons agree that there is no actual lateral ligament, except an area of adherence between mesorectum and pelvic plexus. In laparoscopy, tiny vessels and nerves can be seen penetrating the pelvic plexus to supply the mesorectum (*Figure 12A*), especially when viewing from the retrorectal space. These vessels and nerves can also be observed in corpse with filling the arteries with colored resin (*Figure 12B,C*).

Figure 10 Tiny vessels to the mesorectum. (A) Tiny vessels from the urethra branch of prostate vesicle vessel; (B) tiny vessels supplying mesorectum on the left side; (C) tiny vessels from NVB.

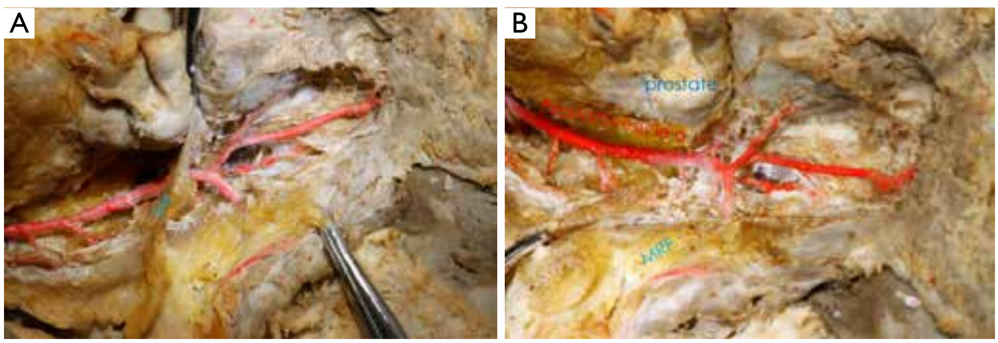

Figure 11 Tiny vessels from prostate vesicle artery to supply mesorectum in corpse.

Tiny vessels directed inter-fasica dissection on the lateral aspect of mesorectum

After the supralevator space is entered, a few gentle outward pushes along the pelvic floor will give a good view of the tiny vessels supplying the mesorectum (*Figure 13A*). Cutting these vessels one by one, followed by gentle push, will help identify the pelvic plexus clearly even in obese patients (*Figure 13B*). After identification of pelvic plexus, divide DVF just behind the tail of seminal vesicle, and a few more tiny vessels may come into view. Cutting these tiny vessels one by one, may facilitate the mobilization of mesorectum and preservation of pelvic plexus (*Figure 13C*).

Tiny vessels directed inter-fasica dissection on the anterolateral aspect

DVF is divided at a level of about 1 cm above the prostate vesicle junction. Apply some gentle pushes before dissecting with monopolar shear or ultrasonic shear, which facilitates the viewing of tiny vessels from the neurovascular junction (*Figure 14A*). Then, cut these tiny vessels and apply more gentle push, and even more tiny vessels will come into sight (*Figure 14B*). This method of dissecting allows you to get a perfect "inter-fascia" dissection between NVB and mesorectum. When dissection goes down near the perineal body, the capsular branches of prostate vessels (the main vessels in NVB) expands dramatically (*Figure 14C*). And this "inter-fascia" dissection will present less risk of bleeding.

A reversed approach of TME for better pelvic auto nerve protection

Even with the above mentioned technique, there is still risk of damage to the NVB and pelvic plexus, partly due to the loose structure, or due to angulation of NVB, and the adverse impact of neoadjuvant chemoradiation (*Figure 15*).

So most recently, we tried a novel approach of dissection. After setting up the retrorectal dissecting plane, the anterior

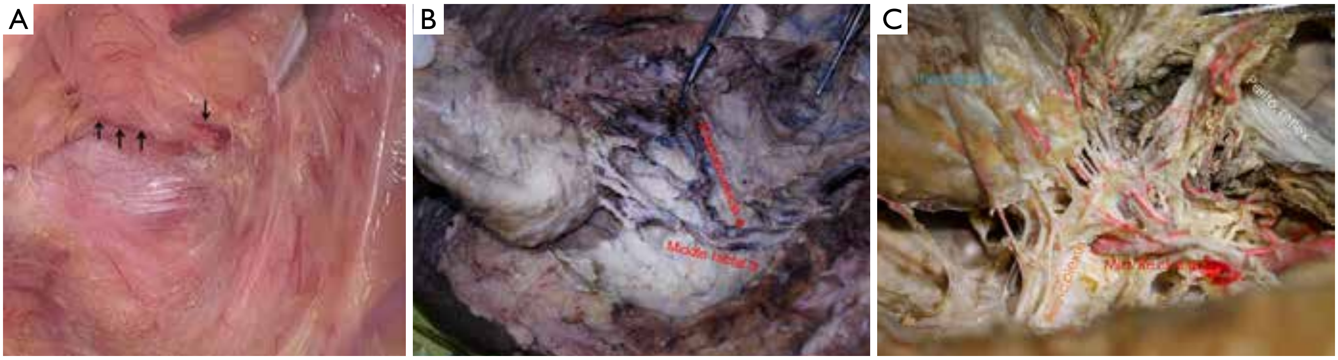

Figure 12 Tiny vessels to the lateral and posterior aspect of mesorectum. (A) Tiny vessels penetrating the pelvic plexus to mesorectum (black arrows); (B) middle rectal vessels give several branches to supply mesorectum without the trunk entering; (C) resein filled corpse indicates tiny vessels passing through pelvic plexus to mesoretum.

Figure 13 Division of tiny vessels facilitate inter-fasciae dissection. (A) Tiny vessels penetrating the pelvic plexus to mesorectum, white triangles indicate the point to divide these vessels; (B) in obese patients, this method facilitate preservation of pelvic plexus; (C) cutting tiny vessels will facilitate inter fascia dissection, red arrows indicate tiny vessels that being cut or had been divided.

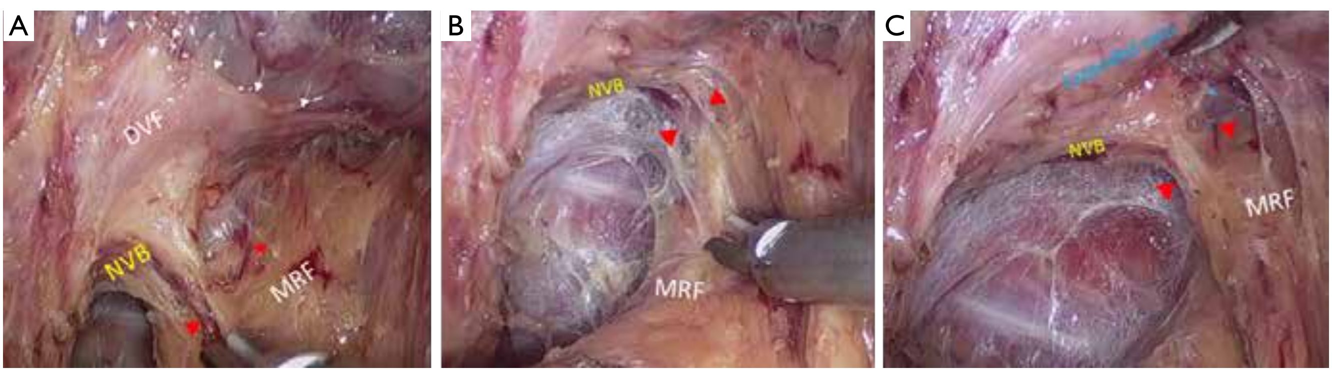

Figure 14 Cutting tiny vessels from NVB one by one facilitates inter-fascia dissection. White arrows indicate the dividing line of DVF, red arrows indicate tiny vessels and the point at where they should be divided. Blue arrow indicates the expanded vein in NVB.

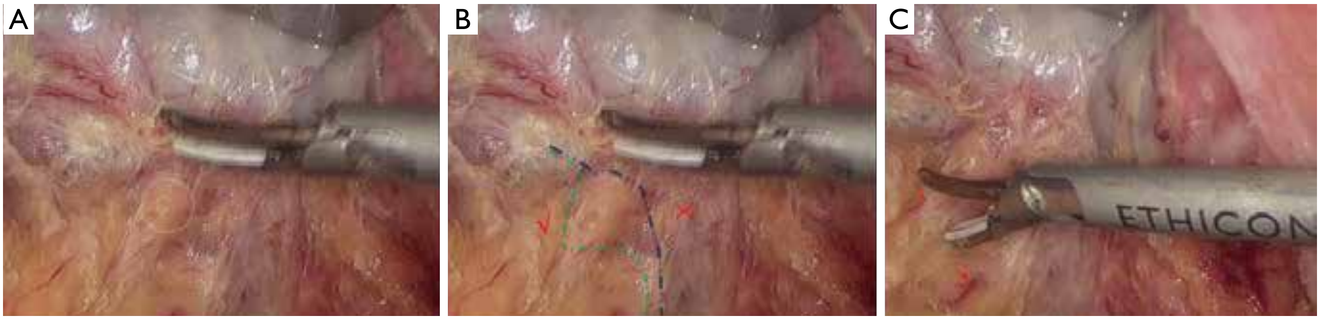

Figure 15 Due to angulation of NVB by retraction, fatty tissue in NVB (white circle) might be mistaken as mesorectal tissue, the blue line indication the wrong dissection plane, the green line the right one. Red arrows indicate tiny vessels from NVB which may help determine the right dissecting plane.

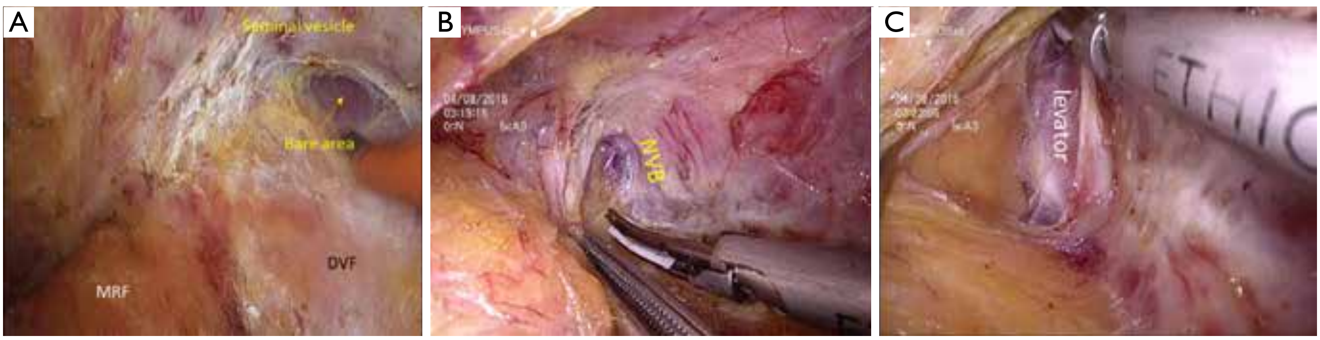

Figure 16 Reversed dissection of mesorectum. (A) Bare area in the anterior aspect of distal rectum; (B) dissect outwardly along neurovascular buddle; (C) supralevator space is exposed prior to dissection around pelvic plexus.

dissecting plane is entered by the same method mentioned above. DVF is transected, advancing of dissection is first carried out in the midline till the bare area (no fat) between prostate and the anterior aspect of rectum (*Figure 16A*) is reached, from where dissection is carried out laterally to reach the levator ani first, without dissecting around the NVB or pelvic plexus in advance (*Figure 16B,C*). To get a good exposure, ventrally retraction on prostate or vagina is applied by the assistant, with the surgeon pushing on the anterior aspect of mesorectum.

After the levator ani is observed, dissection is then carried out along the NVB and pelvic plexus cephalad and dorsally. This technique will ensure a complete preservation of pelvic plexus and NVB (*Figure 17*). The disadvantage of this method is that it might not be indicated for patients with cancerous involvement of the anterior aspect of mesorectum.

How we perform a laparoscopic assisted intersphincteric resection

Dissection from the abdominal side is carried out until the levator hiatus is reached (*Figure 18A*). Then 8 stitches were put around anus to have a good view (*Figure 18B,C*). An Allice forcep is applied on the mucosa near (up or at or below) Deontic line depending on the lower edge of the tumor (*Figure 18D*). Cutting the mucosa under the forcep will allow entering a plane between longitudinal musculature and the external muscle. Then, the intersphincteric dissection is performed first at the posterior aspect till the pelvis is entered. The index and middle finger of the surgeon's left hand is inserted. With the retraction on the verge of the distal end of bowel and the guidance of the finger (*Figure 18D,E*), the intersphincteric crevice can be easily determined. After removal of the specimen, interrupt sutures is put under direct view to finish the coloanal anastomosis (*Figure 18F,G*).

Figure 17 Reversed approach of TME better auto nerve protection and better quality of TME.

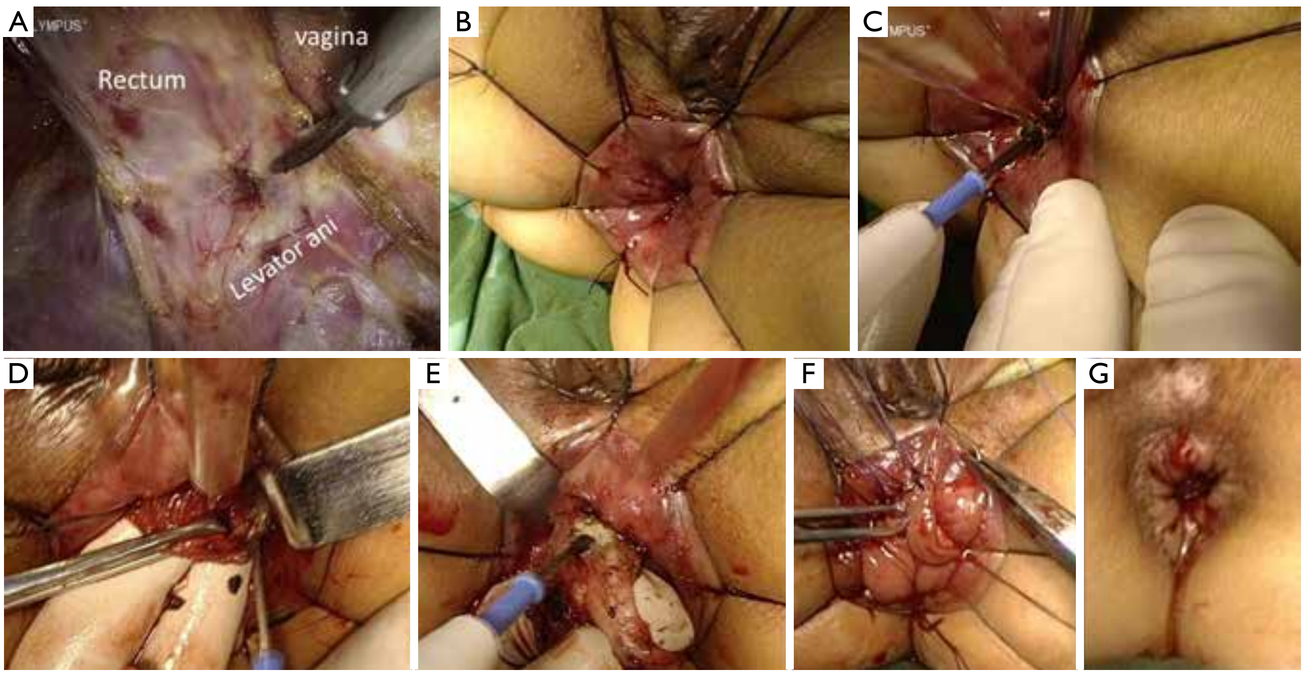

Figure 18 Intersphincteric resection. (A-G) The anal phase with modified perineal manipulation in laparoscopic assisted intersphincteric resection.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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High ligation of inferior mesenteric artery in laparoscopic resection of rectal cancer: is it safe or dangerous?

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Nowadays anterior resection and abdominoperineal excision for rectal cancer have been well standardized in laparoscopic approach. But there are still arguments about the level of the ligation of the inferior mesenteric artery (IMA) (1). Some surgeons tie the IMA at its origin from the aorta (high ligation). Others tie the IMA below the origin of the left colic artery (LCA) (low ligation). It is not clear if there is different incidence rate of anastomotic leakage and survival period between these two different levels of ligation of the IMA after radical resection of rectal cancer.

As everyone knows, the colon has two main sources of blood supply: the superior mesenteric artery (SMA) and the IMA. The main branches of the SMA include the ileocolic artery (ICA), the right colic artery (RCA) and the middle colic artery (MCA), which supplies the cecum, the ascending colon, and the transverse colon. The main branches of IMA include LCA, the sigmoid artery (SA) and the superior rectal artery (SRA), which supply the descending colon, the sigmoid colon and the up-half rectum.

In laparoscopic resection of rectal cancer, high ligation of the IMA appears easier to achieve than low ligation. The other advantage of high ligation is to reduce the tension of anastomosis (2). In theory, the descending colon ischemia and necrosis will not happen after high ligation of IMA in anterior resection for rectal cancer because there are some arterial arches between the MCA from the SMA and the LCA from the IMA. But is high ligation of the IMA really safe?

It is usually considered that there are two arterial arches between the MCA and the LCA, which maximally keep the blood supply for the descending colon after high ligation of the IMA. One is the marginal arterial arch, also known as the artery of Drummond. The other is Riolan's arch.

The artery of Drummond (*Figure 1*) is composed of arterial branches which supply the colon and runs in the mesentery close to the colon as part of the vascular arcade that connects the SMA and IMA. It is named by Hamilton Drummond [1882–1925], an English physician. But because of congenital developmental defects, the artery of Drummond is perhaps incomplete especially at the splenic flexure of colon, where is the site of watershed anastomosis of midgut and hindgut in the embryonic stage of development. This point is also called Griffiths' point (3). At the Griffiths' point, the anastomosis of the artery of Drummond may be substantial, tenuous, or absent (*Figure 2*). Angiographic studies show that anastomosis at Griffiths point is present in 48%, poor or tenuous in 9%, and absent in 43% (3). It means that the proportion of poor development of the artery of Drummond at the Griffiths' point reaches as high as 50%. This has relevance in radiology, as it explains why the splenic flexure watershed site is the most common location for ischaemic colitis.

Riolan's arch represents an important collateral circulation between the SMA and the IMA upon which the descending colon may be dependent. But the definition of Riolan's arch, which named by Jean Riolan [1580–1657], a famous 17th century French anatomist, is deliberately vague. In general, Riolan's arch refers to a distinguishing anatomical entity connecting the MCA with the LCA, additional to the artery of Drummond (*Figure 3*) (4). There are also many other interpretations and synonyms of Riolan's arch (*Table 1*). The rate of emergence of Riolan's

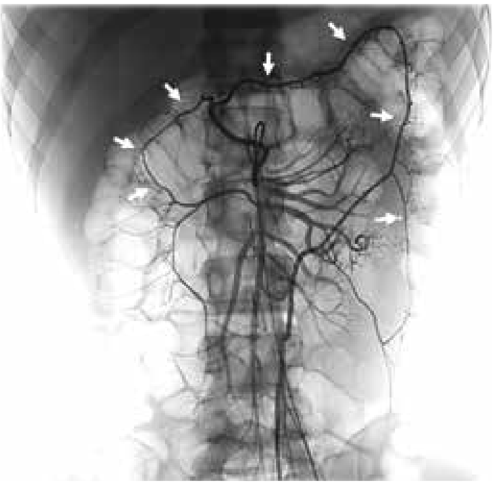

Figure 1 Digital subtraction angiography of SMA shows the artery of Drummond (white arrows). SMA, superior mesenteric artery.

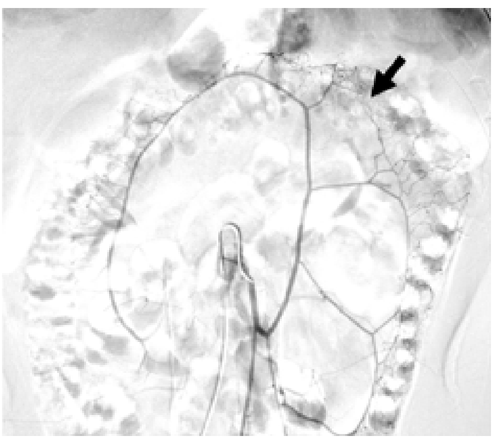

Figure 2 Digital subtraction angiography of IMA shows the absence of the artery of Drummond at Griffiths' point (black arrow). IMA, inferior mesenteric artery.

arch is very different because of the difference of definition, race, research method and sample size in different reports. A book edited by the Chinese Society for Anatomical Sciences reports that the incidence rate of Riolan's arch is 6.19%±1.13% in Chinese people. It illustrates that Riolan's arch is usually in the state of no or only having a little blood flow. Some authors even think that the incidence of Riolan's arch means there is severe stenosis in the SMA or IMA.

Some reports show that the descending colon ischemia or necrosis will happen after high ligation of the IMA. Tsujinaka *et al.* (5) observed that 6 out of 302 patients (2.0%)

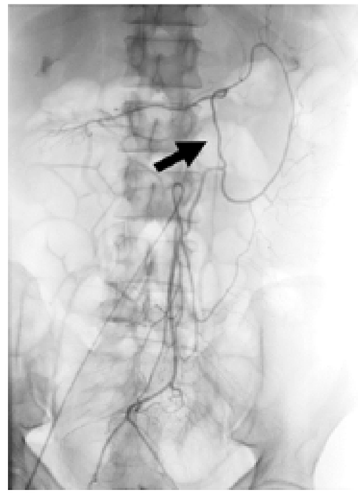

Figure 3 Digital subtraction angiography of IMA shows Riolan's arch (black arrow). IMA, inferior mesenteric artery.

Table 1 Synonyms of Riolan's arch (4)

Central anastomotic artery of colon
Mesomesenteric artery
Middle-left colic collateral
Intermesenteric artery or arcade
Meandering mesenteric artery
Anastomosis (magna) of Riolan
Meandering artery of Riolan
Great colic artery of Riolan
Arch of Treves
Artery of Moskovitch
Artery of Gonzalez
Anastomosis maxima of Haller
Arcus magnus mesentericus

with high ligation of the IMA developed proximal colon necrosis, which were confirmed by secondary surgery. Of these 6 patients, 2 died from associated complications. The results, which are obtained from the univariate analysis showed that advanced age, cerebrovascular disease, and hypertension were significantly associated with colon necrosis. In another report (6), 1,201 patients with sigmoid colon or rectal cancer who underwent high ligation of IMA were analyzed. Ten patients (0.83%) diagnosed

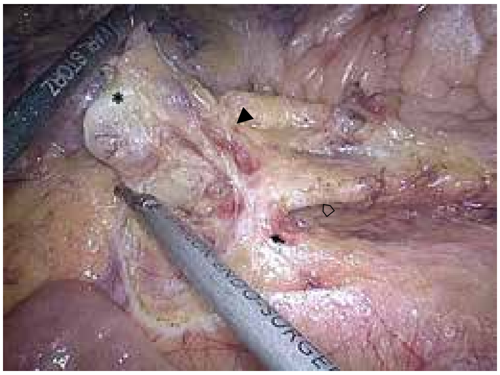

Figure 4 Low ligation of the IMA with dissection the lymph nodes at root of the IMA (→: IMA; ►: LCA; *: the lymph nodes at root of the IMA; ⌂: low lagation point of the IMA). IMA, inferior mesenteric artery.

Figure 5 A 63-year-old male patient with rectal cancer who underwent anterior resection (8). The IMA was tied below the origin of the LCA with dissection the lymph nodes at the root of the IMA. IMA, inferior mesenteric artery; LCA, left colic artery. Available online: http://www.asvide.com/articles/1270

postoperative colonic ischemia. Mortality was 10%. The symptoms of postoperative colonic ischemia occurred on the 5th day (range, 2nd–10th day) after operation. Over all, both the artery of Drummond and Riolan's arch may not provide reliable blood supply to the descending colon after high ligation of IMA. But there were different opinions. Boström *et al.* (7) reported that symptomatic anastomotic leakage occurred in 12.3% (41/334) of patients in the high ligation group and in 10.6% (41/388) in the low ligation group. There was no statistical difference between two groups and high ligation was not independently associated with a higher risk of anastomotic leakage.

In conclusion, despite the controversy, the descending colon ischemia and necrosis after high ligation of IMA in anterior resection for rectal cancer should be pay great attention because of the existence of the Griffiths' point and the low incidence rate of Riolan's arch, especially for the patients with advanced age, cerebrovascular disease, and hypertension. Low ligation of the IMA with dissection the lymph nodes at the root of the IMA (*Figures 4,5*) perhaps is another choice. But that issue requires further study.

Acknowledgements

None.

Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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Laparoscopic total mesorectal excision (TME) with electric hook for rectal cancer

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Abstract: Procedures of laparoscopic total mesorectal excision (TME) with electric hook for rectal cancer are described. Laparoscopy requires cooperation between the surgeon, first assistant surgeon and second assistant surgeon, in order to recognize the inferior mesenteric artery (IMA), the inferior mesenteric vein (IMV), the neurovascular bundle (NVB), and the fibrous tissues between the mesorectum and the surrounding tissues or organs. Some important organs, such as the autonomic nerves, left ureter, left gonadal vessels, and pancreas, should be avoided being injured. Comparing with ultrasound knife, the advantage of electric hook is obvious. Less smog will be produced if the electric hook is used within 2 seconds, and clearer dissectible layer will appear during the TME surgery with electric hook.

Keywords: Rectal cancer; total mesorectal excision (TME); laparoscopic; electric hook

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Positions of the patient, cannulas and the surgical team

The patient should be in steep Trendelenburg position and tilted right side down. The surgeon stands on the patient's right side, the first assistant on the left side, and the second assistant (camera operator) on the left side of the surgeon. The main monitor is placed near the patient's left shoulder, and the second monitor is placed behind the surgeon. Five cannulas (2 mm × 12 mm, 3 mm × 5 mm) are placed as shown in *Figure 1*.

Procedures

The small bowel loops are placed in the right side to expose the duodenum and the inferior mesenteric vein (IMV) (*Figure 2*).

Surgeon must identify the tumor location firstly. The assistant should grasp the pedicle of superior rectal vessels and use an intestinal grasper to push the rectum ventrally and laterally. The promontory should be confirmed, so the surgeon can use the hook to incise the peritoneum at the level of promontory (*Figure 3*).

The surgeon should move to cephalad dissection. While

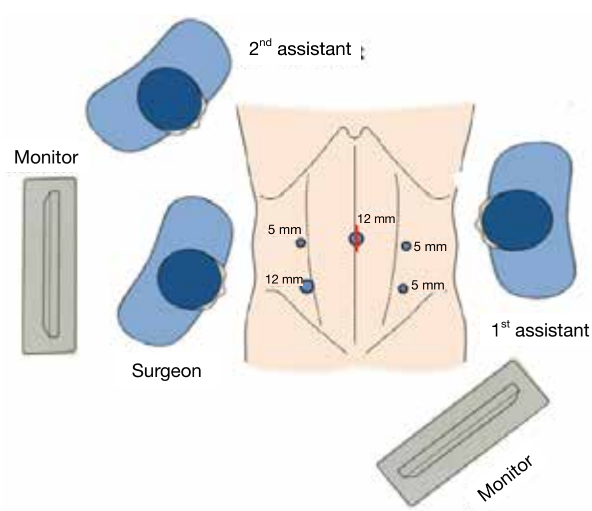

Figure 1 Positions of the cannulas and the surgical team.

Figure 2 To expose the inferior mesenteric vein (IMV).

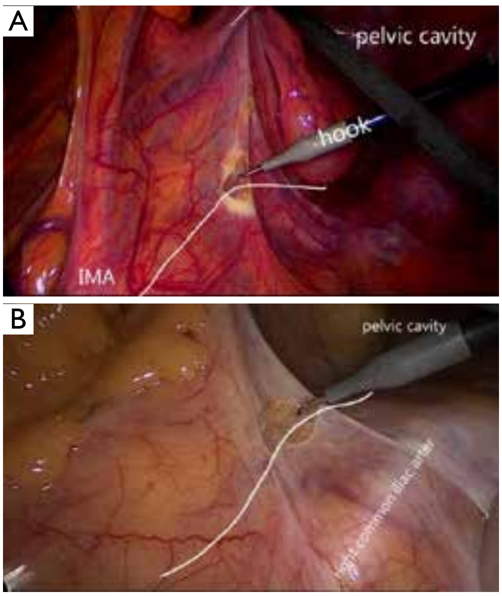

Figure 3 The surgeon can use the hook to incise the peritoneum at the level of promontory.

Figure 4 To cut the subperitoneal connective.

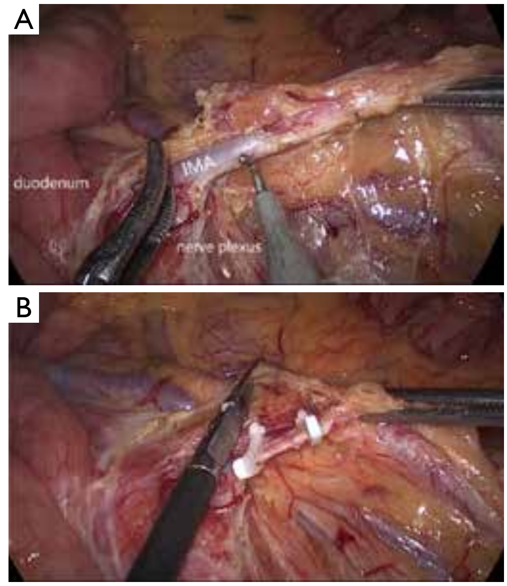

Figure 5 Incision of peritoneum is continued up to the origin of the inferior mesenteric artery (IMA).

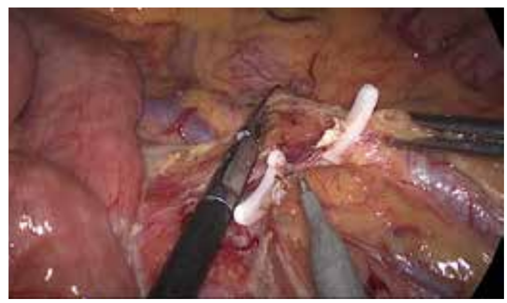

Figure 6 The inferior mesenteric artery (IMA) should be cut between two clips.

cutting the subperitoneal connective, you should avoid damaging the hypogastric nerves (*Figure 4*).

Incision of peritoneum is continued up to the origin of the inferior mesenteric artery (IMA). The surgeon and the assistant should recognize the nerves, the ureter, and the gonadal vessels, and you should also prevent the injuries to them (*Figure 5*). Two absorbable clips are required to occlude the origin of IMA, and then the IMA should be cut between these two clips (*Figure 6*).

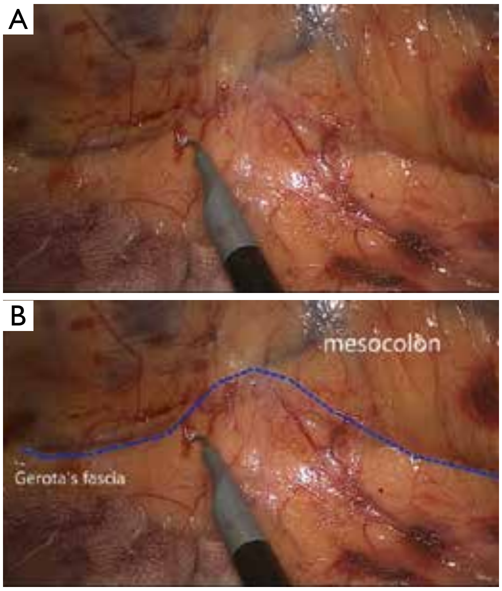

Figure 7 The dissection between the mesocolon and the retroperitoneum.

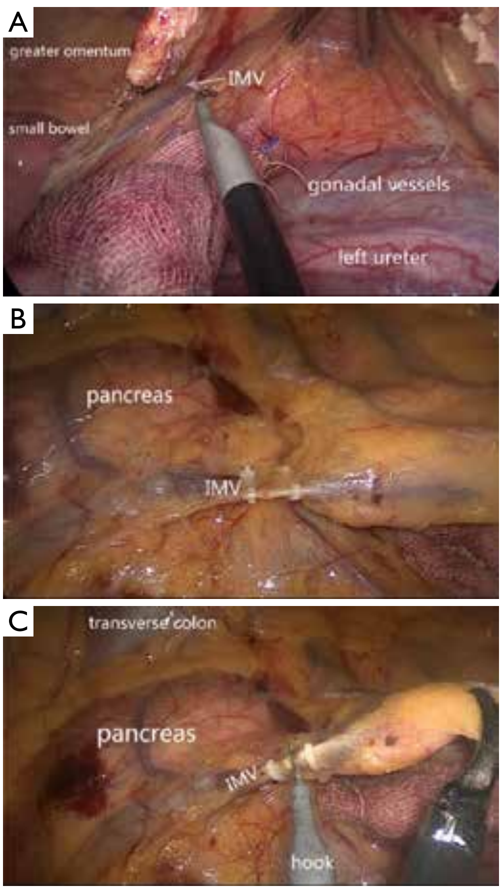

Figure 8 To find the inferior mesenteric vein (IMV) and occlude it.

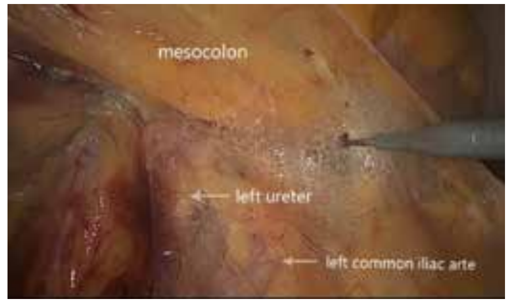

Figure 9 The posterior dissection of the rectum.

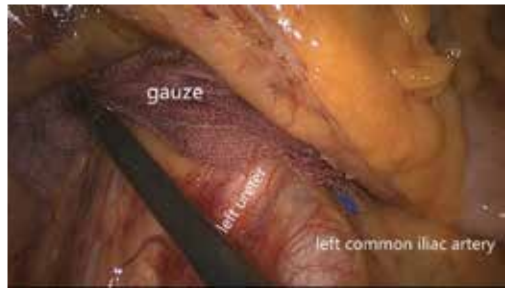

Figure 10 A gauze can be stuffed into the gap as a sign.

The dissection between the mesocolon and the retroperitoneum is advanced laterally and cephalad. Continuing to divide the adipose tissues, in order to create the Gerota's fascia, which is a fibrous membrane covering the left kidney (*Figure 7*). Then the IMV and the pancreas will arise (*Figure 8A*). As same as the IMA, the adipose tissues surrounding the IMV need to be cleaned carefully, and two or more clips are required to occlude the IMV (*Figure 8B,C*).

Following the cephalad dissection, you come back to the posterior dissection of the rectum. Surgeon and assistant should avoid doing harm to the left ureter and the left common iliac arte (*Figure 9*).

Once you have separated the mesocolon and the left common iliac arte, a gauze can be stuffed into the gap between them, in order to be the sign in the next step (*Figure 10*).

The assistant picks the paracolic sulci peritoneum by the left hand and the surgeon picks the mesocolon, in order to keep the tension (*Figure 11*). Traction is very important. Surgeon must be patient and careful to avoid damaging the left common iliac arte and the left ureter. Continuing cutting the paracolic sulci peritoneum until the gauze appears (*Figure 12*), and incision of peritoneum is continued

Figure 11 To divide the colon from the left lateral abdominal wall.

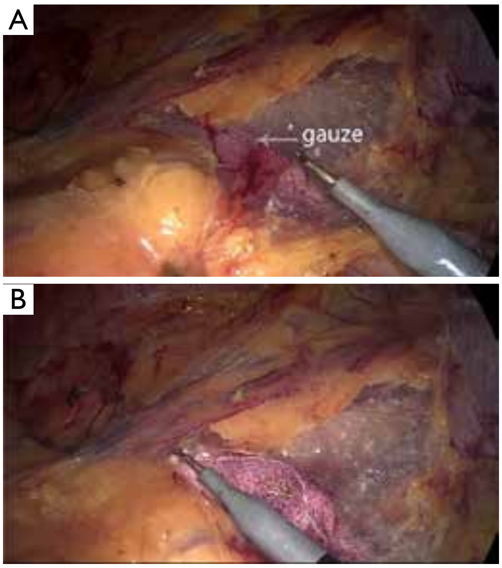

Figure 12 Continuing cutting the paracolic sulci peritoneum until the gauze appears.

up to the splenic flexure (*Figure 13*).

Then the surgeon can move to the posterior dissection of the rectum. The assistant should extend the fibrous tissues between the mesorectum and the retroperitoneum, in order to keep the sufficient traction. The rectal fascia propria can be created so that the surgeon can continue the following dissection. The prehypogastric nerve on both sides, the median or lateral sacral vessels should be protected (*Figures 14,15*).

The lateral dissection on the left side and the right side is similar (*Figures 16,17*). The surgeon now incises the peritoneum carefully, avoiding damaging the pelvic nerve plexus, the neurovascular bundle (NVB) and the seminal vesicle.

The surgeon could use the hook to open the peritoneal

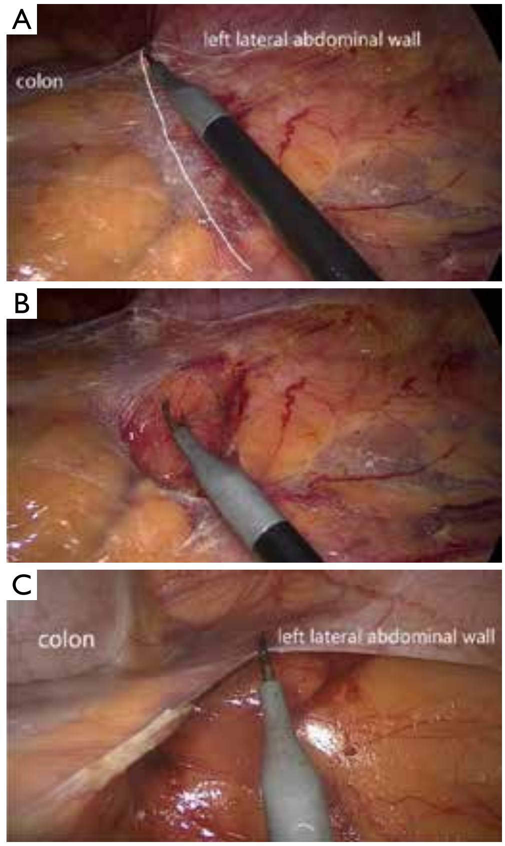

Figure 13 Incision of peritoneum is continued up to the splenic flexure.

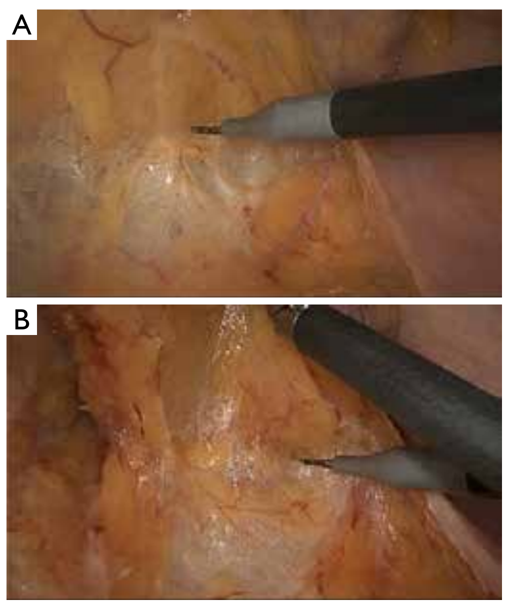

Figure 14 The posterior dissection of the upper rectum.

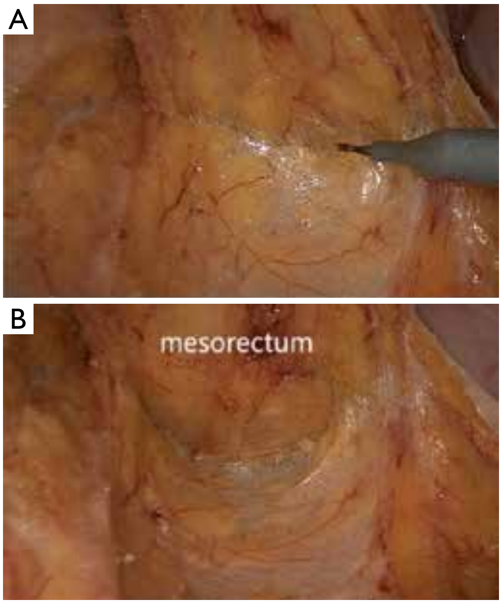

Figure 15 The posterior dissection of the rectum.

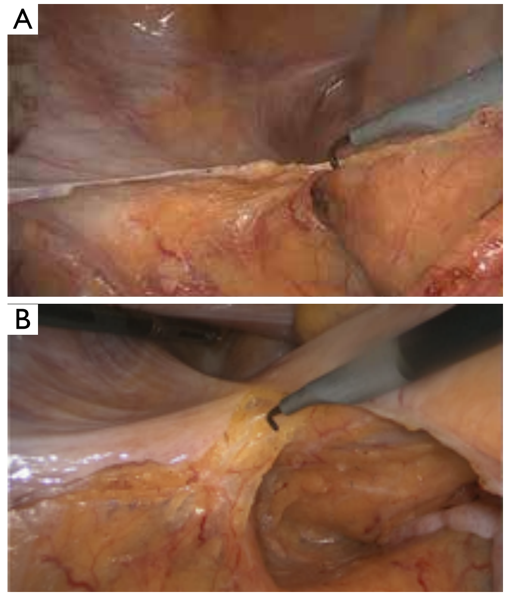

Figure 17 The lateral dissection on the left side.

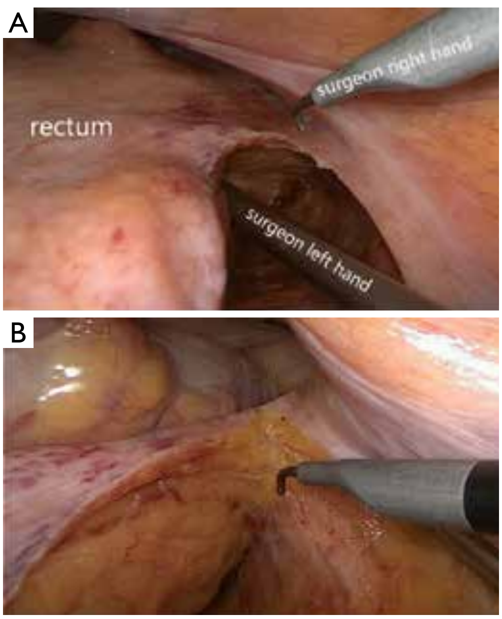

Figure 16 The lateral dissection on the right side.

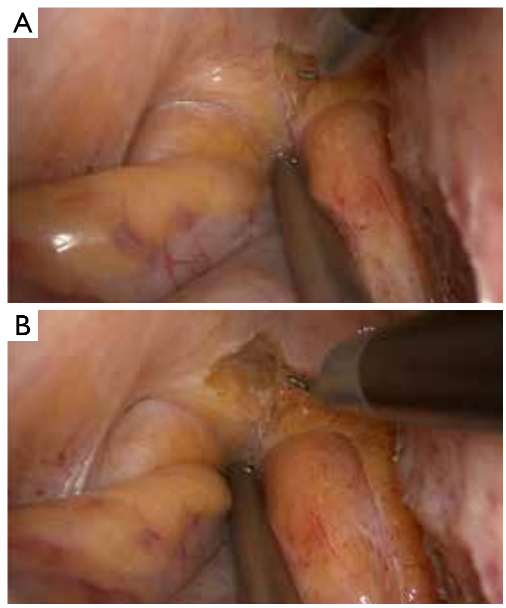

Figure 18 The peritoneal reflection is opened.

reflection. The assistant should push up the urinary bladder by one of his hand, to avoid the damage with bladder. The surgeon should try his best to extend the fibrous tissues between the seminal vesicle and the rectum (*Figure 18*).

There is a fascia called "Denonvilliers' fascia", the fibrous tissues between the rectum and the seminal vesicles, the prostate, and the NVB (*Figure 19*).

The surgeon and assistant should pay attention to the NVB on the both side, preventing to enter into them. The NVB must be everted from the rectum (*Figures 20,21*).

The dissection reaches the pelvic floor, and the so-called lateral ligament is created both in left and right anterolateral

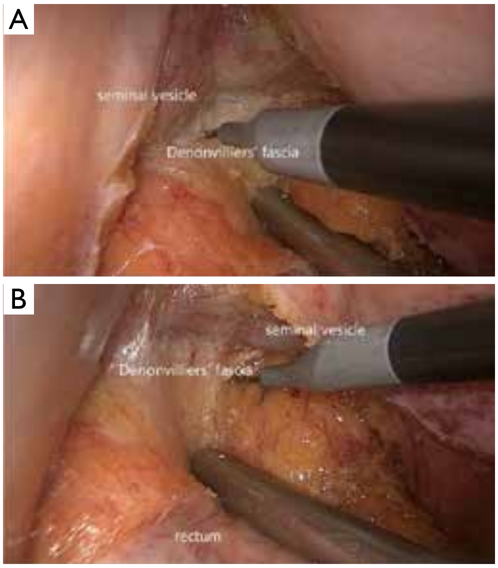

Figure 19 To find the Denonvilliers' fascia.

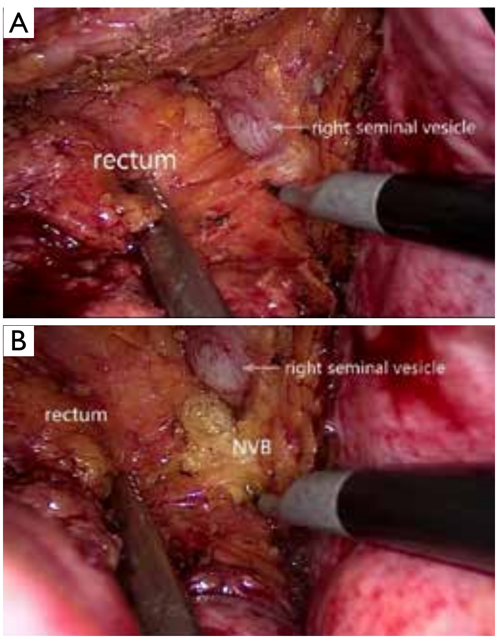

Figure 20 The neurovascular bundle (NVB) on the right side.

corner (*Figure 22*). Cut them off and clean the mesorectum to advance it to obtain a sufficient distal margin (*Figure 23*).

Once the surgeons have finished the dissection, some medical instruments can be used to divide the rectum (*Figure 24*). Then we can see the rectal stump and check it (*Figure 25*). Following to take the tumor from the abdomen,

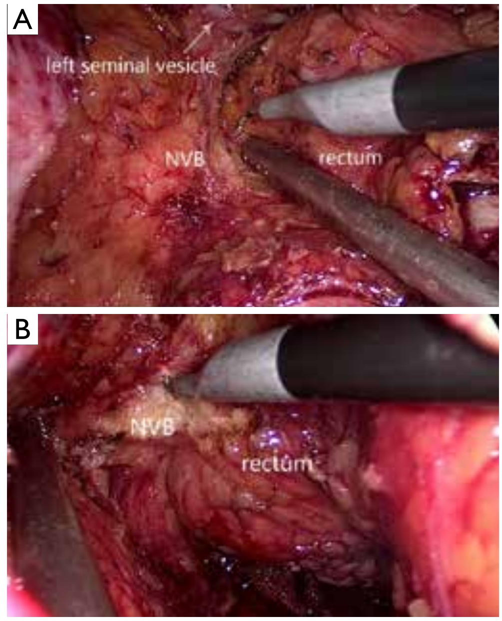

Figure 21 The neurovascular bundle (NVB) on the left side.

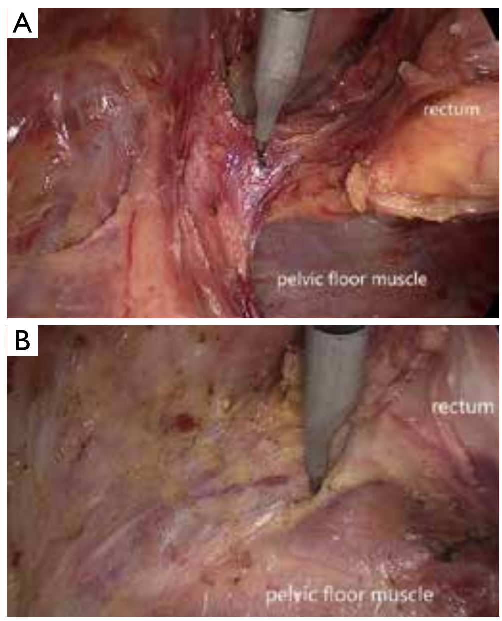

Figure 22 The dissection reaches the pelvic floor.

anastomosis is performed with either a double-stapling technique.

Conclusions

Laparoscopic total mesorectal excision (TME) with electric

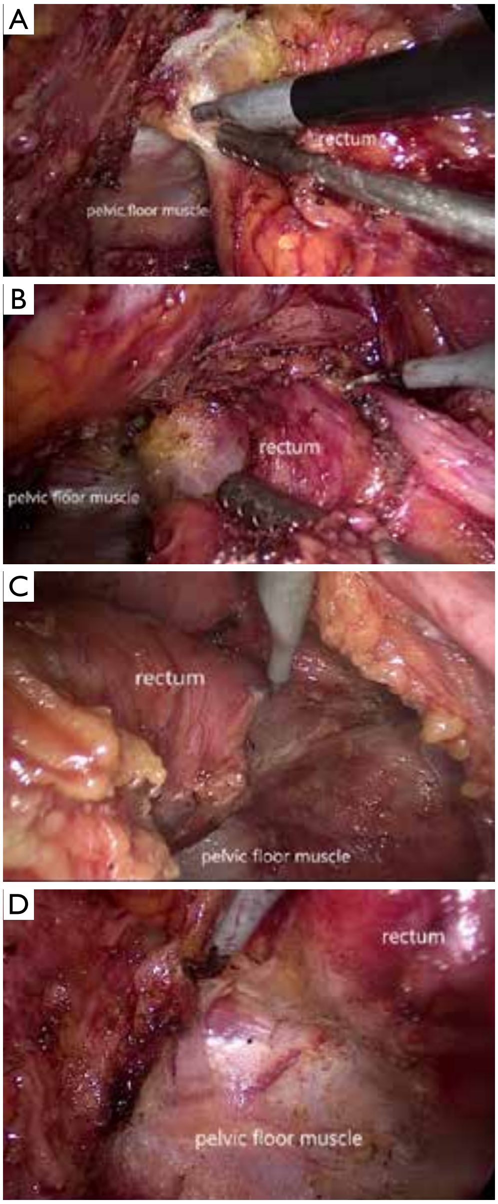

Figure 23 Clean the mesorectum to advance it to obtain a sufficient distal margin.

hook for rectal cancer is described. Comparing with ultrasound knife, the advantage of electric hook is obvious. Firstly, less smog will be produced if the electric hook is used within 2 seconds. Secondly, by using the electric hook, surgeon and assistants can find the clearer dissectible layer. Last but not least, tissue could be mobilized with the electric hook by sharp dissection instead of blunt dissection so that surgeon can prevent some unnecessary damage, such as hemorrhage and perforation.

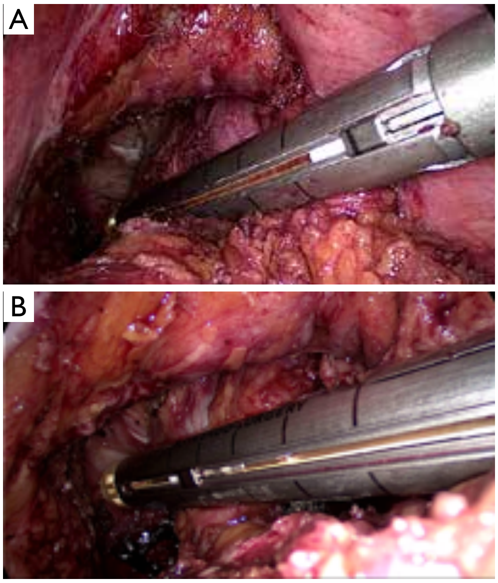

Figure 24 The rectum is divided by an instrument.

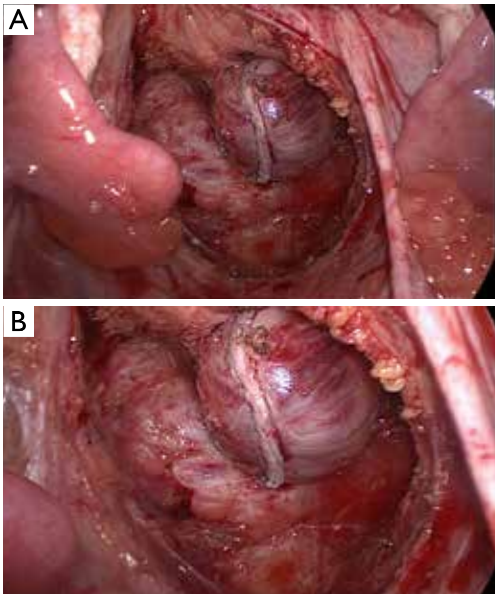

Figure 25 There is the rectal stump.

Laparoscopy surgery with electric hook requires cooperation between the surgeon, first assistant surgeon and second assistant surgeon. Keeping the sufficient traction is important and necessary, which could help the surgeon recognize the correct layer and the organs, including the IMA, the IMV, the autonomic nerves, left ureter, left gonadal vessels, and pancreas (*Figure 26*).

Figure 26 Laparoscopic total mesorectal excision (TME) for rectal cancer (1).
Available online: http://www.asvide.com/articles/1514

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Footnote

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Autonomic nerve preserving in laparoscopic total mesorectal excision

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Abstract: Since the introduction of total mesorectum excision and combined modality therapy has dramatically improved the oncologic outcome for the patients with rectal cancer, the quality of functional outcome has been increasingly important. Urogenital dysfunctions due to intraoperative inadvertent pelvic autonomic nerve damage are well-recognized. Pelvic autonomic nerve preservation may be limited and challenged by the anatomical constrains of the curved narrow pelvis. Laparoscopic technology with the advantages of direct illumination and magnification may enable better visualization and facilitate pelvic autonomic nerve preservation. There are a few key zones at risk of nerve injury and a proper surgical technique with step-by-step checklist at the critical points should be carried on. The increased experience with laparoscopic and understanding of the pelvic nerve anatomy may relate to the improving functional outcomes. Here, we discuss the current understanding of anatomy, key zones at risk and tips and tricks of our experience of nerve preservation during the laparoscopic total mesenteric excision (TME).

Keywords: Laparoscopy; rectal cancer; total mesorectum excision; pelvic autonomic nerve preservation

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Introduction

The adoption of total mesenteric excision (TME) and combined modality therapy has dramatically improved the oncologic outcome for the patients with rectal cancer during the last 3 decades (1,2). Nonetheless, the improved survival was constantly in company with high incidence of organ dysfunction which might severely compromise quality of life (3,4). In addition to the anterior rectal syndrome, urogenital dysfunctions due to intraoperative inadvertent pelvic autonomic nerve damage are well-recognized complications after rectal cancer surgery (5). The incidence of urinary dysfunction including difficulty emptying the bladder and urinary incontinence has been reported from 0% to 35% (4,6). Male sexual dysfunction includes erectile and ejaculatory problems may reach as high as 79.8% and 72.2%, respectively. For females, sexual dysfunction in relation to dyspareunia, difficulty to achieve orgasm and insufficient vaginal lubrication, is plagued but poorly defined and likely neglected in clinical practice (7,8).

Pelvic autonomic nerve preservation under direct visualization and sharp dissection may be limited and challenging by the anatomical constrains of the curved narrow pelvis, especially for the android pelvis with hypertrophic mesorectum. Laparoscopic technology with the advantages of direct illumination and magnification may enable better visualization and thereby hypothetically help to improve pelvic autonomic nerve preservation. As in previous studies, two multicenter randomized control trails comparing laparoscopic with open surgery have reported worse sexual function in laparoscopic surgery (4,9). While, the later studies showed no differences in outcomes or

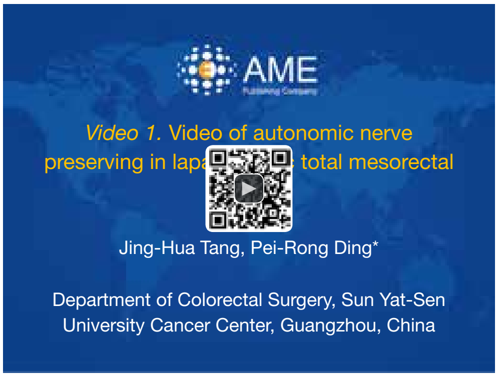

Figure 1 Video of autonomic nerve preserving in laparoscopic total mesorectal excision (14).
Available online: http://www.asvide.com/articles/1517

even in favor of laparoscopic to compare with open surgery (10,11). The increased experience with laparoscopic and understanding of the pelvic nerve anatomy may relate to the improving functional outcomes. A trend towards fewer incidences of urogenital dysfunctions is noticeable with the practice of pelvic autonomic nerve preservation adherence to the TME principles (5,10,12,13).

We believe that favorable urinary and sexual function could be achieved with enhanced vision, adequate traction and countertraction during the laparoscopic TME. Here, we discuss the current understanding of anatomy, key zones at risk and tips and tricks of nerve preservation during the laparoscopic TME (*Figure 1*).

Pelvic autonomic nerve anatomy

Superior hypogastric plexus (SHP) and hypogastric nerves (HN)

The SHP is a network of pre- and post-ganglionic nerves overlying the abdominal aorta. The plexus is located anterior of the fifth lumbar vertebrae, starts underneath of the inferior mesenteric artery (IMA), run over the sacral promontory and then bifurcates into the right and left HN (15,16). The paired HN run about 2 cm medially to the ureter, move obliquely along the posterolateral wall of the pelvis and finally end as afferent fibres of inferior hypogastric plexus (IHP). The SHP comprises sympathetic nerves, which is originated from the sympathetic trunks alongside the tenth thoracic to the third lumbar vertebrae. Injury to the SHP or HN may result in troubles of ejaculation, decreased orgasm and urinary incontinence (16).

IHP and pelvic splanchnic nerves (PSN)

Besides the sympathetic fibres from the HN, the IHP also receives pelvic parasympathetic fibres from the PSN. The splanchnic nerves arising from the ventral roots of S2–S5 enter the pelvis through sacral foramina, running immediately ventral to the piriform muscles, together with the HN forming the IHP that lies laterally on the pelvic wall at the level of the lower third of rectum. Some branches of the splanchnic nerves run medially to the rectum via the so called “lateral ligaments” and make up the medial segment of the IHP. The lateral ligaments are thought to be condensation of fascia on the dorsolateral side of rectum and connect the rectum to the pelvic parietal fascia. Some suggest the ligaments do not exist and the small, inconstant and frequently unilateral middle rectal artery cross the mesorectum independent of any structure (16-18). The anterior portion of the IHP innervates the bladder and sexual organs. In women, fibers from the IHP travel through underneath the intersection of the ureter and uterine artery to the vesicovaginal and rectovaginal septum forming branches to the bladder, the vagina and the uterus (19). In men, these run in the neurovascular bundles (NVB) incline anteriorly at the lateral corners of the seminal vesicles in the 2 o’clock and 10 o’clock direction. These nerves run laterally outside the Denonvillier’s fascia and continue on the periprostatic plexus supplying branches to the prostate, seminal vesicles, cavernous bodies, and the vas deferens (16,20).

Key zones at risk

Origin of the IMA

The SHP is vulnerable to intercepted during high ligation of the IMA which is intended to achieve complete removal of regional lymph nodes. The SHP fibres lie in front of the aorta and are located in a wide area of dissection. The preaortic plexus injured if the IMA pedicle is ligated flush with the aorta (20). The left trunk of the SHP travels along the left side of the aorta and is very close to the IMA at its origin. So mass clamping of the IMA may increase the risk of damage to the left trunk of the plexus.

Posterior rectum

Although there is still controversy about the facial structures (21), posterior dissection of the rectum should carried out at the avascular plane of loose areolar tissue

Figure 2 The SHP is a network of pre- and post-ganglionic nerves overlying the abdominal aorta. By opening the IMA sheath and ligating the pedicle at a distance of 1.5–2 cm from the aorta, Avoiding mass clamping of the IMA, the SHP fibres lying in front of the aorta are preserved. SHP, superior hypogastric plexus; IMA, inferior mesenteric artery.

between the fascia propria anteriorly and the parietal fascia containing the HN posteriorly. A further loose areolar tissue layer could be easily created posterior to the HN. If dissection is too posterior and the HN appears to run into the mesorectum, both the HN and the presacral vein are at risk of damaging. The major risk is to enter the wrong plane at the transition of the mesosigmoid to the mesorectum or not following the correct plane during dissection.

Lateral rectum

At the high level lateral dissection of the mesorectum, the HN is vulnerable to injury if dissection starts or opens the laterorectal reflection of the peritoneum too laterally. During the low lateral dissection, the IHP is vulnerable to injury. The so called "lateral ligament" is a dense connective tissue between rectum and pelvic parietal fascia. The IHP is rarely seen in patients with high body mass index and bulky and fat mesorectum. Injury can occur if the lateral ligament bleeding is not control and blunt dissection is used or excessive medical traction and non-anatomical dissection.

Anterior rectum

There is a very narrow space between the mesorectum and the seminal vesicles and prostate or vaginal. The Denonvillier's fascia is displaced anterior to the mesorectum and posterior to the seminal vesicles and prostate or vaginal. The NVB lie laterally anterior to the Denonvillier's fascia and then go down to the urethra at the apex of the prostate. Excessive traction on the rectum "moves" the NVB in the dissection field on the lateral edges. Blind mass clamping if bleeding is not controlled contributes the damage of the NVB. There is no consensus concerning the proper anterior anatomical plane but if the tumor is anterior, the dissection should carry out anterior to the Denonvillier's fascia, which presents a high risk of nerve damage.

Tips and tricks of nerve preservation in laparoscopic total mesorectal excision

In laparoscopic total mesorectal excision there are a few key zones at risk of nerve injury as mentioned above. To ensure the preservation of pelvic autonomic nerve, a proper surgical technique with step-by-step checklist at the critical points should be carried on without compromise of oncological outcome.

Laparoscopic TME usually starts with a peritoneal incision at the surface of the sacral promontory, dissection from medial to lateral and extend up underneath the duodenum, and then meet the first key area for injury of the IHP. The key of nerve preservation is finding the plane by maintaining sufficient tension. With the help of the assistant lifting the pedicle of the IMA, dissection of the posterior of the IMA could be easy. Under the magnified laparoscopic view, the SHP is visualized covered with ventral fascia. By opening the artery sheath and ligating the pedicle at a distance of 1.5–2 cm from the aorta, the SHP fibres lying in front of the aorta are preserved. Avoiding mass clamping of the IMA and preserving the Gerona's fascia is needed for the left trunk of the SHP running along the left side of the aorta (*Figure 2*).

After the dissection of the left Toldt's space and complete the mobilization of the sigmoid and descend colon, the transition from mesosigmoid to mesorectum is the second zone of iatrogenic nerve injury for the HN. Kinugasa suggest the pre- hypogastric nerves (pre-HGN) fascia anterior to the HN is evident based on historical examination in the retrorectal multilaminar structure. Posterior dissection should be performed at the loose areolar layer between the rectal proper fascia and the pre-HGN fascia (*Figure 3*). The superior rectal artery is situated just anterior to the rectal propria fascia, which could be used as a landmark to find the plane. Surgeons should follow the plane but not create a new plane, use left hand to counter-traction to keep sufficient tension and keep fascia of rectum clear from other tissue (*Figure 4*).

Going all the way down to the level of the forth sacral vertebral will meet the so-called rectosacral fascia which

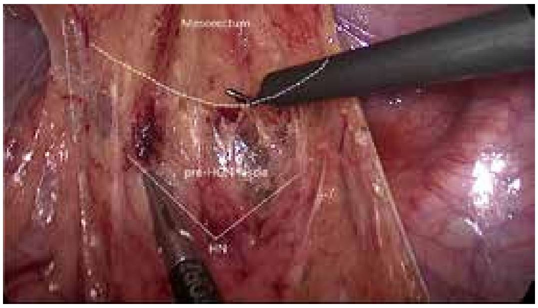

Figure 3 The pre-HGN fascia is anterior to the HN. Dissection should be performed at the loose areolar layer between the rectal proper fascia and the pre-HGN fascia along the dotted line. HGN, hypogastric nerve.

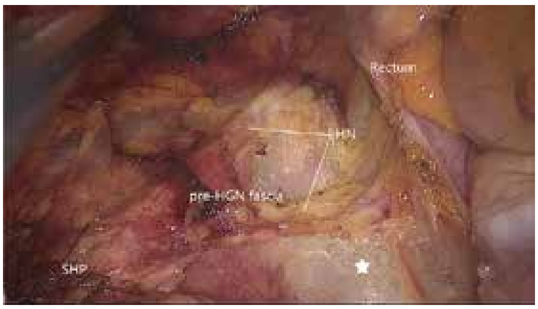

Figure 4 Dissection is too posterior and the pre-HGN fascia is opened. Both the HN and the presacral vein are at risk of damaging. Pentagram shows the wrong plane. HGN, hypogastric nerve.

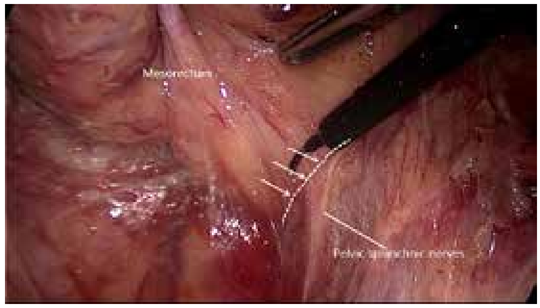

Figure 5 The inferior hypogastric plexus receives fibres from the pelvic splanchnic nerves. There is always a Triangle space lying below rectal fascia and nerve plexus and extending laterally along the line through the triangular space.

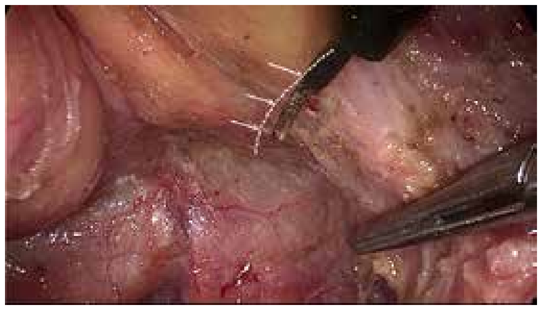

Figure 6 Dissection along the fascia propria and extending laterally along the line through the triangular space is more appropriate.

was thought to be a surgical artifact in Kinugasa's study (21). A sharp incision though this plane will be another loose areolar layer without any risk of nerve damage. The lateral dissection is the third risk zone for injury of the HN and IHP. The lateral dissection is done after the posterior midline dissection has gone as far down to the anorectal junction as possible. Lateral dissection moves from the posterior midline to the left and right posterolateral pelvic wall (*Figure 5*). Some authors suggest under the illumination and magnification of the laparoscopic technology, the autonomic nerves can serve as the landmark and develop a novel concept of nerve-oriented mesorectal excision. However, The IHP is covered by parietal fascia and rarely seen in obese patients (22). Dissection along the fascia propria may be more appropriate (*Figure 6*). Identification of the site where fascia of rectum and IHP merge together is needed. Typically, there is a triangle space lying below rectal fascia and nerve plexus. Extending laterally along the line through the triangular space, the IHP attaching to rectal fascia is effectively shrunk. Dissection need be cautious not to break into the mesorectum or the nerve plexus and always keep good tension and small bite. Using the tips mentioned above, the adherent nerves can be slightly teased and peeled off the rectal fascia. After open the laterorectal reflection of the pararectal peritoneum, dissection to the supra-levator space and anterior plane is one of the most vulnerable parts of mesorectum and nerve plexus. Mesorectum stretching out laterally like a coconut rather than cylinder (*Figure 7*). In order to avoid leftover of mesorectum, dissection should always follow the arc of pelvic floor from posterior to lateral and from known to unknown. After fully mobilization, a clear coconut-like structure can be seen and mesorectum is completely removed.

After complete mobilization of the supra-levator space and lateral part of mesorectum, peritoneum is incised about 0.5 cm anterior to the peritoneal reflection. Here we

Figure 7 Coronal CT image demonstrates the mesorectum stretching out laterally like a coconut rather than cylinder. Dissection should always follow the arc of pelvic floor from posterior to lateral.

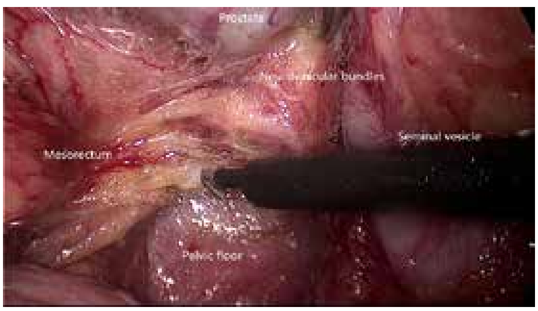

Figure 8 The NVB lie laterally anterior to the Denonvilliers fascia. Transect the Denonvilliers fascia at the base of seminal vesicle, then dissection is along the propria fascia. Fully mobilization of posterior and lateral mesorectum greatly facilitates the preservation of NVB. NVB, neurovascular bundle.

enter the space anterior to Denonvillier's fascia and meet a new risk area of autonomic never injury. Although Heald suggest the Denonvillier's fascia forms the anterior surface of the mesorectum, most opinions recommend dissecting in front of Denonvillier's fascia only when the tumor located anteriorly or there is a risk of compromised circumferential margin. For posterior and lateral tumors, our experience is to transect the Denonvillier's fascia at the base of seminal vesicle, then dissection is along the propria fascia. Fully mobilization of posterior and lateral mesorectum greatly facilitates the preservation of NVB. Dissection just follows the groove and uses the hook parallel but not vertically to the rectal fascia. In some cases, it looks like there is a shining envelope containing the NVB when it is well preserved (*Figure 8*).

The adoption of TME and combined modality therapy has improved the oncologic outcome greatly in the patients with rectal cancer. Urogenital dysfunctions due to intraoperative inadvertent pelvic autonomic nerve damage are well-recognized. Surgeons should be familiar with the pelvic autonomic nerve anatomy especially the key zones at risk and take advantage of laparoscopic technique in order to improve the functional outcomes of TME.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Laparoscopic assisted multi-visceral resection in stage IV rectal cancer

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Abstract: Hepatic metastasis is the difficult part and key point in treating colorectal cancer. Meanwhile, there still exists an argument that if doing hepatic metastasis of colorectal cancer resection simultaneously. Our center is carrying on multidisciplinary treatments of hepatic metastasis of colorectal cancer and has gained some outcomes from the clinical trials. According to the features of this case, we should get simultaneous resection of both primary and metastatic tumor following by the pre-operation MDT discussion. Here, we show the achievement of laparoscopy-assisted right hemicolectomy combined with liver resection. We want to share the experiences and discuss with each other.

Keywords: Laparoscopy; colectomy; hepatectomy; simultaneity

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Liver is the primary hematogenous metastatic organ of colon cancer. Hepatic metastasis is the difficult part and key point in treating colorectal cancer. Generally, hepatic metastasis is the main death reason of colorectal cancer. The principle of treating hepatic metastasis of c is surgical resection of metastatic lesion. Till now, Chinese and foreign experts consensus suggest that colorectal cancer patients with hepatic metastasis that meet the surgery indication should have appropriate surgical treatment.

Usually our strategy for colorectal cancer with hepatic metastasis is MDT discussion. We got the further treatment strategy when experts from different departments have discussed together. We decide whether the patients should get simultaneous resection of both primary and metastatic tumor mainly on the anatomic site of the metastasis, the residual liver function, the number of metastatic lesion and radical purpose. Although the mortality of simultaneous resection surgery is higher than two-period surgical therapy, there are emerging studies showing that the overall survival and disease-free survival rate are similar between the two therapies. Our medical center has carried out laparoscopy-assisted simultaneously multiple organ resection, and has got some results. Here, we show the achievement of laparoscopy-assisted right hemicolectomy combined with liver resection. We want to share the experience and discuss with each other.

Body position

Supine position, hands at body side, avoids hands abduction in order not to influence the operation of surgeon. For better view of the operation field, we change body position by the adjustment of operating table.

Position of surgeon

The primary operator stands at right or between the two legs of the patients. The operator that holds the laparoscopy stands at the left side of the patient, while the operator that holds the assistant pincers stands next to the primary operator. The main purpose of the assistant pincers is helping to show better views. Obviously, during the operation, the three operators could change the position to make the primary operator feel convenient as much as possible.

Figure 1 This video is about the laparoscopic colectomy combined hepatectomy surgery (1). Our team finished the application of laparoscopy operation. This case is the advanced skill compares to other hospitals in China.
Available online: http://www.asvide.com/articles/1518

Trocar position—usually, we use five trocars

(I) Observational trocar: 1 cm upside the belly button, avoid side-effects caused by puncture. This trocar site is chosen because the relative low density of fat. However, when isolating superior mesenteric vein, a vertical sight cannot be avoided. The vertical sight needs operator to accommodate.

(II) Main operational trocar: the primary main operational trocar was 2 cm right of the ligature between the belly button and symphysis pubis; the secondary main operational trocar was 3 cm left of belly button.

(III) Assistant operational trocar: the primary assistant operational trocar was the down border of the right costal arch; the secondary assistant operational trocar was the left down border of the costal arch at the same line with nipple. The assistant pincers was mainly to pull transverse colon, omentum, stomach and liver in order to show the better view.

Operation procedure (*Figure 1*)

We facilitate the middle pathway, from upside to downside, from medial to lateral. First we isolated the ileocolic artery and vein, and then we cut off the colic mesentery along the left side of superior mesenteric vein. Then we dealt with the right branch of middle colic artery, and we clean the six station lymph nodes when opened the omental bursa. We isolated the total colic mesentery according to the CME principle. Finally, we did the anastomosis outside the body. Procedures related to the malignant tumor resection conformed to the no tumor touch principle; we usually carried out D3 radical resection.

Abdominal exploration

Colorectal cancer patients need thoroughly abdominal exploration, from far to near, to be sure whether there were metastatic sites in abdomen.

Reveal the anatomic marks

Change the operating table to make the patients head is high and the legs are low while make the left side of body low and the right side high. Pull the small intestine at the inferior left part of the abdomen by gravity in order not influence the operating maneuver. The primary operator and the assistant put the greater mesentery up of transverse colon. The assistant operator pulls the transverse colon in order to reveal the middle colic vessels, superior mesenteric vein and the horizontal part of duodenum. At this time, the assistant operator pulls the colic mesentery and keeps some tense.

Isolation of ileocolic vessels

The primary operator reveal, isolate and cut off the ileocolic vessels at the bifurcation of ileocolic vessels and mesenteric vessels, be careful about the anatomic variation. After cutting off the ileocolic vessels, isolating the mesentery along the superior mesenteric vein, pull the isolated tissues to the right side and enough space left. In this enough space, we find out Toldt's space. Beginners would use no harm pincers to hold the gauze to facilitate blunt dissection. Blunt dissection help to avoid the side effects to duodenum. When dealing with the mesentery of fat people, be careful about the reproductive vessels and the ureter, for the anatomic markers were not clear in fat patients.

Cut off right colic vessels and the right branch of middle colic vessels

Isolate the mesentery along the superior mesenteric vein. The assistant operator who holds the laparoscopy should adjust a 30 degree. The right side of vessels usually has anatomic variation, so please be sure about the line that vessels flow. During these procedures, be careful about the pancreas.

Clean the lymph nodes at the root of middle colic artery

When cleaning the lymph nodes, we should pay lots of attention, because there are lots of the anatomic variations. The vessels needs to be skeletonized, we must manage the use of ultrasound knife. Be careful about the side effects of ultrasound knife, during these procedures, Toldt's space extent to the paracolic sulci.

Cut off greater omentum and omental bursa

The assistant operator help to pull the great omentum, cut off the great omentum in the middle to the root of transverse colon. Open the omental bursa and clean the sixth station lymph nodes. Isolate transverse colon along omental bursa and keep careful about the gall bladder.

Isolating liver colon treatment. And paracolic sulci

At this time the tissue between right hemicolon and paracolic sulci was only a thin film. Some patients would see the Toldt's line.

Deal with ileocecal part

Carefully recognize the fusion part of ileocecal part and the later abdominal wall. When dealing with these using ultrasound knife, the maneuver should slow down. By this, the right hemicolon were isolated.

Resection of hepatic metastatic lesion

If the metastatic lesion was on the surface of liver, we should define the scope using electronic hook. Resect the metastatic lesion using electrocoagulation. As the liver is brittle, some stitches would be needed to pull the organ. The primary operator pulls the lesion and resects the lesion while the assistant uses the aspirator. The resected lesion should be put into bags according to no tumor touch principle.

Cut off transverse colon and side to end anastomosis

Cut off the transverse colon in the body, also cut off or remain the ileum. Whether cut or remain the ileum depends on the thoughts of primary operator. Elongate the observational trocar hole and make sure the tumor could be carried out through the hole. After the anastomosis, we usually did the reinforce stitches in order to avoid the anastomosis fistula and bleeding.

Close the lesion and abdominal exploration again

After close the lesion, we re-established the pneumoperitoneum. Re-evaluate the anastomosis direction, mesenteric direction. Check that whether there exist side-effects.

Experience

Laparoscopic surgery should follow the no tumor touch principle as the open surgery. However, the operating space is limited so that the cooperation seems important. In the surgery, we should take care of anatomic marks; avoid the small field caused isolation deviation. Thus, we should always adjust back to large views to make sure the isolating sites. Cutting off vessels at the root of the vessels so that we could have enough isolation, then we can decrease the difficulty of anastomosis. Vessels skeletonization by ultrasound knife needs practice and it definitely decreases the blood loss. The assistant that hold the laparoscopy should avoid angle problem to cause the primary operator puzzled.

Acknowledgements

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Pull-through and conformal resection for very low rectal cancer: a more satisfactory technique for anal function after sphincter preserving operation

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Background: The aim of this study was to investigate oncologically whether pull-through and conformal resection technique (PTCR) could replace abdominoperineal resection (APR) in selected patients with very low rectal cancer.

Methods: This was a retrospective review of prospectively collected data. The study was conducted at a tertiary teaching hospital, Shanghai, China from January 2010 to December 2013. All patients who underwent operations because of very low rectal cancer were enrolled in this study. The primary outcome measured was the development of recurrence including distant metastasis and local recurrence. Anal function was assessed with the Wexner incontinence score and digital examination.

Results: A total of 228 patients with very low rectal cancer underwent surgical treatment [coloanal anastomosis (CAA) group 126 patients, APR group 73 patients, and PTCR group 29 patients]. There was no difference in surgical complication rate among the three groups. There were no significant differences in daily fecal frequency, Wexner incontinence score, and rate of satisfactory fecal continence between the CAA and PTCR group. There were no differences in local recurrence and distant metastasis among CAA group, APR group and PTCR group.

Conclusions: PTCR is an anus-preserved procedure with clean distal margin and satisfied anal function without compromising short-term oncological outcomes in selected patients with very low rectal cancer.

Keywords: Very low rectal cancer; anus-preserved procedure; oncological outcomes; anal function outcomes

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When a rectal cancer is located at less than 5 cm from the anal verge (very low rectal cancer), abdominoperineal resection (APR) was generally performed (1). However, the patient's quality of life can be compromised by the social and psychological limitations of a permanent stoma (2). Recently, intersphincteric resection (ISR) with coloanal anastomosis (CAA) and were proposed as alternative procedures to avoid APR (3-5). However, patients undergoing ISR generally have direct impairment of anal sphincter function because the anal internal sphincter, as a part of the anal sphincter complex, is removed. Moreover, dentate line is also removed resulting in an impairment of sensibility and hence also to more incontinence. Therefore, the functional outcomes of ISR or PISR remain an important issue because of sphincter damage and sensory loss (6-9).

An ideal procedure for very low rectal cancer should combine a satisfied preservation of sphincter function with oncological safety. Based on the previous study, we proposed a pull-through and conformal resection technique (PTCR)

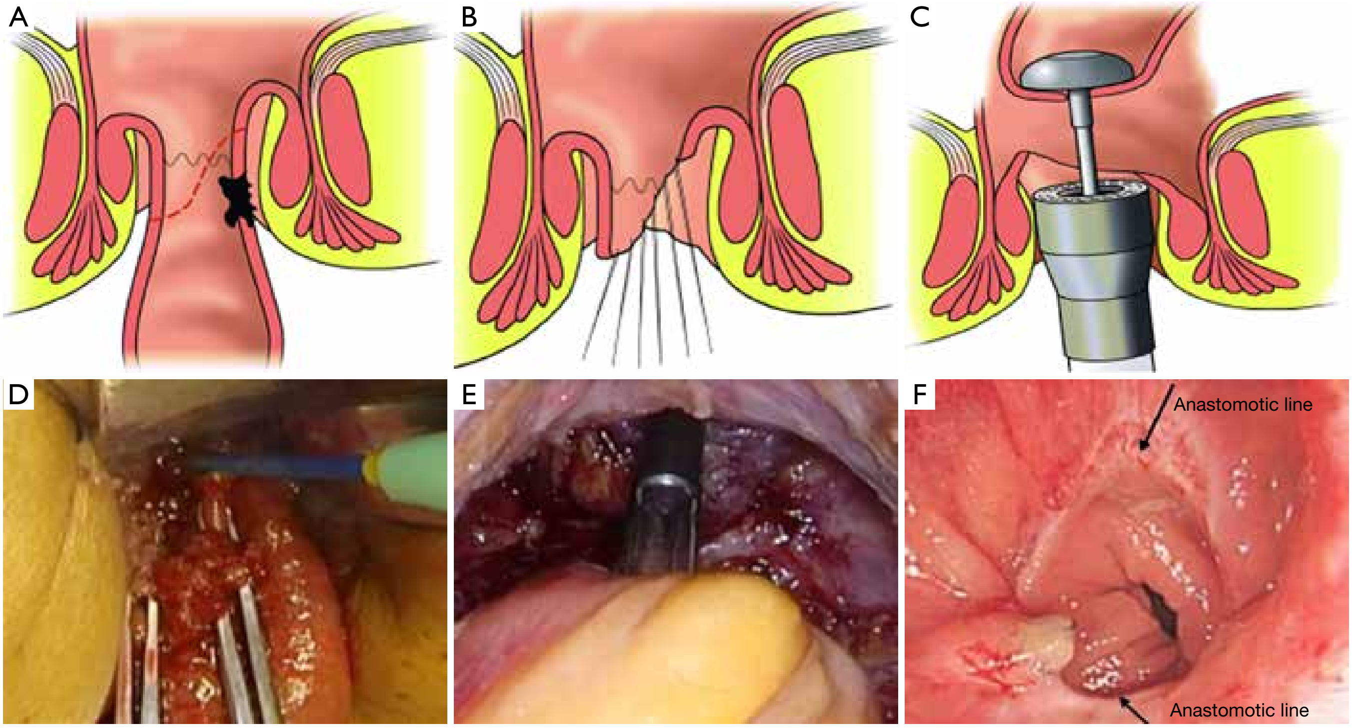

Figure 1 How PTCR performed and surgical results. (A) The rectum was transected in order to pull the rectal stump through the anus. The proposed incisional line was made according to the tumor location and shape; (B) the rectal stump was closed by interrupted sutures; (C) anastomosis was performed by a circular stapler at the normal rectal wall away from the denate line as far as possible; (D) resection of tumor under direct vision; (E) anastomosis was performed with a circular stapler (CDH25); (F) the dentate line and more rectal stump on the contralateral tumor side (long black arrow) were demonstrated to be preserved more well than that on tumor side (short black arrow) by colonoscopy in three months after surgery. PTCR, pull-through and conformal resection technique.

in selected patients with very low rectal cancer (9).

Inclusion criteria are: (I) well-moderately differentiated adenocarcinoma; (II) tumors located less than 1 cm from the dentate line; (III) less than 3 cm in diameter; (IV) tumors were mobile; (V) invasion of the internal sphincter but not the external sphincter and/or levator ani; (VI) no evidence of distant metastases; and (VII) patients with normal anal function before operation.

Exclusion criteria are: (I) patients underwent local excision; (II) patients with severe comorbidities.

Operative techniques

PTCR for very low rectal cancer was performed as follows. The sigmoid colon was mobilized, and inferior mesenteric artery was cut at the origin of the aorta. The rectum was mobilized until coming to the level of the dentate line between internal anal sphincter and external anal sphincter. The techniques of total mesorectal excision (TME) and autonomic nerve preservation (ANP) were used. When purse-string was finished by thick silk thread at the site of proposed anastomosis, the rectum was transected in order to pull the rectal stump through the anus. At the same time, the anal sphincter was dilated to four fingers. The sutures was held by long hemostatic forceps and inserted into the lumen of the distal rectum, and then pulled out through the anus. The rectal stump is rinsed using sterile distilled water. The proposed incisional line was made according to the tumor location and shape. The internal sphincter and dentate line of the tumor side were removed, while preserving the opposite normal rectal wall, internal sphincter and dentate line as more as possible. At the same time, the rectal stump was closed by interrupted sutures. Anastomosis was performed by a circular stapler (CDH25) at the normal rectal wall away from the denate line as far as possible (*Figure 1*). A protective diverting loop ileostomy was created in all patients, and was closed at 3 to 6 months after surgery if no anastomotic leakage was present.

A total of 228 patients with very low rectal cancer underwent surgical treatment (CAA group 126 patients, APR group 73 patients, and PTCR group 29 patients). There was no difference in surgical complication rate among the three groups. All patients were followed up every 3 months during the first 2 years after surgery, then every 6 months during the following 3 years, and annually thereafter. The contents of surveillance included interview of anal functions, clinical examination, chest radiography, abdominal ultrasound, and tumor markers. Colonoscopy and pelvic CT/MRI were performed every 1 year after surgery. There were no significant differences in daily fecal frequency, Wexner incontinence score, and rate of satisfactory fecal continence between the CAA and PTCR group. There were no differences in local recurrence and distant metastasis among CAA group, APR group and PTCR group.

Notes

APR with permanent colostomy is performed ranging from 25% to 35% in very low rectal cancer patients (10-12). As previous studies suggested that patients with a stoma have a poorer quality of life than those without a stoma and as many patients consider life with a permanent colostomy unacceptable (13,14). These unpleasant results of APR could be greatly improved by sphincter preservation operation. As a new sphincter preservation technique, PTCR has been used to provide promising results for avoiding permanent colostomy in patients with very low rectal cancer.

Patients undergoing the APR were more prone to develop delayed postoperative convalescence than patients receiving the sphincter preservation operation, as demonstrated by the higher rate of surgical complications and longer functional recovery (15). The higher rate of surgical morbidity in the APR patients was supposed to mainly result from the additional perineal dissection in the APR (15). In our clinical work, there were significant differences in intraoperative blood loss, operating time, and length of postoperative hospital stay between the CAA group and the APR group. There were no statistical differences in above three parameters between the CAA group and the PTCR group. The results demonstrated that PTCR for very low rectal cancer was technically feasible and safe. Also, assessment of oncological outcomes with recurrence and survival is necessary to confirm the safety of PTCR.

The central idea of PTCR is to design the excision line according to tumor location and scope and to get more normal rectal stump including the internal anal sphincter, the dentate line, and a safe incisional margin. The resection scope of PTCR includes only a part of internal anal sphincter and dentate line on the tumor side. The dentate line and sphincter complex on the opposite side is completely preserved in order to preserve the opposite rectal wall as much as possible, the anastomosis was done in the remaining wall of rectum, it's possible to keep the anastomosis line 1 to 3 cm above the dentate line, this will much more improve the function of the anal and rectum after operation (*Figure 1A-F*). In this study, the distance from the anal verge of the CAA group was significantly higher than that of the APR group and PTCR group. However, there was no significant difference between the APR group and PTCR group. It is well known that postoperative anal function is strongly associated with rectal stump length. There was no different in postoperative anal function between the PTCR group and CAA group. Our results suggested that PTCR got equal preservation of anal function as CAA group in very low rectal cancer patients by appropriate preoperative selection.

As previous mentioned, the key point of successful PTCR is appropriately selection of patients. This kind of procedure has strictly indications. Firstly, it is adopted only when the very low rectal cancer showed absence of external sphincter and levator ani involvement. Secondly, it should be restricted to tumors less than 3.0 cm in diameter. The rectal stump bearing the tumor must be pulled out of the narrow anal canal during the procedure, the excision should be under direct vision to keep the distal margin clear. Excessive extrusion of the tumor may also lead to intra-operative rectal perforation, resulting in local recurrence. Thirdly, PTCT should be performed in patients with normal anal function.

In conclusion, PTCR is a procedure with a concept of organ preservation. This procedure showed clean distal margin and satisfied anal function without compromising oncological outcomes in selected patients with very low rectal cancer.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Laparoscopic anterior resection of rectal cancer with lymph node dissection around the inferior mesenteric artery with preservation of the left colic artery (LAR-LND-PLCA)

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Background: Laparoscopic anterior resection of rectal cancer with lymph node dissection around the inferior mesenteric artery (IMA) with preservation of the left colic artery (LAR-LND-PLCA) is a highly difficult operation. According to our rich experiences of laparoscopy surgical techniques recent years, we can proficiently master the surgical techniques and difficulties of LAR-LND-PLCA base on the anatomy of blood vessels and the interfacial space.

Methods: A 59-year-old patient who was diagnosed as rectal cancer underwent LAR-LND-PLCA. Combined with this case, we share the surgical technology of LAR-LND-PLCA base on our experience.

Results: The length of operation was 120 min with bleeding of about 50 mL. The patient recovered well postoperation and discharged from hospital on the 7th day.

Conclusions: LAR-LND-PLCA is effective and safe for the rectal cancer. Because it is too difficult, so it must be done in the rich experienced hospital.

Keywords: Rectal cancer; laparoscopy; preservation of the left colic artery

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Introduction

Colorectal carcinoma is the second most commonly carcinoma in females and the third in males. In 2012 there are about 1.4 million new cases and 693,900 deaths (1). And approximately one third of all colorectal carcinoma are rectal cancer.

The anatomy of rectum is complex, and we need a good understanding of the anatomy of the rectum, good psychological quality, excellent surgical technique and the operation team with the tacit understanding to complete the laparoscopic anterior resection of rectal cancer with lymph node dissection around the inferior mesenteric artery (IMA) with preservation of the left colic artery (LAR-LND-PLCA). Here (*Figure 1*), we share the LAR-LND-PLCA surgical skills by a case of rectal cancer.

Methods

Surgical indications

LAR-LND-PLCA is suitable for the cancerous lesion located within 12 cm of the anal verge by rigid proctoscopy.

The contraindications of LAR-LND-PLCA are as follows: patients with severe cardiopulmonary in sufficiency, T4b, obstruction or tumor >6 cm in size.

In the video, the patient is a 59-year-old man diagnosed to be moderately differentiated rectal cancer after CRT, and preoperative tumor staging was ycT3N1M0 by MR (*Figure 2*).

Figure 1 LAR-LND-PLCA (2). LAR-LND-PLCA, laparoscopic anterior resection of rectal cancer with lymph node dissection around the inferior mesenteric artery with preservation of the left colic artery. Available online: http://www.asvide.com/articles/1203

Figure 2 Abdominal MRI scan.

Surgical position

After anesthesia, the patient is placed in lithotomy position and Trendelenburg position. In the operation room, there are two monitors placed right above the head and between the patient's legs. The surgeon stands on the right side of the patient. The first assistant stands on the left side of the patient. The second assistant stands on the left side of the surgeon.

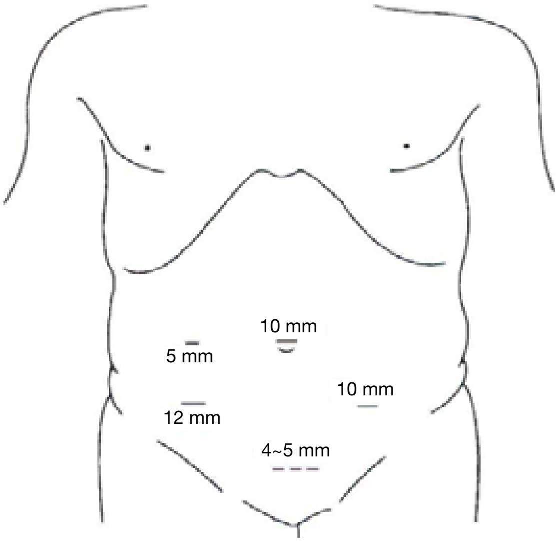

Figure 3 Trocars position.

Surgical procedures

In this operation, we need five trocars, of which two 12-mm and three 5-mm trocars. Above of the navel we puncture into 12 mm trocar and put in 30 degree laparoscopy. Pneumoperitoneum was established with carbon dioxide (CO_2) and the intra-abdominal pressure was maintained at a constant 12 to 15 mmHg. Other trocars were placed in position to see *Figure 3*. The first step is laparoscopic exploration to determine whether there was distant metastasis or spread.

And then we performed a central way to open the right side of the rectum ditch and separated the left Toldt's fascia.

At the same time, we should dissect the lymph nodes along IMA, vein and their branch and preserved the left colic artery. After branching the left colic artery of IMA, we ligated the IMA and IMV (*Figures 4,5*).

Then we can free the interspaces around the rectum and cut rectum according to the TME principle.

We extended the right side abdomen 12 mm trocars hole to about 5 cm. Through this incision, we took out the rectal cancer specimens and cut the colon in the cancer proximal 10 cm, then made an end-to-end anastomosis through the

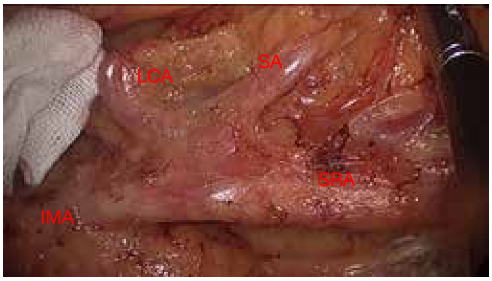

Figure 4 The branch of IMA. IMA, inferior mesenteric artery.

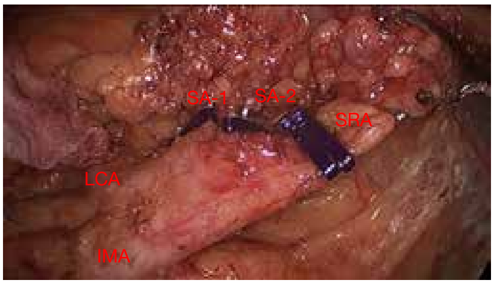

Figure 5 Ligating the IMA. IMA, inferior mesenteric artery.

Figure 6 Pathological specimens of rectal cancer.

anus using the anastomosis staplers.

At last, we made prophylactic ileostomy and suture the trocar holes and the incision.

Results

Operation time was 120 minutes, and the amount of bleeding was 50 mL. The postoperative pathological results showed that the poorly-differentiated adenocarcinoma with

Figure 7 Pathological specimens of rectal cancer.

ypT2N1aM0 (IIIA) stage among which 1/14 lymph node-positive (*Figures 6,7*). The patient recovered well without complications and discharged from hospital 7 days after surgery.

Discussion

Some studies shows that laparoscopy is associated with the same short-term and long-term outcomes with comparing the open operations (3,4). Some scholars reported that LAR had the advantages of less bleeding, faster recovery and shorter hospital stay in the short-term endpoints (5,6). And locoregional recurrence and disease-free and overall survival are the same between laparoscopic-assisted and open operation (3,4,7,8). So LAR may be considered based on some principles in NCCN Guidelines for Rectal Cancer Version 2.2016.

Curative resection of rectal cancer included “high tie” and “low tie” of the IMA. “Low tie” included preservation of the LCA and lymph nodes dissection over the root of IMA (*Figure 8*). But it was controversial whether a high or low ligation of the IMA was superior. Some experts believed that there were no significant differences in the complication rate, operative time, the amount of blood loss, the number of days and OS and RFS rates between “low tie” and “high tie” with LND (9). But some scholars thought high tie may increase anastomotic leakage, because it reduced intestinal blood supply (10).

LAR-LND-PLCA LAR is a very difficult surgery and need skilled surgical techniques. So if it is difficult to deal with the problems in the laparoscopic surgery, please consult a rich experienced surgeon or change to open surgery.

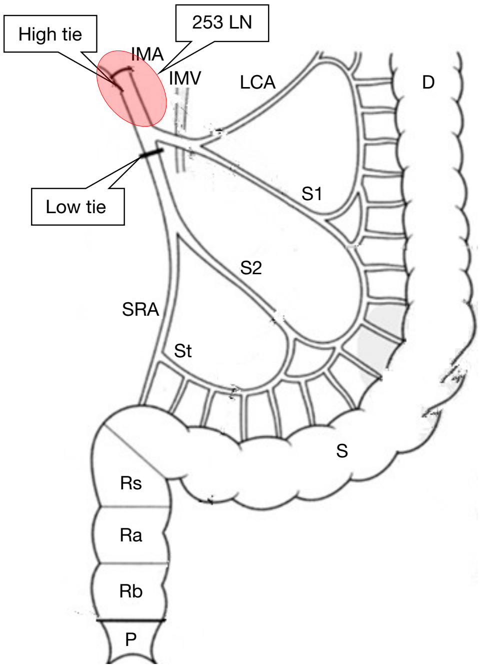

Figure 8 "High tie" and "low tie".

Conclusions

LAR-LND-PLCA is effective and safe for the rectal cancer. Because it is too difficult, so it must be done in the rich experienced hospital.

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None.

Footnote

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Informed Consent: Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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Transperineal extralevator abdominoperineal excision performed by double laparoscopic approach with no position change

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Background: The aim of this study was to assess the feasibility of such an approach and to appraise short-term outcomes.

Methods: The abdominal phase and perineal phase of the operation were both performed laparoscopically simultaneously. All patients were enrolled in an enhanced recovery programme.

Results: The conversion rate to laparotomy was 0%. All patients had circumferential resection margins (CRM) >1 mm; no intraoperative tumour perforation (IOP) occurred. The median length of stay was 8 days.

Conclusions: Double laparoscopic-assisted extralevator abdominoperineal excision (ELAPE) can be safely performed without compromising short-term outcomes.

Keywords: Abdominoperineal excision (APE); double laparoscopic approach; rectal cancer

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Introduction

Conventional abdominoperineal excision (APE) for low rectal cancer is associated with higher rates of circumferential resection margin (CRM) involvement (1), intraoperative tumour perforation (IOP) and local recurrence and leads to poorer survival when compared with anterior resection. In response to these concerns, Holm *et al.* (2) emphasized the importance of full removal of the pelvic floor. Extralevator abdominoperineal excision (ELAPE) or cylindrical APE aims to improve the oncological outcome through removal of increased tissue in the distal rectum and *en bloc* excision of the levator ani. This creates a cylindrical surgical specimen without a waist and is associated in early reports with reduced CRM involvement, IOP and local recurrence compared with conventional APE.

The technique of ELAPE has been described with the patient in the prone jackknife position and a myocutaneous flap is used to repair the plevic defect. The operation has the disadvantages of a long operation time, greater trauma, and requiring the assistance of a plastic surgeon. Laparoscopic colorectal resection is now widely established and its benefits and safety have been extensively reported (3). To simplify the operation, we have been performing ELAPE with transperineal ELAPE performed by double laparoscopic approach without a change of the position of the patient.

Patient selection and pre-operative preparation

Patients with tumours located within 5 cm of the anal verge were treated with ELAPE procedures. This decision was confirmed at a multidisciplinary team meeting after the surgeon had reviewed the patient, confirmed tumour location with MRI and discussed surgical options with the patient (ultra-low AR *vs*. ELAPE in those patients with a tumour at approximately 5 cm).

The patients had preoperative bowel preparation the day before surgery. Prophylactic antibiotics were administered before the incision.

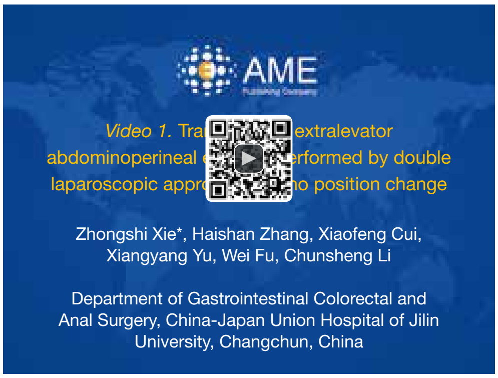

Figure 1 Transperineal extralevator abdominoperineal excision performed by double laparoscopic approach with no position change (4). Available online: http://www.asvide.com/articles/1266

Procedure (*Figure 1*)

A standardized surgical procedure was performed by two experienced rectal cancer surgeons, working simultaneously throughout the whole procedure (*Figure 2*).

Abdominal approach

The patients were placed in the Trendelenburg and right lateral tilt position.

Port distribution was as follows: a 10-mm umbilical port together with a 30-degree teleangle scope inside (2D EndoEYE 10 mm video laparoscope, Olympus KeyMed), a 10-mm port at the planned right iliac fossa , two 5-mm ports inserted in each flank, and the last 10-mm port at the planned left sided colostomy site (Covidien, Mansfield, MA, USA). A high tie of the inferior mesenteric vessels (Lapro-Clip, Covidien, Mansfield, MA, USA) (*Figure 3*) and a complete mobilization of descending-sigmoid colon were performed. ELAPE was performed according to the description by Holm *et al.* (2) with the abdominal portion involving laparoscopic mobilization of the mesorectum as far down as the origin of the levator ani muscles. This level

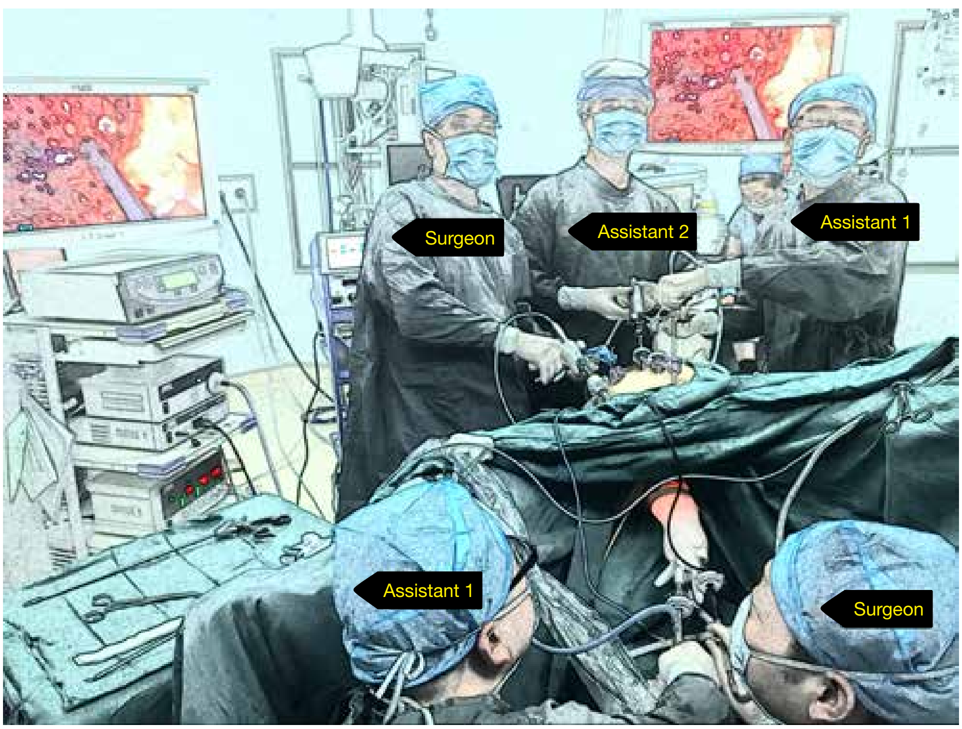

Figure 2 Two team work simultaneously.

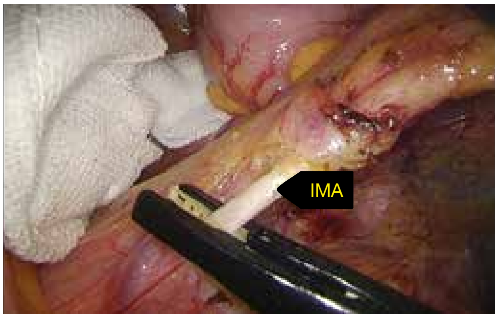

Figure 3 High tie of the inferior mesenteric vessels.

Figure 4 Incision line on the skin of patient undergoing abdominosacral amputation of the rectum.

Figure 5 Wound protector open ischiorectal fat.

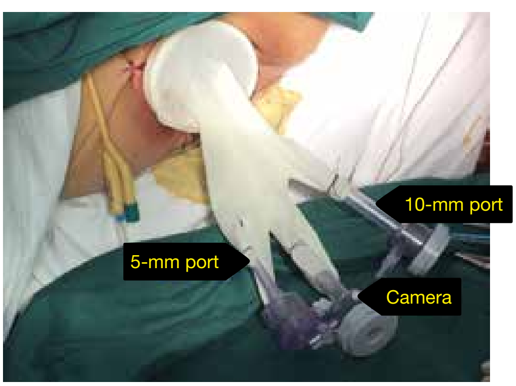

Figure 6 Use a 3-port technique made by glove.

Figure 7 The vision of "down to up".

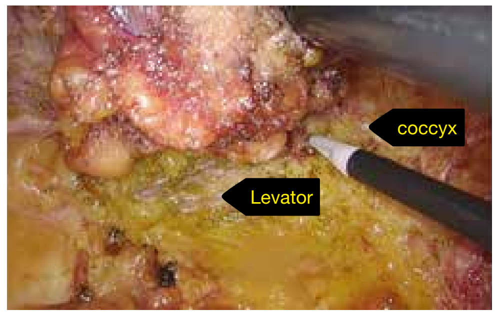

Figure 8 Dissection around the sphincter complex and followed the surface of the levators.

was defined laparoscopically by the neurovascular bundle laterally, the upper part of the vagina/seminal vesicles anteriorly and the coccyx posteriorly. The bowel was divided proximally, and a stoma was formed after closure of all trocar sites.

Trans-perineal approach

Perineal dissection consisted of dissection of the anus outside the external anal sphincter with preservation of the perianal skin and ischiorectal fat (*Figures 4,5*). Used a 3-port technique made by glove, the pelvic cavity was inflated with CO_2 to a pressure of 7–8 mmHg (*Figure 6*). Dissection continued around the sphincter complex and followed the inferior surface of the levators to a point laterally where they originate from the pelvic sidewall (*Figures 7,8*), connected each other on the left side to the level where the abdominal dissection was terminated (*Figure 9*). Then amputated the puborectalis and remove the specimen by the guide of abdominal team (*Figure 10*).

An abdominal drain was sited in pelvic and directly closed the perineal wound in layers.

Figure 9 Connected each other on the left side where levators originate from the pelvic sidewall.

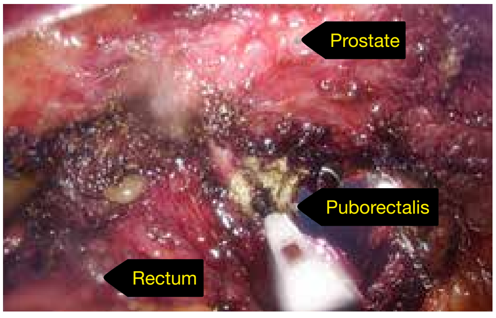

Figure 10 Amputate the puborectalis and remove the specimen by the guide of abdominal team.

Post-operative management

All patients had CRMs >1 mm; no IOP occurred. The median length of stay was 8 days. After surgery, the planned follow up for the patient was every 3 months for the first 2 years and then every 6 months for the following 3 years.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study is approved by the institutional ethical committee of China-Japan Union Hospital of Jilin University and obtained the informed consent from every patient.

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Hand-assisted laparoscopic surgery in Crohn's disease

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Abstract: Considering the advantages of hand-assisted laparoscopic surgery (HALS) in patients with higher BMI and complex adhesions, it has become an alternative to laparoscopic surgery for the treatment of Crohn's disease (CD) and other colorectal disease. Several studies have reported that HALS still maintains the advantages of laparoscopic surgery and has no differences compared with traditional procedure in the clinical outcomes. According to recent relevant literatures and personal experience, we report the five-step procedure of HALS in CD in this article: incision, placing the hand-assist device, cecal mobilization, hepatic flexure mobilization, resection and anastomosis.

Keywords: Hand-assisted laparoscopic surgery (HALS); Crohn's disease (CD); surgery procedure

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Introduction

In patients with Crohn's disease (CD) who may have undergone multiple open surgeries, it is usually difficult to explore fully laparoscopic surgery again, especially if complicated by abscesses, fistulas or anastomotic leaks. Thus, there comes another alternative to laparoscopic surgery for the treatment of colorectal diseases named Hand-assisted laparoscopic surgery (HALS), which is commonly used in patients with higher surgical complexity or BMI (1,2). Several studies have reported that HALS maintains the advantages of laparoscopic surgery and has no differences compared with full laparoscopic surgery in the aspects such as duration of operation, pain, time for recovery, and hospital stays (3-7). The application of HALS in colectomy allows surgeons to have tactile feedback and manual assistance, and make the treatment of large inflammatory phlegmons or fibrotic masses easier, such as those associated with diverticulitis or CD (8,9). Similarly, the hostile abdomen with numerous adhesions or complex fistula may be more efficiently sorted out with a hand in the peritoneal cavity. This technique may broaden the application of minimally invasive colectomy (10).

Preparation

Firstly, the patient is in supine position, then straps or bean bag are needed for the security of patient when steep table position changes (4). Secondly, a nasogastric or an orogastric tube is placed for decompressing the stomach and a urinary catheter is placed in patient's bladder.

Operating room personnel used for this procedure are identical as for an open right hemicolectomy. The nurse and assistant stand on the patient's right side initially, while the surgeon is on the other side facing patient's right colon. After all the trocars are placed, the assistant moves to the left side of patient in order to direct the camera.

Step 1: incision

In HALS, the first port was placed via a cut-down procedure

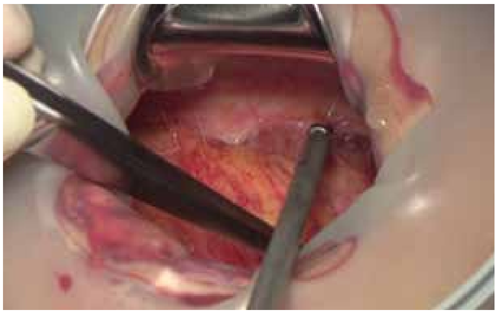

Figure 1 Operation internally via the basal port.

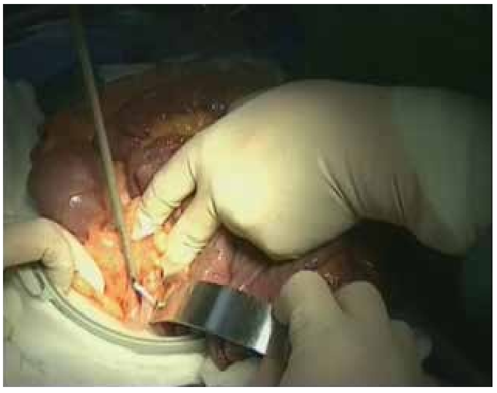

Figure 2 Operation externally via the basal port.

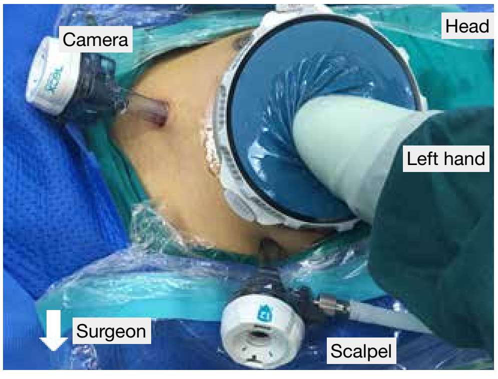

Figure 3 Placement of trocars and blue-disc.

and an ENDOPATH DEXTRUS™ (Ethicon Endo-surgery Inc., Cincinnati, OH, USA) was placed through a 7 to 7.5 cm midline incision around the umbilicus (1).

With the minimal invasive incision, the whole small bowel can be exteriorized and the proximal inflammation can be checked up to 5 cm from the ligament of Treitz. The surgeon is allowed to measure the remaining length of small bowel as well. At this point, complete intestinal inspection is an indication for early conversion to an open surgery, if necessary (11). One of the greatest benefits of HALS is this immediate access to the peritoneal cavity via the minimal invasive incision (*Figures 1-3*). The surgeon can examine the peritoneal cavity before making decision on whether to proceed with a laparoscopy or change into laparotomy (9). The laparoscopic equipment is kept in the operating theater remained intact. If intraperitoneal condition is favorable, the hand-assist device could be placed through this incision and the HALS could be performed. Otherwise, laparotomy could be performed by simply extending the incision. The author has used this benefit to reduce the rate of conversion to laparotomy, which might generate the most expense and are associated with the poorest outcomes. In addition, it also reduces the risk of trocar-related complications (12).

Step 2: placing the hand-assist device

Once HALS is decided to be performed, the hand-assist device should be placed through the incision before the establishment of pneumoperitoneum. This allows evaluation and cut of abdominal adhesions (*Figure 1*), and facilitates the placement of the trocars under direct vision in order to avoid intra-abdominal injuries by trocar (13).

Via the basal port, small bowel and peripheral adhesion could be observed directly, even exteriorized (*Figure 2*). Adhesions beneath the incision could be directly released, which could save a lot of work under fully laparoscopy. Sometimes, great vessels like ileocolic artery could also ligate via the basal port.

The trocar pattern described here is for right-sided colectomy under direct observation, and it can be changed according to the site of lesions and surgeon's preference (*Figure 3*).

(I) The 12-mm camera port is localized 5 cm below the margin of basal port, slightly right or on the midline. This position of camera can clearly observe the surgical trunk of right colectomy, while avoiding interfering with the surgeon's hand and the internal ring of the hand-assist device.

(II) The 12-mm trocar for surgeon is placed in the left upper quadrants at 5 cm above the umbilicus, or equal to the umbilicus. This position could allow the surgeon to easily reach the hepatocolic ligament.

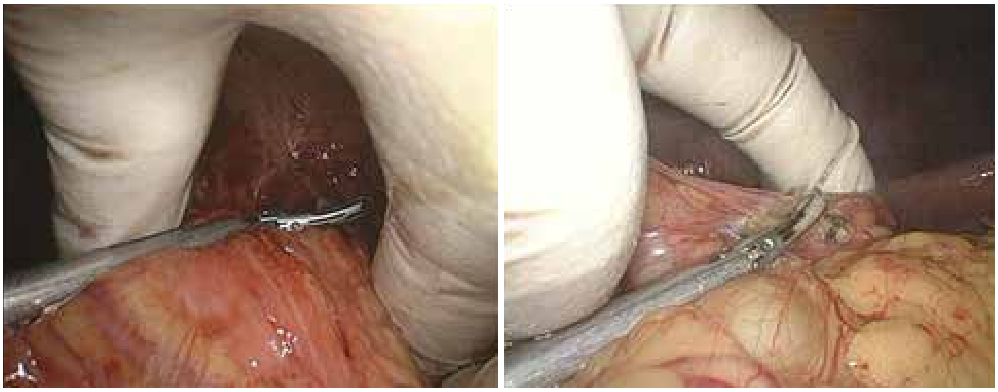

Figure 4 Dividing inflammatory adhesions using ultrasonic scalpel with hand-assist.

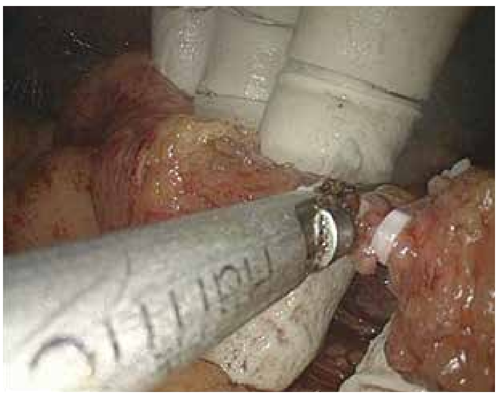

Figure 5 Vessel ligation via hand-assist laparoscopy.

Step 3: cecal mobilization

The patient should be right side inclined upward lying position, which makes the small bowel and omentum fall to the left upper quadrant, exposing the cecum (4). The small bowel is mobilized to left upper quadrant with the hand and endo Babcock clamp. By grasping the bowel wall near the base of the cecum by surgeon's hand and pulling cephalic and to the left, the inflammatory adhesions around cecum would be divided using ultrasonic scalpel (*Figure 4*). The surgeon should change the direction and strength of retraction by hand and fingers to achieve better exposure and tissue resistance. After releasing the critical adhesions, appropriate plane beneath the base of the small-bowel mesentery and around the cecum can be seen. Carefully open the overlying peritoneum membrane, then the correct retroperitoneal plane will be totally exposed.

Moving cephalic and laterally, incising the white line of Toldt's as much patience as possible, while the right colon is retracted medially and cephalically by surgeon's hand. Ileocolic vessel can be hold in fingers, and ligated by clips (*Figure 5*). Properly broaden the plane to expose the duodenum from the covering mesentery.

The ureter is visualized as it courses over the right iliac vessels. It should be identified carefully before and after opening the peritoneum. The peristalsis could help to discriminate ureter form the gonadal vessels and the psoas tendon. If the ureter is suspected to be involved in the abscess or fistula by preoperative CT images, a temporary ureteral stent should be implanted before the abdominal procedure, and removed 1 or 2 days after surgery.

Step 4: hepatic flexure mobilization

Surgeon can now stand between the legs of patient, or still at the right side. In order to expose the attachments in the region of hepatic flexure, the patient is moved to reverse Trendelenburg with the right side lifted up, which makes the omentum and the colon move caudal (4).

Carefully inserting the fingers into the plane between the peritoneum overlying the hepatic flexure and lateral-inferior wall of duodenum, to extend the plane between them (*Figure 6*). Incising medially until the gastrocolic ligament is divided. With the exposure by hand and fingers, plane between the gastrocolic ligament and the underlying transverse colon can be perfectly found (14).

Keeping the hepatic flexure elevated and held toward patient's feet by hand-assist is very important. The surgeon need to make the anterior surface of the duodenum visual and intact so they can confirm that the hepatic flexure is mobilized toward the midline adequately.

After cutting the hepatocolic and gastrocolic ligament,

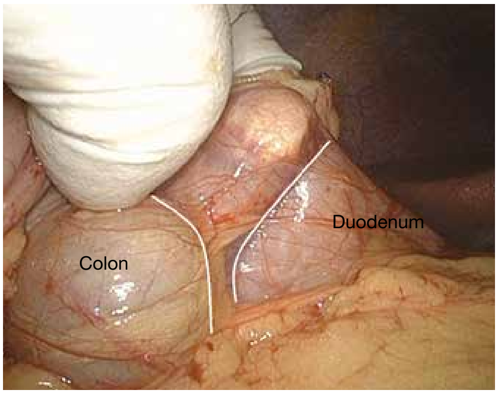

Figure 6 Using fingers to help detach the peritoneum and search for the plane.

the mesentery covering duodenum can also be detached under direct observation via the small incision around umbilicus. This could avoid injuries around the root of superior mesenteric vein. Once the duodenum and head of pancreas are fully exposed and the entire right colon is mobilized towards the midline, it is sufficient for exteriorization. Fully mobilization of the hepatic flexure to the midline makes extraction easier, which, if preferred, allows the surgeon to perform a wide stapled anastomosis.

Step 5: exteriorization, resection, and anastomosis

If mobilized properly, the colon from the terminal ileum to the mid transverse colon can be pulled out via the periumbilical incision. Adequate exteriorization of bowel and mesentery permits easier identification and ligation of the right colic or the right branch of the middle colic vessels than intracorporal vessel ligation.

Because of the variable anatomy of the right colon blood supply, it is necessary for the surgeon to identify the origins of the ileocolic, right colic, and right branch of the middle colic vessels relative to the superior mesenteric artery, before ligation is performed. Saving the right branch of the middle colic vessels can provide best blood supply to the anastomosis (4).

We also recommend side-to-side anastomosis between transverse colon and terminal ileum. The mesenteric defect is better to be closed (15,16).

Once the anastomosis is completed, the pneumoperitoneum is insufflated again for the inspection of anastomosis to ensure no volvulus of the two limbs in case of post-operative internal hernias. The abdomen and trocar sites are also checked for bleeding, and the fascia of the trocar sites is closed. Then the incision is closed after the pneumoperitoneum is deflated and the hand-access device is removed (17).

Human's hand with five individual fingers is an exquisite instrument which give tactile feedback to the surgeon. Hand-assist procedure in difficult inflammatory cases should not be overstated. Occasionally, it may create problems with visualization for the novice during their early learning period, and may force the operator to creatively solve ergonomic problems (18,19).

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Footnote

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Reduced-port laparoscopic surgery for rectal cancer

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Abstract: Although laparoscopic surgery for rectal cancer was less invasive than open surgery, there were several puncture holes and one small assisted incisions. This paper introduced the reduced-port laparoscopic surgery (RPLS) for rectal cancer, without increasing the difficulty of the operation, reducing the trauma and improving cosmesis.

Keywords: Reduced-port laparoscopic surgery (RPLS); rectal cancer

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Introduction

Laparoscopic surgery for rectal cancer has developed rapidly in recent 10 years because of its low invasiveness, good short-term and long-term outcomes, good cosmesis, and cost-effectiveness (1-3). Conventional laparoscopic surgery need 4–5 puncture holes and one 3–4 cm assisted incision and will leave 5–6 surgical scars. To reduce surgical invasiveness and improve cosmesis, surgeons proficient in conventional laparoscopic and endoscopic surgery have recently developed more advanced single-port laparoscopic surgery (SPLS) techniques as well as natural orifice transluminal endoscopic surgery (NOTES). NOTES has not been widely used in clinical practice because of the limitation of operative approach, incision closure and special equipment. Since 2008, Bucher (4) and Remzi (5) firstly used single port laparoscopic technology in the field of colorectal cancer. SPLS for colorectal cancer has become a hot spot for research because of its more prominent minimally invasive advantages and better cosmetic results. But SPLS for rectal cancer also has not been widely used in clinical practice because the operation of SPLS for rectal cancer was difficult and the abdominal cavity drainage tube could not be placed or placed through the incision which leaded to poor drainage effect and increased the incidence of incision infection and incision hernia. Reduced-port laparoscopic surgery (RPLS) for rectal cancer which had one incision and one port concentrated multiple punctures of conventional laparoscopic surgery into the auxiliary incision and retained the right lower abdomen port. RPLS had less invasive than conventional laparoscopic surgery and was easier to master than SPLS. The peritoneal drainage tube could place through the right lower abdomen port. So RPLS was accepted by more clinicians and was one of the options for rectal cancer (6,7).

Clinical summary

The patient was female, 42 years old, height 166 cm, weight 53 kg and BMI 19.2. She presented with hematochezia for five days. The tumor was rectal adenoma canceration. Tumor size was about 1.5 cm × 1.5 cm. The distance of tumor from the anal verge was 6 cm. Chest, upper and lower abdomen, enhanced CT did not find distant metastasis. Pelvic MRI showed a thickening of the rectal, mild reinforcement.

Preoperative assessment

The case should be carefully selected in the early stage of RPLS. We routinely select patients with moderate to lean body size (BMI <23) and with a higher demand for cosmesis. T stage of tumor should be less than T3, and the tumor size should not be too large. The patient had no abdominal and pelvic operation history, no cardiopulmonary dysfunction and no other traditional laparoscopic surgery

Figure 1 The location of the trocar.

contraindications.

Anesthesia, patient position, incision and port placement and operation procedure

The umbilicus or lower abdomen median longitudinal incision was 3 cm long. The retractors were placed in incision.

General anesthesia was adopted. The patient was placed in the supine position, with moderate legs separated, the right arm fixed on the right side of the body and the left arm abducted 90 degrees. The patient was put in the Trendelenburg position at 30° and tilted right side-down at an angle of 15°. The umbilicus or lower abdomen median longitudinal incision was 3 cm long. The retractors were placed in incision. The surgical sterile rubber glove was fixed to the outer ring of the incision retractor and the 5, 12, 5 mm trocars entered the abdominal cavity via thumb, middle finger, pinkie finger of the surgical sterile rubber glove respectively (*Figure 1*). After pneumoperitoneum by CO_2 gas, the peritoneal cavity was examined to determine whether RPLS was possible and to ensure that there were no peritoneal metastasis. The 12 mm trocar was placed in the right lower abdomen. When dissecting the inferior mesenteric vessels, the surgeon stood on the right side of the patient, the assistant stood on the left side and the second assistant stood between the legs of the patient (*Figure 2*). After dissecting the inferior mesenteric vessels, surgery and assistant position unchanged, the second assistant stood on the side of the patient's head (*Figure 3*). After getting sufficient distal margin, the rectum was divided using an Endo GIA Stapler. The bowel was extracted through the incision retractor, after removing the covering glove. After delivery of the specimen, anastomosis was made with a 28 mm stapling device. The pelvic drainage tube was placed through the right lower abdomen port (*Figure 4*).

Figure 2 The position of the surgeon.

Postoperative management

Anastomotic leakage is one of the most serious and major complication in rectal surgery. The pelvic drainage tube was very important in the early diagnosis of anastomotic leakage. The drainage tube should be kept unobstructed, and the volume and character of the drainage fluid were closely observed after the operation. The patient was semi supine 6 hours after the operation and began ambulation on first days after the operation.

Comment

The average age of colorectal cancer patients in china was 10 years younger than that of European and American countries, and about 40% patients were younger than 40 years old (8). We need to pay attention to the radical cure for rectal cancer patients, also the cosmesis.

RPLS that we carried out for rectal cancer concentrated multiple punctures of conventional laparoscopic surgery

Figure 3 The position of the surgeon.

Figure 4 The position of Incision and drainage tube.

into the auxiliary incision and retained the right lower abdomen port, reduced the puncture hole and damage and had good cosmetic effect. The operation was easier than SPLS due to the retention of the right lower quadrant 12 mm port. The pelvic drainage tube that placed through the right lower abdomen port was appropriate and conducive to the early discovery and treatment of the anastomotic fistula. The operation was completed by conventional laparoscopic instruments, so that it was easy to spread. RPLS was safe, feasible and one of the options for rectal cancer.

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Technique of laparoscopic-assisted total proctocolectomy and ileal pouch anal anastomosis

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Contributions: (I) Conception and design: B Wu; (II) Administrative support: B Wu; (III) Provision of study materials or patients: B Wu; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: Total proctocolectomy (TPC) with ileal pouch anal anastomosis (IPAA) is the procedure of choice for patients with ulcerative colitis (UC) requiring surgery and familial adenomatous polyposis (FAP). Laparoscopic TPC with IPAA has been applied since the early 2000s and demonstrated to be feasible and safe. J-pouch with a stapled anastomosis has been the preferred technique for its efficiency and good long-term functional outcome. The technical aspects of laparoscopic TPC with IPAA are presented in this article.

Keywords: Laparoscopy; restorative proctocolectomy; ileal pouch anal anastomosis (IPAA); ulcerative colitis (UC); colorectal

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Introduction

Total proctocolectomy (TPC) with ileal pouch anal anastomosis (IPAA) was first described in 1978 (1). Since then, this procedure has been applied to patients with ulcerative colitis (UC) and familial adenomatous polyposis (FAP) as a first choice. Laparoscopic-assisted TPC with IPAA has been applied since the early 2000s (2). Several reports have demonstrated that laparoscopic operations are feasible and safe, with decreased postoperative time in hospital, better cosmetic result, fewer intra-abdominal adhesions, and less wound complications (3-5).

Laparoscopic-assisted TPC with IPAA has been gradually gaining acceptance. Stapled ileal J pouch-anal anastomosis has been the preferred technique for its efficiency and good long-term functional outcome (6). We have employed laparoscopic-assisted TPC with IPAA for the treatment of UC and FAP since 2010. Most of our patients underwent a two-stage procedure while patients with acute severe UC underwent a three-stage procedure. Here we present our current technique and experience of laparoscopic-assisted TPC with IPAA followed at our centre.

Patient selection and workup

Laparoscopic-assisted TPC with IPAA has become a first choice surgical procedure for UC patients who require surgery and FAP. The surgical strategy for UC patients depends on whether they are elective cases or emergency (7).

IPAA can be performed as a one, two or three stage procedure. In elective cases the procedure is performed either as a two or one stage (pouch construction without a diverting ileostomy) procedure. In our practice, we prefer a two-stage approach as the standard procedure. A restorative proctocolectomy with an IPAA and diverting loop ileostomy is the first stage while reversal of loop ileostomy is the second stage operation.

Patients with acute severe colitis who are in poor general conditions and/or experiencing the side effects of corticosteroids or immunomodulators should led to a three stage procedure. A total colectomy with end ileostomy will

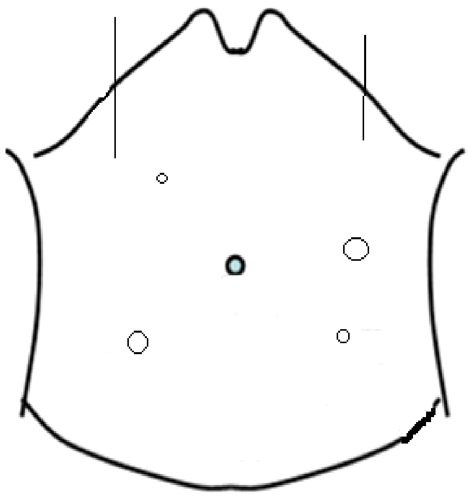

Figure 1 Port placement.

precede the pouch procedure as the first stage in the three stage approach. A restorative proctectomy approximately 3–6 months later with completion proctectomy, IPAA and diverting loop ileostomy is the second stage followed by reversal of the ileostomy as the final stage.

Pre-operative preparation

A multidisciplinary approach between the gastroenterologists and surgeons is essential if the patient has a diagnosis of UC.

The patient's medical condition should be optimized prior to surgery, by correcting anemia, coagulopathy, hypovolemia, electrolyte or acid-base imbalances, and any nutritional deficiencies. Corticosteroids should be weaned if possible. Failure to wean from prednisolone 20 mg daily or equivalent for more than six weeks prior to surgery, should postpone pouch construction to a second stage (7).

Patient's tolerance of prolonged general anaesthesia should be assessed. All patients received oral mechanical bowel preparation. The patients were managed with a single dose of broad-spectrum intravenous antibiotics preoperatively.

Equipment preference card

Commonly used laparoscopic instruments:

(I) Video camera unit;
(II) Light source;
(III) CO_2 insufflator;
(IV) 30-degree laparoscope (5 or 10 mm);
(V) Suction/irrigator;
(VI) Veress needle;
(VII) Scissors with cautery attachment;
(VIII) Babcock graspers;
(IX) Atraumatic bowel handling graspers;
(X) Circular stapler;
(XI) Laparoscopic linear stapler;
(XII) Hem-O-Lock;
(XIII) LigaSure (optional);
(XIV) 5-mm harmonic scalpel.

Procedure

Patient position and room setup

Patient is positioned in Trendelenburg with low lithotomy, both arms by side of patient and tucked in, legs in Allen stirrups such that the thighs are level with the abdomen. During the operation, wide position swings and steep inclinations of the operating table are required to assist in achieving proper exposure of the operative field. Take care of the legs position to avoid injury to the peroneal nerves and other pressure-related injury.

Two monitors are best placed on both sides of patient. The position of the surgeon should be ergonomically altered depending on the dissection of individual segment of the colon. The key to the appropriate position of the surgeon is to maintain a parallel view with the laparoscope, working instruments, and the monitors.

Port placement

Pneumoperitoneum is established with Veress needle and 10-mm port is inserted through supraumbilical after induction of anaesthesia. The 30-degree laparoscope is introduced through the 10-mm trocar. The 12-mm working port in through the right lower quadrant rectus abdominis muscle (the site for the ileostomy, identified prior to insufflations). The 5-mm ports are inserted in right upper quadrant, left upper quadrant and left lower quadrant at mid clavicular line (*Figure 1*). The intra-abdominal pressure is set at 12 mmHg and flow at 10 L/min.

Operative steps

There are five main phases in the operation. First phase is consisted of mobilization of the rectum, sigmoid colon

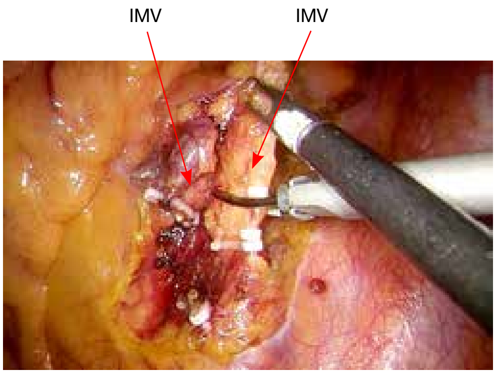

Figure 2 Superior hemorrhoidal and sigmoid vessels are isolated and divided between clips.

Figure 3 Presacral space dissection toward the pelvic floor, which is similar to TME. TME, total mesorectal excision.

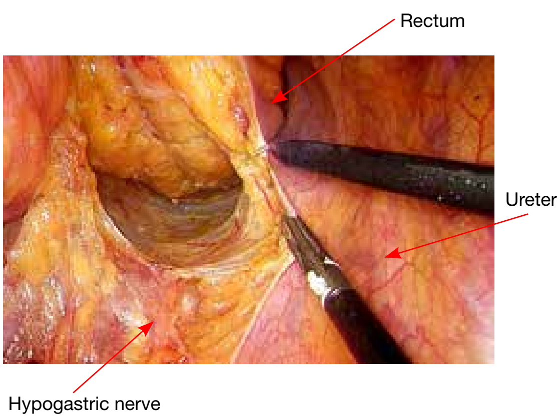

Figure 4 Dissection of the right lateral side of rectal mesentery.

and transection of the rectum as far as the pelvic floor. Second phase consisted of mobilization of the descending colon, splenic flexure and left half of the transverse colon. Third phase consisted of mobilization of terminal ileum, cecum, ascending colon, hepatic flexure, and the right half of transverse colon and lengthening of root of mesentery. Fourth phase is consisted of specimen extraction and creation of ileal J-pouch outside abdomen, return to laparoscopy and ileal pouch-anal anastomosis. Fifth phase is construction of ileostomy.

Mobilization and division of the sigmoid colon and rectum

The primary operating surgeon stands on the right side of the patient, with the camera surgeon and assistant surgeon standing on the patient's left side. In steep Trendelenburg position small intestinal loops are gravitational migrated to the upper abdomen and sacral promontory is identified. In female patients, the uterus may be suspended to the lower anterior abdominal wall by a sling suture passing through the body of the uterus and brought out over the abdominal wall, just above the symphysis pubis.

With the retraction of the sigmoid colon cephalad and medially, the peritoneal incision is then extended distally to the midrectum entering the presacral space. The presacral space is developed by the division of the fine adhesions and care should be taken to protect hypogastric nerves and both ureters. Then mobilization is made in the avascular plane behind the mesenteric vessels. The superior hemorrhoidal and sigmoid vessels are isolated and divided between Hemolock clips (*Figure 2*). As disease is not malignant, there is no need to clear the root of inferior mesenteric artery, which may damage super hypogastric nerve (8).

After vascular ligation, dissection continues down the presacral space in this avascular plane toward the pelvic floor, which is similar to total mesorectal excision (TME) (*Figure 3*). The dissection continues laterally on either side until it meets posteriorly developing a presacral plane (*Figures 4,5*). During posterior and lateral dissection, care must be taken to avoid injury the inferior hypogastric nerves on sidewall of pelvis. Anterior dissection is commenced posterior to Denonvilliers' fascia (*Figure 6*) (9). Take care to avoid injury to seminal vesicles and neurovascular bundle (NVB).

The mobilization continues down to the pelvic floor (*Figure 7*). The rectum is then divided at the pelvic floor using a reticulating endoscopic 60 mm linear cutting stapler (*Figure 8*). An adequate distal margin approximately 2 cm above the dentate line is confirmed by digital examination, which is performed to confirm the location of the distal staple line after placement of the stapler and before division of the bowel (*Figure 9*).

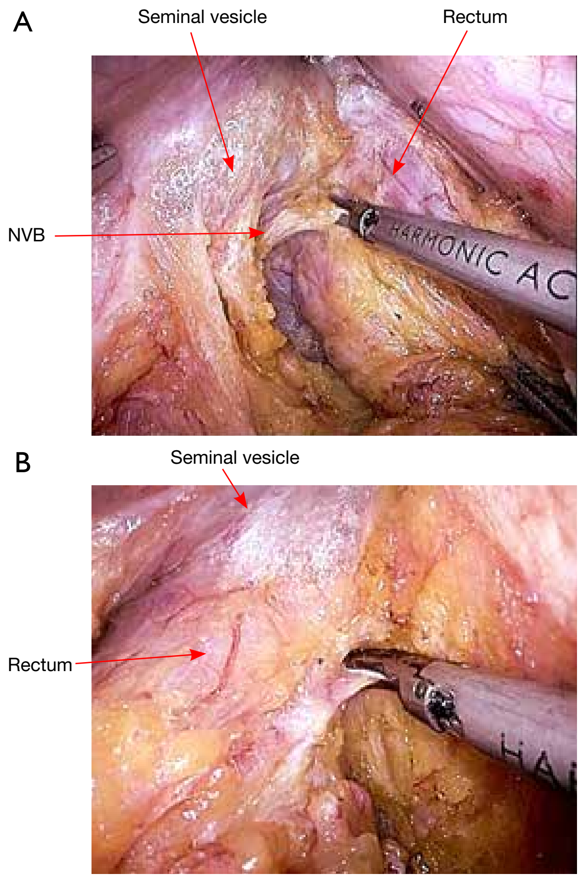

Figure 5 Mobilization left (A) and right (B) side of the rectum.

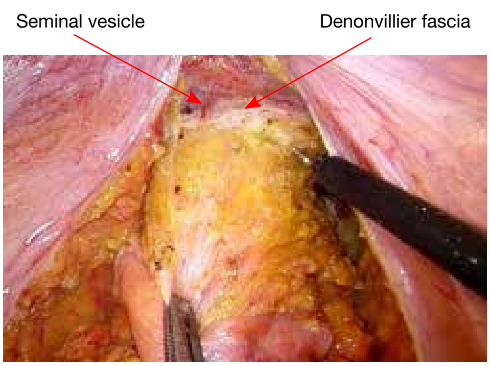

Figure 6 Anterior mobilization of the rectum.

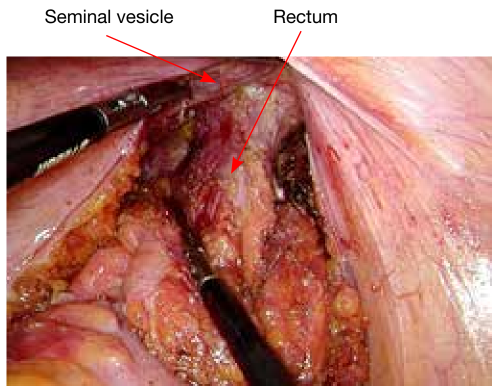

Figure 7 View of the rectum after mobilization.

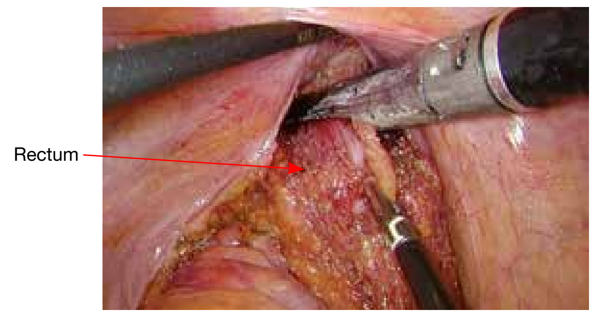

Figure 8 Distal rectum divided by EC60A.

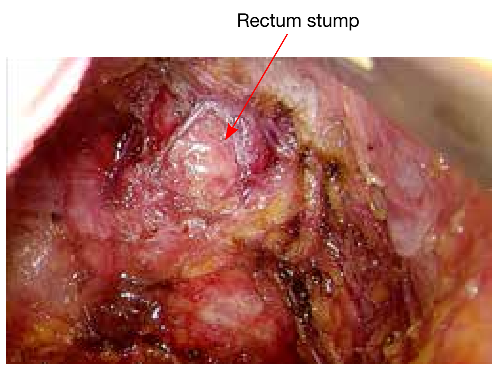

Figure 9 Rectal stump after low division.

Mobilization of descending colon, splenic flexure and left half of transverse colon

After mobilization of the sigmoid colon and rectum, surgeon starts left colectomy standing on right side of patient. Camera surgeon stands on left of surgeon and assistant surgeon between the legs of the patient. The patient is rotated with the left side up, and the small bowel loops are swept to the right side of the abdominal cavity using the atraumatic bowel graspers.

The rectosigmoid mesentery is stretched up toward the left lower quadrant, the descending colon is stretched up toward the left upper quadrant. The descending colon mesentery is incised lateral to the inferior mesenteric vein

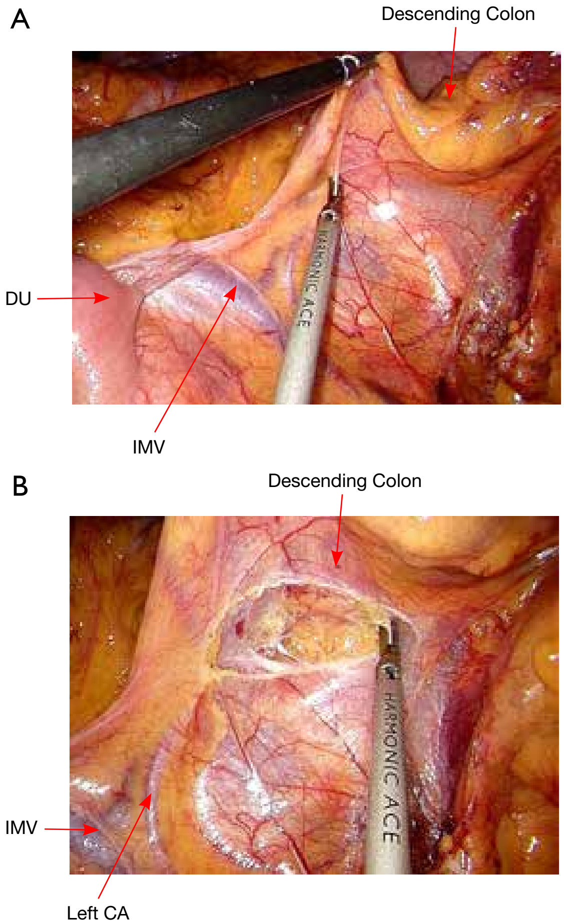

Figure 10 Descending colon mesentery incised.

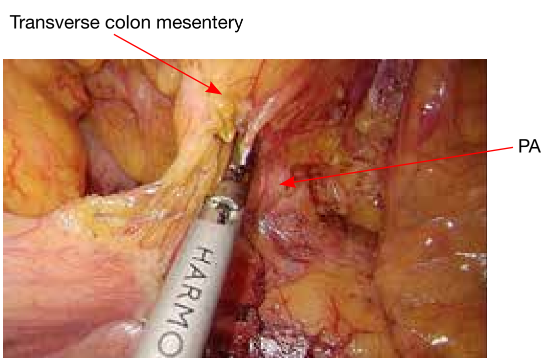

Figure 11 Mobilization of the transverse colon mesentery.

(IMV) (*Figure 10*). The left colonic vessels are isolated and divided between Hemolock clips. Expose the plane between mesocolon and left Gerota's fascia to mobilize the left colon mesentery. Mobilize the left colon up along the Toldt's

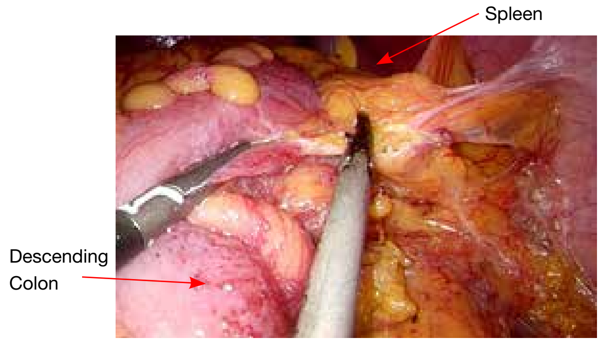

Figure 12 Splenic flexure mobilization.

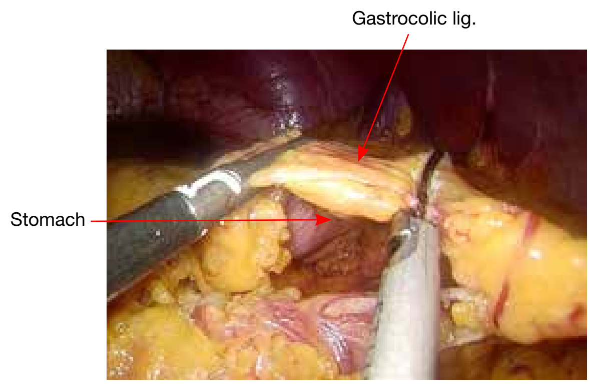

Figure 13 Division of greater omentum.

fascia until the inferior margin of pancreas and then uncover the body and tail of pancreas (*Figure 11*). During the phase, dissection is carried out from medial to lateral and down to up. Take care to protect the gonadal vessels and left ureter. Lateral attachments of descending colon are divided with ultrasonic shears, until splenic flexure is mobilized (*Figure 12*).

The assistant grasps the greater omentum superior to the distal transverse colon and retracts upward toward left. The surgeon dissects the omentum with the countertraction and enters the greater sac. The dissection is then advanced toward the splenic flexure (*Figure 13*). The left half of transverse colon is mobilized, taking the greater omentum and protecting the gastroepiploic arcade.

Mobilization of the right colon and terminal ileum

After splenic flexure and left half of transverse colon were mobilized (*Figure 14*), the surgeon moved to the patient's left side, camera surgeon between the patient's legs and an assistant surgeon on the right side of the patient. The

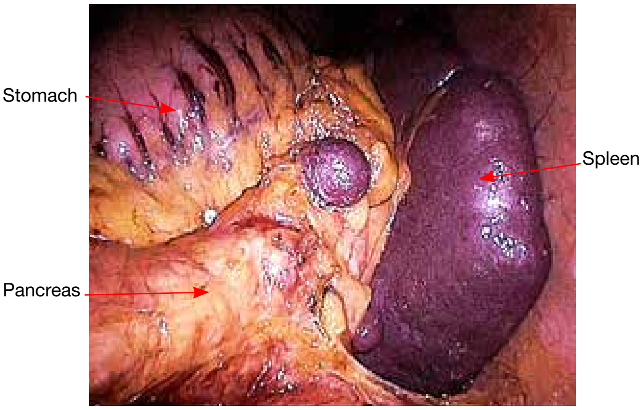

Figure 14 View after splenic flexure mobilization.

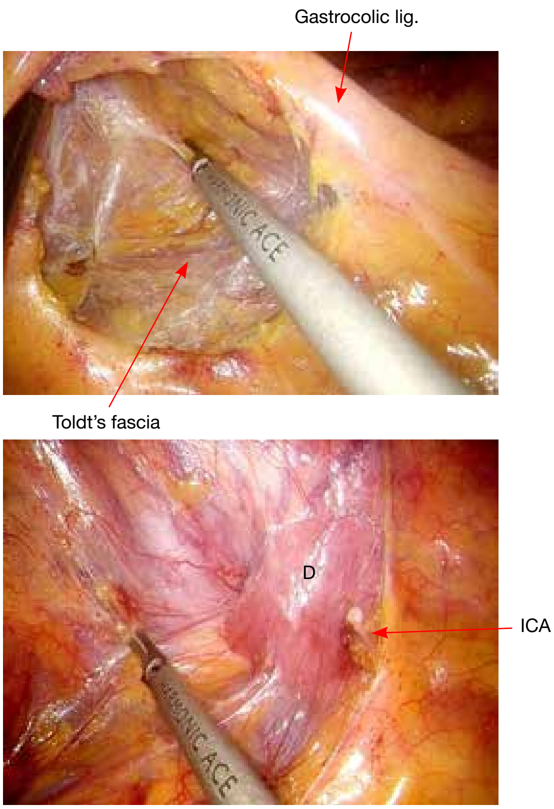

Figure 15 Exposing the surgical plane of right Toldt's fascia.

operation table is tilted right side up and head low. The small bowel loops are swept to the left side of the abdominal cavity.

The dissection commences with the opening the peritoneum of right mesocolon. From medial to lateral direction, creates a plane between mesocolon and right Gerota's fascia. As the ileocolic pedicle is mobilized, Toldt's

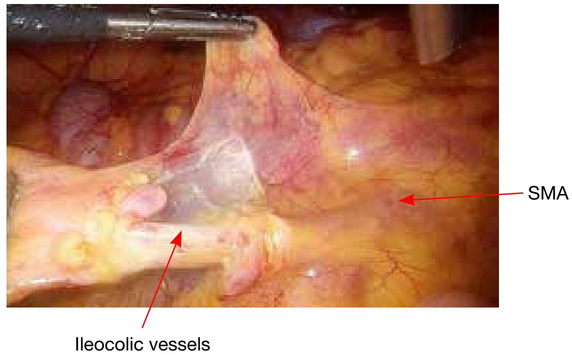

Figure 16 Mobilization of the ileocolic vessels.

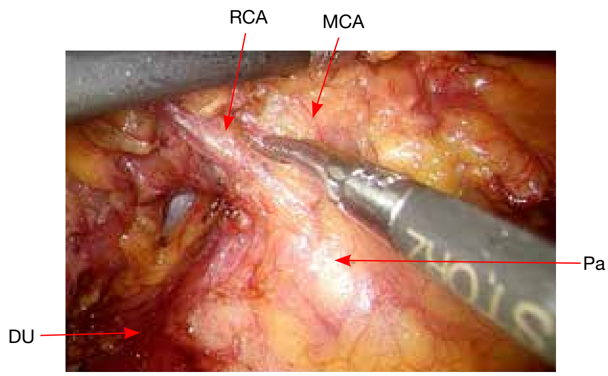

Figure 17 Mobilization of the middle and right colic vessels.

fascia is carefully protected on the retroperitoneum, thereby protecting the ureter, the duodenum, and the retroperitoneal structures (*Figure 15*). Dissection is carried out using ultracision. The ileocolic vessels are isolated and divided between Hemolock clips (*Figure 16*).

Then the peritoneal incision is extended superiorly toward the transverse colon, and then the dissection continues along the transverse colon inferiorly. The middle colic vessels and right colic vessels are then carefully mobilized and divided (*Figure 17*). The root of small bowel mesentery is mobilized adequately, so that the distal ileum loop will reach to the pelvic floor with no tension.

After the colon is freed from the peritoneal attachments on the medial side, the dissection continues along the white line of Toldt, starting from the cecum to the hepatic flexure and then right half of transverse colon.

Specimen extraction, creation of ileal pouch and pouch anal anastomosis

After mobilization of entire colorectum, in this phase, we

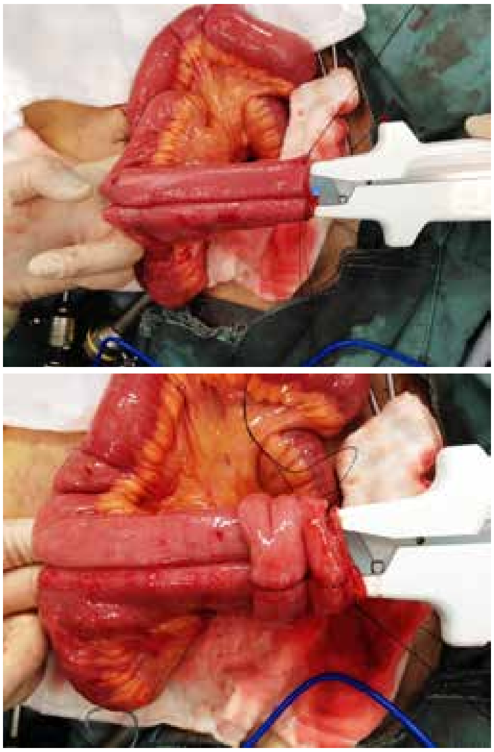

Figure 18 Applying linear GIA 100 stapler to create ileal pouch.

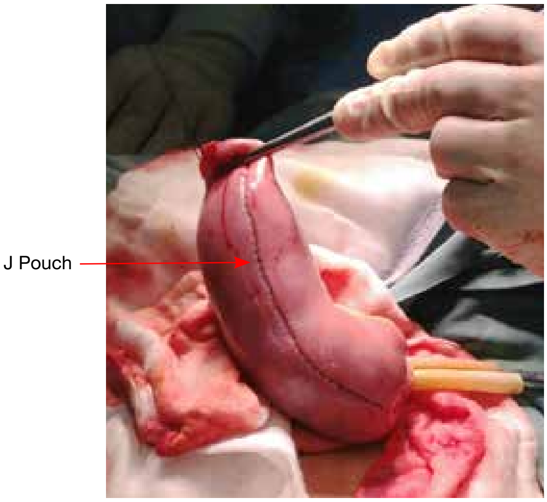

Figure 19 Pouch is flushed with saline.

prefer a 5-cm ventral midline incision into the abdominal cavity. Insert a plastic sheath in abdominal incision to protect the wound. Then, the TPC specimen is extracted, and sufficient length of distal ileum is brought out.

The pouch designs used for IPAA include J, S, or W

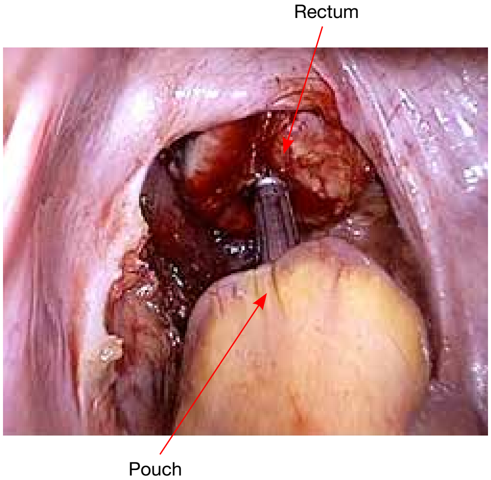

Figure 20 Attaching anvil to EEA stapler.

type. The J-pouch is the most commonly used, for its good functional outcomes and easier to construct (7). A J-pouch is constructed from the terminal 40 to 50 cm of small intestine in a standard fashion. The distal ileum segment is folded into two segments. At the pouch apex, a 1 cm enterotomy is made longitudinally. A side-to-side anastomosis of the two segments of the ileum is done by firing two linear GIA 100 mm staplers (*Figure 18*). The blind loop of the J-pouch is closed by another linear stapler and then oversewn with 3/0 absorbable sutures.

The inside of pouch is inspected and cautery or sutures at stapler line are used to achieve complete hemostasis. Insufflation using saline is performed to confirm the integrity of the pouch (*Figure 19*). The anvil of 29 mm circular stapler is inserted in the pouch apex, fixed with a purse-string suture. Put the pouch into the pelvic floor to judge the pouch tension. A tension-free anastomosis is very important to IPAA operation. Ileocolic vessels ligation at the origin of SMA and adequate mobilization of small bowel mesentery are useful to decrease pouch tension. Small peritoneal incisions over the superior mesenteric vessels border can be done as an additional pouch lengthening maneuver. After all these maneuvers, if there is still obviously tension, permanent end ileostomy is inevitable.

The pouch is then returned to the abdomen. The small bowel should be correctly oriented to prevent torsion of the mesentery. Insert the EEA stapler gun per anum, and fix the anvil to its head (*Figure 20*). An ileal pouch-anal anastomosis is then fashioned without torsion or tension

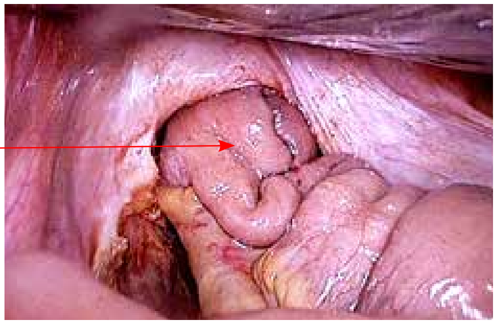

Figure 21 Pouch anal anastomosis completed.

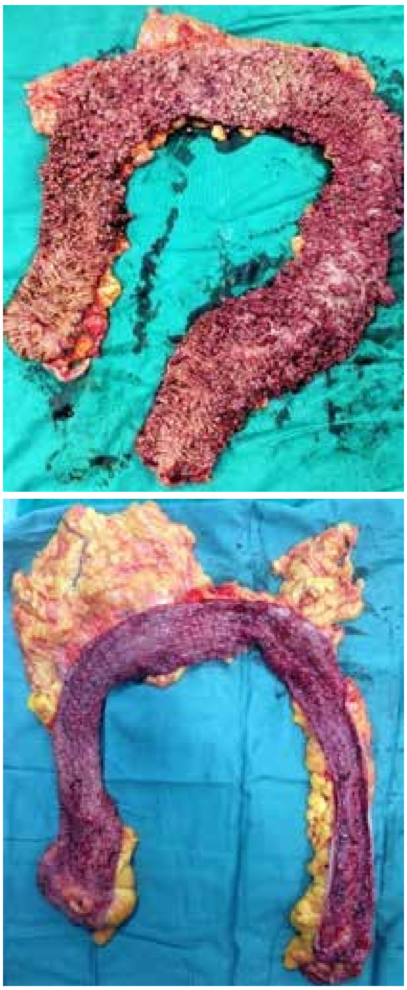

Figure 22 Specimen of FAP (A), UC (B). FAP, familial adenomatous polyposis; UC, ulcerative colitis.

(*Figure 21*). An air test is performed to ensure there is no leak. After confirming hemostasis and instrument count, a pelvic drain is placed.

Construction of loop ileostomy

Finally, take out the 12-mm trocar at right lower quadrant (previously marked ileostomy site), and expand the incision to about 3 cm. Loop of ileum (about 40 cm proximal to the anastomosis) is brought out. A temporary diverting ileostomy is constructed. Midline abdomen incision and ports are then closed in layers. Specimen is send to pathological examination (*Figure 22*).

Post-operative management

We do not recommend broad-spectrum intravenous antibiotics postoperatively. Clear liquid diet is started when the bowel function resumed. Bladder catheter is removed on fifth post-operative day. Drainage tube is removed when bowel sounds are present and output is low, usually on postoperative day 4–5. The patient is discharged from the hospital once he or she is mobile, and the ileostomy is well functioning. Sutures are removed on seventh post-operative day if no wound infection is present.

The patients with peristomal skin problems should be followed up by an ostomy nurse specialist. Ileostomy reversal is performed after confirming pouch integrity after approximately 12 weeks. The patients will be followed up in our out-patient clinic at 2 week, 1 month, 3 months and yearly.

Tips, tricks and pitfalls

(I) Care should be taken during handling of bowel in patients particularly in UC patients due to increased fragility of the tissues. Atraumatic graspers should be preferred to avoid direct grasping of the colon.

(II) In benign conditions, lymph nodes near the root of inferior mesenteric artery need not to be dissected, which may damage superior hypogastric nerve.

(III) As disease is benign, in order to avoid any nerve injury, we prefer to use similar TME dissection.

(IV) The rectum should be divided at the pelvic floor and the staple line less than 2 cm above the dentate line.

(V) J-pouch with double stapling technique has been the preferred technique, because it is easier to create and get good functional outcomes.

(VI) A tension-free anastomosis is very important to IPAA operation. Ileocolic vessels ligation at the origin of SMA and adequate mobilization of small bowel mesentery can provide an anastomosis with no tension.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Techniques of laparoscopic total proctocolectomy and ileal pouch anal anastomosis patients with ulcerative colitis

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Abstract: The incidence of ulcerative colitis (UC) is increasing in adults and children worldwide. Despite the advances in drug therapy, surgery is also an important treatment. Total proctocolectomy (TPC) with ileal pouch anal anastomosis (IPAA) is the gold standard surgical treatment of UC since its introduction in 1978 by Parks and Nicholls. Laparoscopic TPC with IPAA, as a new approach for UC patients, has been applied and demonstrated to be feasible and safe. Similar to many other laparoscopic surgeries, laparoscopic TPC with IPAA benefits the patients with better outcomes in terms of cosmesis, pain and early recovery, especially in young patients. As for the surgeons, laparoscopy can provide a broad field of vision, which facilitates the surgery in the deep pelvic as well as with less tissue damage. In general, the surgery involves total colectomy, rectal dissection, pouch creation and anastomosis of pouch to the anal canal.

Keywords: Laparoscopic surgery; techniques; total proctocolectomy (TPC); ileal pouch anal anastomosis (IPAA); ulcerative colitis (UC)

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Introduction

Ulcerative colitis (UC) is a chronic inflammatory disease that occurs in the colonic and rectal mucosa. Most patients with UC can be effectively managed medically. However, up to 15% to 30% of patients eventually require surgery. Choosing the right timing for surgery is critical to UC patients. The delay in surgery may lead to a deterioration in the physical reserve and aggravate the condition of the patient's malnutrition, resulting in complicated postoperative outcomes.

Total proctocolectomy (TPC) with ileal pouch anal anastomosis (IPAA) was firstly introduced by Parks and Nicholls (1) in the late 1970s and it is now widely recognized the gold standard surgical treatment for most UC patients requiring surgery. It was initially described with an "S" pouch and a "J" configuration was subsequently introduced by Utsonomiya (1,2). Both were described with a handsewn anastomosis to the dentate line after mucosectomy of the rectal cuff. Over the next decade, multiple variations including J, S, H, and W pouches were evaluated. Because of the easy construction and efficiency of evacuation, the J configuration was subsequently accepted as the preferred technique (3). Over the past decade, improvements in surgical techniques and the accumulation of surgical experience have effectively improved the clinical outcome of patients who underwent ileal-pouch anastomosis (4). IPAA surgery is widely used by surgeons, mainly because of its acceptable morbidity and quite low mortality rates, respectively, 19–27% and 0.2–0.4%. In addition, the quality of life is almost the same as the healthy people (5).

The emergence of laparoscopic IPAA is a great advance in the surgical treatment for the UC patients. In 1992, Peters firstly performed IPAA surgery laparoscopically on UC patients (6). However, due to the complex course of chronic diseases, chronic malnutrition, intestinal fragility and other factors, the surgeon thought that laparoscopic surgery is not good choice at the beginning. Moreover, the surgeons did not have enough laparoscopic colon surgery experience and suitable equipment such as stapling device. In addition, laparoscopic IPAA is technically challenging. With the subsequent accumulation of surgical experience and the emergence of dedicated laparoscopic surgical equipment, laparoscopic IPAA surgery is gradually being carried out widely.

Indications for surgery

For patients who required TPC-IPAA surgery, surgical indications between laparoscopic and open IPAA do not differ too much. Usually, uncontrolled bleeding, perforation, and malignancy are the absolute indications of surgery for UC. Moreover, the following situations can also be considered for surgery: severe UC that is refractory to medical treatment, toxic megacolon, uncontrolled symptoms, and situation that continuous medical treatment is impossible due to side effects (7).

Use of laparoscopic IPAA should be carefully considered if the patient is in any of the following situations: previous surgery with large abdominal incisions; emergency situations (i.e., toxic megacolon, perforation, or fulminant UC) (8).

Operative strategy

There are three choices for IPAA surgery which contains one-, two- and three-stage procedure. For those who have a favorable physical condition, one- or two-stage surgery is generally chosen (9). When patients are in poor general conditions, a three-stage procedure would be the better choice.

One-stage procedure includes pouch construction and no diverting ileostomy. For two-stage procedure, restorative proctocolectomy with IPAA and a protective ileostomy are performed in the first stage and then closing the ileostomy after 3-6 months (depending on the patient's specific circumstances) in the second stage. For three-stage procedure, a total colectomy with end ileostomy are performed in the first stage; subsequently a restorative proctectomy with IPAA and diverting loop ileostomy are performed after 3–6 months; finally, the ileostomy is reversed in the third stage.

Preoperative preparation

In order to develop the optimal treatment plan, preoperative multidisciplinary discussion will help to adjust the patient status and medication before and after surgery. A preconceived plan of the surgery should be made before surgery, based on preoperative evaluation, history, endoscopic findings, and radiologic studies but not on the operative findings.

The nutritional status of patients should be optimized prior to surgery. Moreover, anemia, low albumin should be corrected and the infection should be well controlled. Mechanical bowel preparation is used as deemed clinically appropriate. Although preoperative stoma marking seems insignificant, it is extremely important for patients in their postoperative care. The surgeons should keep in mind that the stoma is an important trail of this operation for the patients. A good stoma position should be easy to care and improve the quality of life for patients. Before surgery, prophylactic broad-spectrum antibiotics are given by intravenous injection.

Procedure

Patient position

Patient is placed in a position of Trendelenburg with low lithotomy. The arms are wrapped and tucked to the sides of the body; in order to minimize traction injury to brachial plexus, padded supports are applied to the shoulders. Legs are put in Allen stirrups and the thighs are level with the abdomen in order to prevent the peroneal nerves from injury.

Port placement

The surgical approach using standard laparoscopic techniques requires initial creation of pneumoperitoneum, generally at 12 to 14 mmHg. There are several ways for the port placement during the surgery (8,10,11). One method described by Luca Stocchi (12) from the Cleveland Clinic shows that they usually choose four ports. The first one is at the site of supraumbilical midline and pneumoperitoneum is established through this port. Then a 5-mm port is inserted in the position of left lower quadrant or the left interclavicular line along the transverse umbilical line. A 12-mm port is inserted in the right lower quadrant or the right interclavicular line along the transverse umbilical line. And the last 12-mm port is situated on 2 to 3 fingerbreadths cephalad to the pubic bone and 2 cm to the right of the midline. Most of the laparoscopic rectal dissection is through the latter port, and it is also used to place the endostapler for transection at the anorectal ring if there is a total proctocolectomy (TPC) at once.

Operative steps

The technical requirements are very high in laparoscopic TPC-IPAA. The technical requirements and norms for mobilization of colon and rectal are as strict as that in radical surgery for colorectal cancer. The surgery can be divided into three parts in general. The first part is total abdominal colectomy. Then rectal dissection together with ileal-pouch anal anastomosis would be the next part. Finally, the ileostomy is performed.

Total abdominal colectomy

When it comes to total colectomy, the rectum, the whole colon, and terminal ileum need to be carefully and fully mobilized. In this part, here is a main trick that you should make your best to preserve the right and ileocolic vessels as well as the right marginal vascular arcade that later gives help to the division of the superior mesenteric vessels.

It can be divided into two parts which contains right transverse and right colonic mobilization and left transverse and left colonic mobilization. The operation begins at the level of the middle part of the transverse mesocolon, in contact with the transverse colon. For the purpose of preserving the right colic and terminal ileal vessels, it should be careful not to damage the network of marginal arteries, which will vascularize the right colon. In this way, it is possible to gain a better lengthening of the terminal small bowel with a preserved vascularization. The network of marginal arteries has been preserved to the ileocecal junction. A mobilization is carried out by dividing posterior attachments of the cecum after ileal division. And then the attachments of the ascending colon and hepatic flexure are divided.

The division of the transverse mesocolon is following. At the level of its mesenteric border, a distance should be stayed from the transverse colon. Since the pancreas is located posteriorly, meticulous care should be taken to prevent it from incidental injury. Preserve the greater omentum and free from its attachments to the transverse colon through dividing the colo-omental ligament. The intervention continues towards the left and finally in contact with the left transverse colon. Once the surgeons have changed their position and are to the patient's right, using the trocars located in the right iliac fossa and in the right flank. According to left colectomy principles, the descending colon is freed from its lateral attachments. The mesocolon is then divided in contact with the colon.

Next step is freeing the descending colon. Using a medial posterior approach to divide lateral attachments of the descending mesocolon. The sigmoid colon is then reached and division of the sigmoid mesocolon can begin. In this time, the surgical operation should keep away from the aorta and the iliac vessels. This also allows to stay away from the nerve plexus. Because UC is a benign disease, it is unnecessary to perform an oncological resection which would include the lymph nodes.

Rectal dissection accompanied with IPAA

Once the sigmoid mesocolon has been divided, the pelvis is exposed. And then it moves to the rectal dissection. Usually, it is performed in contact with the rectal wall. The anatomical planes are progressively cleared by applying traction and counter-traction. As contact is maintained with the rectal wall, it can be observed. The dissection should be continued away from pelvic walls and nerve plexuses, thus avoiding plexus injuries and genitourinary disorders as much as possible.

The dissection's inferior limit is controlled and it could stop at the level of the pelvic floor. A gastrointestinal anastomosis (GIA) linear stapler device is applied to the lower rectum. It is not an oncological procedure, but a procedure close to the rectal wall so as to preserve the posterior portion of the mesorectum which will be used as a bed for the future reservoir. A division is performed at the level of the terminal small bowel.

After mobilization of entire colorectum, the specimen is carefully extracted from the abdominal cavity through a 5-cm ventral midline incision. The distal ileum is brought out for a sufficient length and used for the construction of the pouch.

The division of colon and rectum differs from that in colorectal cancer. Since UC is a benign disease, it is not necessary to remove a large area of mesentery which contains the lymphatic structures. Furthermore, it is not appropriate for the surgeon to excise the parietal peritoneum widely when in division of the rectum. Because there is a potential injury in sympathetic and parasympathetic nerves, it is suggested that the posterior rectal dissection should be performed between the rectal wall and the mesentery, or at least through the mesorectum. The presacral nerves and the sympathetic innervation to the pelvic viscera would be avoided by this maneuver. The intact nerves are especially important for men. Erection is a parasympathetically mediated response that is transmitted through the nervi erigentes. The injury of the two nerves would have adverse impact on impotence and ejaculation. The injury of the nerves can be prevented by careful intraoperative identification.

A tension-free anastomosis is important for successful pouch surgery. There are several methods to gain enough length of intestine apart from mobilizing the small bowel mesentery to the third part of the duodenum near superior mesenteric artery. Another viable way is ligating the ileocolic vessels at the origin of the superior mesenteric artery. The technique described by Kirat which seems a useful way to estimate the tension of the anastomosis by grasping the apex of the pouch and pulling down to the anastomosis level to simulate the IPAA and evaluate the tension (13). In addition, several horizontal incisions of mesenteric anterior and posterior of superior mesenteric artery by translumination can be made to gain some extra length, particularly for those whose previous surgery lead to adhesions or fibrosis of the peritoneum. All methods can be used for a tension-free anastomosis.

There are several types of pouch, including J, S, or W type. Because of the good functional outcomes and its easy construction, the J-pouch is the first choice for most surgeons (13). Usually, the terminal small intestine with a length of 30 to 40 cm is used for constructing the J-pouch. The selective ileum is placed in two parallel segments, and each one is about 15 to 20 cm long. Then longitudinally cut the intestine with a 1.5 cm incision at the pouch apex. The two segments of the ileum are stitched together by side-side anastomosis with two cartridges of linear stapler (75 or 100 mm) which is put into the intestinal cavity through previous enterotomy at the pouch apex. Subsequently the closure of blind loop of the J-pouch is finished by a linear stapler, and it is generally reinforced by continuous sutures. It is necessary to check whether suture line bleeding is present and hemostasis is ensured. Finally, the normal saline is used to test the integrity of the pouch.

The pouch is then placed back to the abdomen and makes sure the small bowel in a correct orientation. The ileal pouch-anal anastomosis should be finished without torsion and free of tension. Finally, ensure that there is no leak by an air test.

Construction of loop ileostomy

When the operation is performed for UC, the small intestine is spared. The surgeons should make the best to preserve the full length of the small bowel in UC patients. Some people think that although the distal 2 to 3 cm of ileum is resected, it has no influence on absorption, while Neal found that even proper resection of ileum may lead to adverse results that the peristalsis of small bowel is accelerated and the absorption of nutrients is impaired, so as the water and electrolytes (14).

As with sigmoid colostomy, it is better to have a very large opening than a small one. To avoid torsion of the distal ileum on itself, some anchoring would be required. A few sutures placed from the serosa of the ileum and its mesentery to the parietal peritoneum may be also helpful. When ileostomy is completed, then abdomen is closed in layers.

Postoperative management

Once the bowel function returns, the patient can start clear liquid diet. Bladder catheter is usually removed five days after surgery. When the intestinal function is restored, the drainage tube can be removed. Since the patient can get out of bed for free activities and the ileostomy is normal, he or she could be discharged from the hospital. Sutures are removed about 1 week after surgery if no wound infection develops.

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Footnote

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Laparoscopic techniques and strategies for gastrointestinal GISTs

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Abstract: The laparoscopic approach is widely accepted surgical treatment for gastrointestinal submucosal tumors (SMTs). In this chapter, we will introduce laparoscopic techniques and strategy for gastrointestinal SMTs, in accordance with those for gastrointestinal stromal tumors (GISTs). The indication for a laparoscopic approach has been related to tumor size. The upper limit of tumor size has increased, according to recent trends, and there is no established guideline for a lower limit. All patients undergoing laparoscopic surgery receive preoperative examinations including gastrofiberscopy, upper gastrointestinal radiography, computed tomography (CT), and endoscopic ultrasonography (EUS). Gastric tumors <20 mm in diameter measured by EUS or CT are preoperatively localized by gastrofiberscopic clipping of the mucosa covering the SMT. While maintaining the principle of local resection with a negative resection margin, different surgical techniques are required depending on the location and configuration of the tumor. A single dose of a second-generation cephalosporin is administered to patients as a prophylactic antibiotic before or immediately after operation. If a patient undergoes wedge resection, a semi-bland diet will be provided within 48–72 hours. However, in cases of proximal or distal gastrectomy, the diet will be restricted for several days. A "no-touch" technique, by which the risk of tumor dissemination can be minimized, includes grasping the surrounding tissues, holding the threads sutured at the normal serosa around the tumor, and using a laparoscopic stapler or bag during laparoscopic resection.

Keywords: Laparoscopic; submucosal tumor (SMT); gastrointestinal stromal tumor (GIST)

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Introduction

Laparoscopic surgery has been widely accepted in all surgical fields, since laparoscopic cholecystectomy was introduced in the late 1980s (1) Surgical treatment for gastrointestinal submucosal tumor (SMT) has not been excluded from this trend. Laparoscopic wedge resection has been a widely accepted procedure for SMTs of stomach (2). Additionally, laparoscopic surgery has been feasibly performed for SMTs of small bowel, even though this procedure is rarely applied due to the low prevalence (3).

However, as we perform laparoscopic surgery for an SMT of gastrointestinal tract, the possibility of gastrointestinal stromal tumor (GIST) should be considered at all times. GISTs sometimes show malignant behavior and account for a considerable portion of gastrointestinal SMTs. Therefore, surgeons should focus on certain principles when laparoscopic surgery is used for SMTs presenting with features of GISTs, even though GISTs are mostly confirmed by postoperative pathologic examination. In this chapter, we will introduce laparoscopic techniques and strategy for gastrointestinal SMTs, in accordance with those for GISTs.

Patient selection and work up

Patient selection

The indication for laparoscopic approach has been related to tumor size. In case of gastric SMTs, the limitation of tumor size for laparoscopic surgery has traditionally been considered "diameter not more than 2 cm," but it has become larger based on the recent evidences. In 2006, Otani *et al.* (4) reported that laparoscopic surgery had been feasibly performed for SMTs up to 5 cm in diameter. Moreover, some researchers also reported their experiences of laparoscopic surgery for larger SMTs (>5 cm, but <10 cm) (5,6). This limit regarding tumor size is expected to be higher in the near future. With respect to this issue, the current guidelines do not state an absolute indication regarding tumor size (7,8). In addition, there is no lower limit on tumor size. Actually, in our institute, the indications for laparoscopic surgery include the relatively small SMT (<10 mm in diameter and definitely visible by endoscopy), regardless of symptoms (9).

Meanwhile, with regard to SMTs at small bowels, a size limit for laparoscopic approach has not been established. Unlike the stomach, as these organs are mainly composed of tubular structures, laparoscopic manipulation can be easily performed (10). For example, even if we encounter a large jejunal or ileal tumor, this condition may be controlled by manipulating the nearby segments. However, duodenal SMTs require some considerations regarding tumor size, since the 2^{nd} portion of duodenum correlates with the surrounding structures (i.e., biliary or pancreatic duct).

Work up of the selected patient

All patients undergo preoperative examinations to clarify the clinical diagnosis. Preoperative data include the tumor size, location, growth pattern, and the presence of metastasis is determined through the combined evaluation using gastrofiberscopy, upper gastrointestinal radiography, endoscopic ultrasonography (EUS), and computed tomography (CT). Endoscopic biopsy or EUS is performed only when clinically indicated.

Pre-operative preparation

Before operation, tumors <2 cm in diameter measured on CT or EUS are localized by gastrofiberscopic clipping of the mucosa covering the SMT. With respect to small gastric SMTs, the general information regarding tumor characteristics (e.g., location and shape of tumor) are intuitively provided by CT gastrography, in which virtual gastroscopy and surface-shaded volume rendering techniques are included (9).

After general anesthesia is induced, the patient is placed in the supine position, with his or her legs abducted. At first, a scope port is established on the umbilical area, and pneumoperitoneum is made by carbon dioxide infused through the scope port, with an insufflation pressure of 12 mmHg. Then, a flexible or 30-degree rigid scope is inserted through this port. After we performed diagnostic laparoscopy, two ports are additionally established on the upper abdomen to allow identification of the tumor location and to apply a laparoscopic linear cutter. The operator surgeon is usually positioned on the right side of the patient, with the scopist positioned between the patient's legs, managing the scope. An assistant surgeon can be additionally positioned on the left side of patient.

Procedure

In general, the principle of surgical treatment for GISTs is local resection with a negative resection margin (2). Laparoscopic surgery is no exception to this general principle. In addition, according to the location and configuration (i.e., exophytic versus endophytic) of tumor, the different surgical techniques are requested.

Anterior wall of stomach

Exogastric approach is predominantly applied for exophytic tumors at the gastric anterior wall (2). In this condition, we can isolate the tumor by manipulating the surrounding normal tissue with laparoscopic instruments (11). Then, to acquire the oncologic safety margin, laparoscopic linear stapler should be applied to the normal tissue of stomach (*Figure 1*). If the gastric wall is excessively resected, this procedure can result in deformity or stenosis of the gastric lumen (2). Thus, laparoscopic linear stapler should be applied perpendicularly to the longitudinal axis of the stomach (11).

Recently, eversion method, another technique to prevent stenosis, has been introduced (12). When a large endophytic SMT is located at the gastric anterior wall, it is difficult to trace the tumor in the serosal surface. In this situation, eversion method involves a gastrotomy, through which the tumor can be everted out of the stomach. Then, laparoscopic linear stapler is applied to the stalk of the everted tumor. Simultaneously, the gastrotomy can be closed with the linear

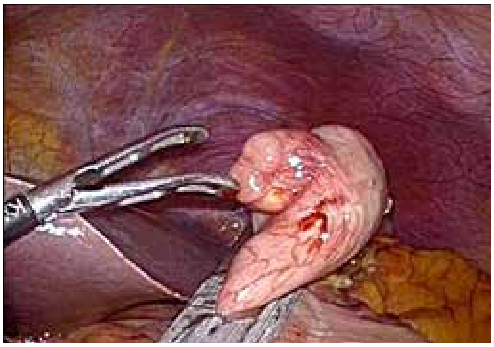

Figure 1 Exogastric approach for the tumor at anterior gastric wall.

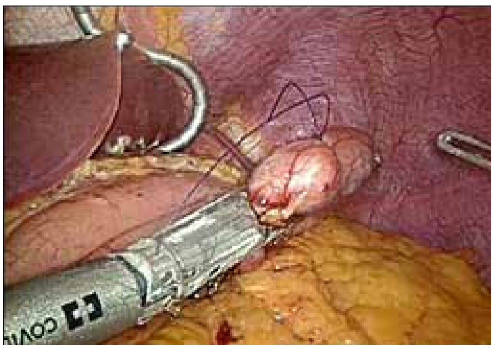

Figure 2 Exogastric approach for the tumor at posterior gastric wall.

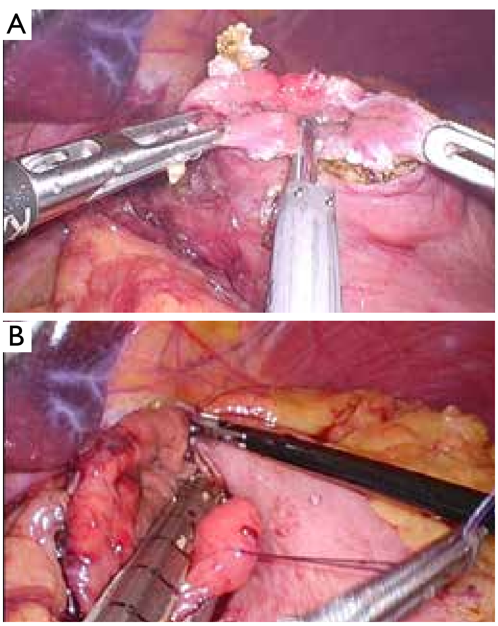

Figure 3 Transgastric resection for the tumor at posterior gastric wall. (A) Gastrotomy on anterior gastric wall; (B) resection of tumor with laparoscopic linear stapler.

Figure 4 Intragastric resection of the tumor at posterior gastric wall. Courtesy of Sang-Il Lee, Department of Surgery, Chungnam National University School of Medicine.

cutter. At this time, the gastrostomy should be made near the point at which the tumor is expected to locate. In addition, as for exogastric approach, the direction of laparoscopic stapler should also be perpendicularly arranged to the longitudinal axis of the stomach.

Posterior wall of stomach

If SMTs are located at the gastric posterior wall, the appropriate approach is adopted according to whether the tumor is exophytic or endophytic. If it is possible to mobilize and rotate the stomach, the exogastric approach can be applied for an exophytic lesion (*Figure 2*) (13). However, an endophytic lesion mostly requires the more complex approaches, since the tumor localization is not easy during laparoscopic surgery. In general, either transgastric or intragastric approach can be applied.

As shown in *Figure 3*, transgastric approach is to resect the tumor through an anterior gastrotomy (14). This gastrotomy can be closed by either hand-sewing or stapling (The direction of stapling line should be arranged perpendicularly to the longitudinal axis of the stomach).

The intragastric approach is to resect the tumor with laparoscope and instruments inserted into the gastric lumen (*Figure 4*) (15). In order to prevent the retraction of trocar, balloon trocar is recommended for use in this method (16). Recently, several surgeons reported single-incision intragastric approach (15). In this procedure, the stomach is brought out and incised through a single umbilical incision, which is kept open with a wound retractor. Then, the tumor is manipulated and resected via a commercial 4-holes single port inserted through the gastrotomy.

Figure 5 Laparoscopic techniques and strategies for gastrointestinal GISTs (19).
Available online: http://www.asvide.com/articles/1497

Figure 6 Wedge resection of the tumor at the 2nd portion of duodenum.

Lesser curvature/prepyloric antrum of stomach

When SMTs are located at the lesser curvature or prepyloric antrum, laparoscopic wedge resection is challenging procedures (2). As these areas characterized by the low distensibility, postoperative stenosis of the gastric lumen may occur. In addition, there is a risk of vagus nerve injury, which can induce delayed gastric emptying or functional gastric outlet obstruction (2,11). With these reasons, many surgeons prefer full-thickness resection of the tumor without laparoscopic stapler (2). In this method, gastric wall should be closed by hand sewing. Distal gastrectomy can be considered unless stenosis or deformity can be avoided.

Esophago-gastric junction (EGJ)

Laparoscopic surgery for SMTs at EGJ is also technically demanding procedure. If the lesion shows a malignant potential, invasive approach is sometimes required (2). In other words, radical surgery is rather safer than wedge resection, because the attempt to get an adequate resection margin can result in stenosis of EGJ. With this reason, in several institutes, total gastrectomy has been performed for EGJ tumors. Even if laparoscopic proximal gastrectomy was introduced in 1990s (17), most surgeons have avoided this procedure on account of late complications, such as reflux esophagitis or stricture, regarding esophago-gastrostomy (2). Double tract reconstruction is one of the potential solutions for this issue. Recently, Ahn *et al.* (18) reported that less reflux and stricture are showed after laparoscopic proximal gastrectomy with double tract reconstruction.

Nevertheless, for most SMTs including GISTs, proximal gastrectomy is also excessive procedure. Intragastric or transgastric approach is a useful option for benign or even some malignant lesions (*Figure 5*). In addition, for certain benign lesion, laparoscopic enucleation can be a good solution to prevent stenosis of EGJ (20).

Small bowel

Meanwhile, SMTs of small bowel is resected extracorporeally or intracorporeally based on the surgeon's preference. When wedge resection is tried for a duodenal turmor (*Figure 6*), it is important not to involve the papillary region. In addition, gastrojejunostomy is often necessary, as duodenum is also risk of postoperative stenosis. In case of jejunal of ileal SMT, extracorporeal resection is easily performed through an umbilical port wound even though the tumor is large (3,11). However, it is important to avoid the iatrogenic spillage of tumor cells during the whole time of laparoscopic surgery. In addition, when the tumor invaded to the adjacent organ, conversion to open surgery should be considered.

Completion of laparoscopic surgery

After resection of tumor, the specimen is placed in a vinyl bag, which is delivered through the umbilical port wound that is slightly enlarged to accommodate the tumor. After hemostasis is achieved and integrity of the staple line is confirmed, the abdominal cavity is irrigated and the port wounds are closed.

Post-operative management

If the patient undergoes wedge resection, a semi-bland diet will be provided within 48–72 hours. However, in cases involving proximal or distal gastrectomy, the diet will be restricted for several days.

Whether adjuvant chemotherapy is administered should be determined according to the postoperative pathologic report, in which the final diagnosis is also revealed. The final pathologic report includes the immunohistochemical staining profile, tumor size, tumor mitotic index, and resection margin status. The lesions in which the postoperative immunohistochemical staining is positive for CD117 (KIT) are diagnosed as GISTs, and mutation analysis for the c-KIT mutation is also performed (9). GISTs are divided into four groups according to the Risk Assessment Classification proposed by Fletcher *et al.* (21). Mitotic figures for all specimens are counted in 50 randomly selected high-power fields by the experienced pathologist.

Tips, tricks and pitfalls

As some GISTs carry malignant potential, we should always consider the possibility of intraperitoneal dissemination caused by manipulation of the tumor during laparoscopic approach (11). In most SMTs with benign features (i.e., lipomas leiomyomas, schwannomas, and granular cell tumors), laparoscopic approach cause little concern regarding peritoneal dissemination because those tumors seldom recur (22,23). However, since some SMTs are diagnosed as GISTs, there is a risk of high grade malignancy. Although most GISTs show an acceptable prognosis after laparoscopic surgery (24), such a favorable outcome cannot be expected in the patient who undergoing tumor rupture.

With regard to this issue, many surgeons take 'tumor size' into consideration, with an assumption that large tumors may require more manipulation than small, increasing the opportunity for dissemination. With this reason, laparoscopic surgery has been generally recommended for relatively small GISTs (i.e., diameter ≤2 cm) based on the GIST Consensus Conference in 2004 (25). However, the tumor size is not the only factor to decide the applicability of laparoscopic procedure. Regardless of size, open surgery may be necessary in highly vascular or fragile tumors, due to increased risk of tumor bleeding or rupture. Therefore, during laparoscopic surgery for SMT, it is desirable to handle the tumor without grasping it directly. This principle has been widely accepted, and we currently have several tips for manipulating the tumor without touching it. A "no-touch" technique, described in 2002, includes grasping the surrounding tissues, holding the threads sutured at the normal serosa around the tumor, and using a laparoscopic stapler or vinyl bag (26). By applying these techniques in laparoscopic surgery, we can minimize the risk of tumor cell dissemination.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Laparoscopic resection of gastric wall tumor

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Abstract: Laparoscopic resection of gastric wall tumor is commonly performed nowadays. The exact surgical procedure was decided according to the location, size and morphology of the tumor. In this video, we performed a laparoscopic resection of a 5 cm tumor located at distal posterior gastric wall near the greater curvature. Technical consideration was discussed.

Keywords: Laparoscopic; gastric wall tumor; resection; suture repair

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Introduction

Incidental gastric wall tumor is increasingly diagnosed by upper endoscopy and imaging studies performed for other symptoms. These lesions are commonly small in size and asymptomatic. While gastrointestinal stromal tumor (GIST) is the commonest submucosal tumor located at proximal stomach, other tumors are leiomyoma, lipoma, schwannoma, etc.

Endoscopic enucleation is performed for smaller tumor in selected patients. Surgical treatment by wedge resection of stomach, partial gastrectomy or total gastrectomy is commonly required for larger lesions.

Laparoscopic resection of gastric wall tumor is advocated due to its minimally invasive nature. Comparison of laparoscopic and open resection of gastric GISTs was performed and comparable results in terms of efficacy, safety, and length of hospitalization were demonstrated in many studies (1-8). Latest meta-analysis showed that there was no observed difference in operative time, adverse events, estimated blood loss, overall survival and recurrence rates between laparoscopic and open surgical resection of gastric GISTs, supporting that laparoscopic resection is safe and effective for gastric GISTs. Laparoscopic resection was associated with a significantly shorter length of hospital stay (9). International guideline suggests that laparoscopic wedge resection can be used for tumors ≤5 cm (10).

Patients

A 57-year-old gentleman, with good past health, presented with intermittent mild upper abdominal pain for 1 year. CT scan abdomen was performed and showed a 4 cm × 5 cm tumor near distal body of stomach. Upper endoscopy revealed a submucosal tumor at posterior wall of distal greater curve and it appeared to originate from muscularis propria layer on endoscopic ultrasound.

Pre-operative preparation

The patient was kept fasted for 6 hours prior to surgery. The operation was performed under general anesthesia with endotracheal intubation. A Fr 14 gastric decompression tube and urinary catheter were placed. Prophylactic cefuroxime 1.5 g was administrated intravenously on induction.

Equipment preference card

High definition laparoscopic video system, pneumoperitoneum system, ultrasonic dissector, laparoscopic instruments including atraumatic graspers, needle holder, scissors, 4–0 maxon suture and plastic specimen bag were prepared.

Procedure

The patient was placed in a supine position with legs

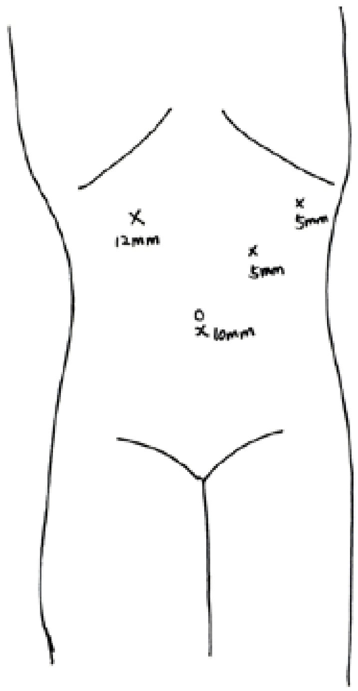

Figure 1 Sites of trocars.

Figure 2 Laparoscopic resection of gastric wall tumor (11). Available online: http://www.asvide.com/articles/1034

separated. The chief surgeon stood between the legs. The assistant stood on the left side and the camera operator stood on the right side of the patient. A 10-mm trocar was placed in subumbilical region and pneumoperitoneum was created. The intra-abdominal pressure was maintained at 12 mmHg. The other trocar sites including a 12-mm trocar at right upper quadrant mid-clavicular line, two 5-mm trocars at left upper quadrant mid-clavicular line and anterior axillary line are shown in *Figure 1*.

Laparoscopic assessment was performed and a tumor bulge was identified in distal stomach. The greater omentum was dissected free from the greater curvature of stomach by ultrasonic dissector. The lesser sac was entered and the posterior wall of distal stomach and antrum was exposed. A 5-cm tumor was noted arising from posterior gastric wall near greater curvature. Gastrostomy was made with ultrasonic dissector next to the tumor. Circumferential full thickness resection of gastric tumor was performed. The tumor was immediately put into a plastic specimen bag. Hemostasis of gastric wall was secured. The gastrostomy was suture repaired with 4–0 maxon in continuous manner. (*Figure 2*) The peritoneal cavity was cleansed with warm normal saline. The specimen was then retrieved via subumbilical trocar site after enlargement.

Role of team members

- Chief surgeon: Dr. Xuefei Yang;
- Assistant: Dr. Fion S. Chan;
- Camera operator: Dr. Li Jiang;
- Anesthetist: Dr. Xinhe Liu;
- Scrub nurse: Kaisong Hou.

Post-operative management

The patient was prescribed intravenous cefuroxime for 1 day. Gastric tube was removed on day 1 and fluid diet was commenced on day 3 after the operation. The patient was fit for discharged on day 4 with esomeprazole for 2 weeks.

Histopathological examination of resected specimen confirmed the diagnosis of schwannoma. Immunology exam showed S-100 diffusely strong positive, CD34 focal weak positive, SMA negative, Desmin negative, CD117 focal suspected positive, ki67 about 1–4% incidental mitotic count.

Tips, tricks and pitfalls

Proper exposure of tumor is sometimes difficult for tumor located at posterior wall of stomach. This is facilitated by transection of greater omentum and exposure of lesser sac.

Resection of tumor with linear stapler is sometimes performed for pedunculated gastric wall tumor with extra-gastric extension. This minimizes the risk of tumor seeding and peritoneal contamination by gastric content. However, this is not suitable for tumor with intra-gastric extension or involvement of a wide area of gastric wall. Otherwise, incomplete resection of tumor may result or more extensive resection of gastric wall adjacent to the tumor is inevitable. Furthermore, resection by linear stapler is not suitable for tumor located along gastric lesser curve or close to cardia and pylorus.

Gastrostomy followed by resection of gastric tumor with clear margin was performed in our patient due to the wide area of gastric wall involvement. Ultrasonic dissector, with good hemostatic performance for gastric wall vessels, is used to resect localized gastric wall tumor. Careful and gentle manipulation of tumor during dissection should be practiced to avoid breakage of tumor capsule and rupture of the tumor. Immediate placement of tumor in a plastic specimen bag and adequate peritoneal lavage were performed to reduce risk of tumor seeding.

Suture repair of gastrostomy can be difficult without good exposure and close cooperation between the chief surgeon and assistant. Omental fat next to the edge of gastrostomy should be dissected free to facilitate proper placement of sutures. Gentle pull of the suture material is very important especially when the suture repair is performed in a continuous manner.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Sleeve and sleeve plus

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Abstract: Obesity is an epidemic issue that will cause type 2 diabetes, cardiometabolic diseases, stroke, osteoarthritis, sleep apnea and some kinds of cancer. These diseases may be lethal and usually cause high cost of medical expenditure. Many studies have reported that bariatric surgeries are much superior than intensive medical therapies in reaching therapeutic goal of weight loss and resolution of co-morbidities. The golden standard procedure, laparoscopic Roux-en-Y gastric bypass (LRYGB) has most satisfied resolution rates of metabolic diseases especially in type 2 diabetes mellitus (T2DM). However, needs for long-term supplement of vitamins and higher rates of complications makes bariatric surgeons to invent other modified surgical techniques. Due to short learning curve and satisfied surgical results, laparoscopic sleeve gastrectomy (LSG) now is worldwide accepted. However, comparing with LRYGB, LSG could not achieve the same remission rates of obesity-related comorbidities especially T2DM. Therefore, a new surgical procedure: loop duodenojejunal bypass with sleeve gastrectomy (LDJB-SG) has been invented. Today, we review the sleeve gastrectomy and LDJB-SG from basic surgical methods to possible mechanisms: weight-dependent and weight-independent mechanisms (intestinal inversion and change of gastrointestinal hormones) to discuss the roles of these two surgical procedures in bariatric surgery.

Keywords: Sleeve gastrectomy; sleeve plus; loop duodenojejunal bypass with sleeve gastrectomy (LDJB-SG); bariatric surgery; diabetes mellitus type 2 (T2DM)

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Introduction

Obesity is an issue of epidemic concerns affecting all ethnicities, ages, and genders (1-3). In United States, about 35% of the adult population are considered to be obese (1,3). Obesity has strong relationship with numerous and various comorbid conditions such as diabetes, stroke, cardiometabolic diseases, obstructive sleep apnea (OSA), joint diseases (osteoarthritis), gallbladder problems and many cancers, as well as negative effect on quality of life (1-3). The rise of various bariatric surgeries have been well established in recent decades, especially for patients with morbid obesity, in terms of weight reduction, obesity-associated co-morbidities, and quality of life have been proved the effectiveness and safety (1,4-7). In addition, recent evidence has also shown bariatric surgery achieved better long-term survival than conventional medical treatments (8-12). The most common bariatric surgery procedures include laparoscopic Roux-en-Y gastric bypass (LRYGB), laparoscopic sleeve gastrectomy (LSG), laparoscopic adjustable gastric band (LAGB), and laparoscopic bilio-pancreasatic diversion with duodenal switch (LBPD-DS).

We acknowledge that the LRYGB (*Figure 1*) is the worldwide-accepted golden standard surgery for morbid obesity and type 2 diabetes mellitus (T2DM). However, its long-term complications such as marginal ulcer, dumping syndrome, iron deficiency anemia, Osteoporosis *et al.* make

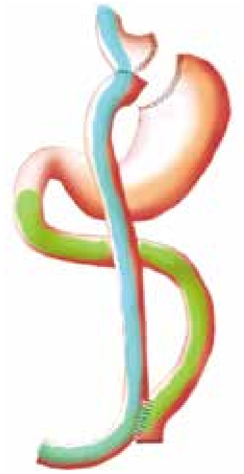

Figure 1 Roux-en-Y gastric bypass.

Figure 2 Sleeve gastrectomy.

the birth of the LSG, which now is the primary and basic bariatric procedure. Sleeve gastrectomy is designed to be the restrictive component of BPD-DS in the beginning. For those high risk patients (ex. super-obesity or poor cardiopulmonary function patients), LSG was used as the first-step surgery prior to the two-stage procedure. It now becomes the primary one-step procedure (13-15). The simplicity of the procedure, effectiveness of weight loss, less postoperative morbidities and prominent resolution of comorbidities makes LSG become so popular. Although LSG has satisfied weight loss comparing with intensive medication therapy, LRYGB is still better than LSG on many espects such as the resolution of T2DM and results of weight reduction. In order to reach a comparable results with LRYGB without its disadvantages, we invented a new procedure: loop duodenojejunal bypass with sleeve gastrectomy (LDJB-SG).

LSG

LSG (*Figure 2*) provides desirable and quick weight loss with less vitamin deficiency (16). It involves only vertical resection of stomach of greater curvature side and creates a longitudinal and high pressured gastric tube.

Operative techniques

Mostly surgeons place 4–5 ports during performing LSG. Via the subxiphoid incision, a Nathanson's liver retractor or our liver suspension technique are used to lift left hypertrophic liver (16,17). The gastroepiploic vessels are divided along the greater curvature. It begins 4–6 cm from the pylorus to the angle of His and left crus of diaphragm. And then along with a 38 French bougie, a vertical gastrectomy is performed with endoscopic staplers. The resected stomach is extracted via umbilical port. Single-incision trans-umbilical LSG also could be performed, which was associated with better cosmetic appearance, less need for analgesics, relatively scarcer complaints of postoperative pain, and more pleased over-all patients satisfaction compared with conventional multi-port LSG (17,18).

Weight loss results of LSG

Recent few years, more literatures are published to report weight loss results between intensive medication treatment, LSG and LRYGB. In the randomized controlled trial of Surgical Treatment and Medications Potentially Eradicate Diabetes Efficiently (STAMPEDE) reported by Schauer *et al.* showed surgical groups had better percentage weight loss result from baseline, with weight reductions of 24.5%±9.1%, 21.1%±8.9% and 4.2%±8.3% in the gastric-bypass group, sleeve-gastrectomy group and medical-therapy group respectively (P<0.001 for both comparisons). And there was no statistically significance between LSG and LRYGB groups on % excess weight loss (%EWL) for 3 years follow-ups (19). Lee *et al.* found in veterans population, LRYGB achieved the most weight loss in kg, body mass index (BMI) reduction, %weight loss, and %EWL, followed by the LSG procedure, and AGB yielded the least weight loss (1). A 4-year weight change of multisite clinical veteran cohort study who underwent LRYGB, AGB and LSG showed weight loss compared with baseline BMI were 27.5%, 10.6%, 17.8% respectively (20) which revealed LRYGB had better weight loss. Other previous studies (21-24) also had the same conclusions of shorter-term weight loss (1–3 years).

For long-term weight regain, 30.5% for AGB; 14.6% for SG and 2.5% for LRYGB were observed (20,25). Arman *et al.* (26) recently showed a 11-year-follow-up outcomes of LSG, despite of the low follow-up rates (only 59%), the % excess body mass index loss was 62.5% in 11+ years. In our center, 63.71% EWL was reported at postoperative year 5 (27). Meta-analysis data also suggested that LRYGB resulted in a greater %EWL than LSG. It should be the size of the sleeve, the amount of antrum retained, and the amount of fundus resected that account for the variable weight loss results of LSG (28).

As for adolescent or young adult group, Maffazioli *et al.* found there was no statistically significant difference on body weight loss or weight regain after following up for 18 months in both LRYGB & LSG groups (29) which was consistent with Inge *et al.* (30) and Cozacov *et al.* (31) studies.

LSG has adequate and satisfied weight loss in both short-term and long-term results. Although LRYGB may showed superior in weight loss, its need of long-term vitamins supplement, nutritional and metabolic complications make patients backward.

Co-morbidities resolution after LSG

Morbid obesity attributes to many serious co-morbidities such as T2DM, dyslipidemia, sleep apnea, hypertension, osteoarthritis, blindness, amputation and gastro-esophageal reflux disease (GERD) (28). There are many therapies for morbid obesity including intensive medical therapy, behavior change, and even acupuncture, the alternative treatment. However, none of them can effectively resolve these problems or can provide the sustained success (19,28). Bariatric surgery results in not only the excellent outcome of sustained weight loss but also the advantage of comorbidities remission (32). More recently, many studies implicate bariatric surgery as a metabolic surgery because it also provides remission or improvement in T2DM in mildly obese patients (33-36).

Diabetes mellitus resolution result

In STEMPEDE trial, at 3 years, the target glycated hemoglobin level of 6.0% or less was achieved in 5%, 38%, 24% of the patients in the medical group, gastric-bypass group ($P<0.001$) and sleeve-gastrectomy group ($P=0.01$) respectively. There was also no statistically significant difference on LSG and LRYGB groups (19). According to Swedish Obese Subjects (SOS) study which comparing bariatric surgery with conventional medical treatment: the higher rates of diabetes remission at 2, 10 and 20 years and less long-term complications including total-cause mortality and major cardiovascular events were found in surgical treatment group (12,19,37,38). Some literatures showed LRYGB was still superior to LSG on resolution of insulin secretion and sensitivity. It's also be the LRYGB, not the LSG, that reduce more truncal fat compared with subcutaneous fat (39). In our center experience, a 5-year-follow up of LSG showed 66.66% resolution of T2DM by definition of lesser or no use of diabetes medications (27). Nosso *et al.* found that for the morbid obese T2DM patients, in both LRYGB and LSG groups in terms of different hormonal and metabolic mechanisms involving in weight loss and T2DM remission one year after surgery, there were almost the same improvements of glucose profile in these two procedures. Weight loss is the key point of diabetes remission in morbidly obese T2DM patients one year after surgery (40).

It can't be denied that weight loss changes the adipotoxicity in human body is the main cause of improvement of metabolic diseases in the early phase. However, there are more current data suggest that hormonal modulations, not weight loss alone, contribute to the beneficial effect of bariatric surgery for T2DM (41). LRYGB and LSG both change the islet function activity by altering enteroinsular axis. Gut hormones changes after LRYGB on ghrelin, peptide YY (PYY), and glucagon-like peptide-1 (GLP-1) are well documented (32). Similar to LRYGB, although to a lesser degree, LSG increases GLP-1 responses to meal ingestion (39,42) whereas gastric banding have no effect on postprandial glucose excursion or insulin and gut hormone responses (43). LSG indeed can improve T2DM to some extent.

Cardiovascular related markers resolution result

Hypertension

Among obese population, the most common co-morbidity is hypertension. Adipose tissue deposition can impair renal function and lead to blood pressure change (44). The possible mechanism is the altered neuroendocrine response, renin-angiotensin-aldosterone (RAA) system. LSG and

LRYGB can result in a significant blood pressure reduction due to decreased cardiac stroke volume and lipotoxicity to the kidney after weight loss (45). In our center experience, a 5-year follow ups of LSG showed 100% resolution of hypertension (27). Otherwise, Li *et al.* meta-analysis showed the LRYGB is still more favored in remission rate of hypertension than LSG (28).

Dyslipidemia

From STEMPEDE trial, comparing medical and surgical treatments, 3-year-follow up showed much better sustained lower triglyceride and higher high-density lipoprotein (HDL) cholesterol levels in both LRYGB & LSG groups (19). In our 5-year-follow up of LSG, 50% resolution of hyperlipidemia was noted (27). Lee *et al.* reported 73.7% remission of dyslipidemia by a multicenter retrospective comparative cohort study of LSG (46). Li *et al.* meta-analysis showed 49.5% remission of hypertension of LSG compared with 71% of LRYGB (28).

OSA

Obesity is the most significant predisposing factor for OSA. According to de Sausa *et al.*, elevation of 6 kg/m^2 in BMI increases four times risks of developing OSA (47). The possible pathophysiological mechanisms of OSA are: (I) obese patients with OSA have 42% more fat in their neck, resulting in pharyngeal lumen narrowing; (II) leptin resistance which has a key role on controlling body-weight and respiratory center (48-50). A systemic review and meta-analysis made by Buchwald *et al.* reported OSA was resolved in 85.7% of obese patients with OSA (21). LRYGB is still the predominant choice of the surgery that has a better resolution rates than LSG (21,50,51). In fact, many literatures (50-53) discussed the differences in surgical efficacy maybe explained by weight-dependent and weight-independent effects (acronym BRAVE+ I: bile flow alteration, restriction of gastric size, anatomical gut rearrangement and altered flow of nutrients, vagal manipulation and enteric gut hormone modulation + improvement of systemic inflammation, such as soluble TNF-receptor 2, leptin which can increase neuromuscular control of pharyngeal diameter). Recent study done by Amin *et al.* revealed increase orexin levels after bariatric surgery is another possible weight-independent mechanism of early improvement of OSA (54). Both LRYGB and LSG can improve OSA in early phase of postoperative period (55). Dilektasli *et al.* reported sleeve gastrectomy can improve excess daytime sleepiness and sleep quality 6 months after the surgery (56). No matter what kinds of bariatric surgeries is chosen, OSA is a strong indication of bariatric surgery.

Nonacoholic fatty liver disease (NAFLD)

NAFLD is an important comorbidity of obesity and nonalcoholic steatohepatitis (NASH) is a precursor to the development of liver cirrhosis that may necessitate liver transplantation in the long run (57). Many literatures in recent years pay emphasis on the bariatric efficacy of improvement of NAFLD (29,58). There are no definite results on which type of surgeries has the best resolution rate. However, LSG seems to have a better improvement of liver function when comparing with LRYGB postoperative 6–12 months to date. According to Billeter *et al.*, after 1 year follow up, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels were both reduced in LRYGB and LSG groups. However, it's the LSG group that has much lower AST and ALT levels than LRYGB and completely resolved the biochemical signs of NAFLD 12 months after the surgery (41% patients still had elevated ALT levels in LRYGB group) (58). Praveen *et al.* reported histological improvement of NAFLD within postoperative 6–8 months for both SG and LRYGB. However, SG appears to have a better effect on liver histology although this result did not reach statistical significance (59). In addition to weight loss, many experiments suggest change in bile acid metabolism and signaling through farsenoid-X receptor (FXR) which affects fatty acid metabolism of the liver may be the possible explanations of LSG on improvement of NAFLD (60-62).

Complications of LSG

There are early and late complications of LSG. When comparing with LRYGB, LSG is still a procedure with lower readmission and re-operation rates. Staple line leaks, bleeding, and strictures are the commonly reported complications following LSG. Shi *et al.* reported average rate of LSG complications in a systemic review: approximately 3.57% of bleeding rate, 12.1% of major complications, 1.17% of leak rate and mortality rates between 0 and 3.3% (63). International Sleeve Gastrectomy Expert Panel Consensus Statement 2011 [38] showed: 1.06% of leak rate, 0.35% of stricture with 1.05–1.85% of overall conversion rate and 3.66–5.1% of postoperative gastric fistula (64). LSG which as a longer staple lines has comparable leak rates to LRYGB which has shorter ones (65).

Gastroesophageal reflux disease (GERD) is the most

Figure 3 Loop duodenojejunal bypass with sleeve gastrectomy.

common chronic complications complained by the patients and usually need to do revisional surgery which LRYGB is usually chosen. About 11–33% patients have GERD reflux in long-term follow ups (66) after LSG. Until now, there were no sufficient evidences to show the relationship between LSG and GERD. Chiu *et al.* (67) reported a systemic review showing no conclusive relationships on LSG to GERD. Keidar *et al.* implied when a relative narrowing of the middle stomach combined with a dilated upper stomach after the LSG, GERD may happen even without any complete obstruction (68). This functional obstruction would result in severe esophageal dysmotility with reflux symptom. Patients may reduce the incidence of GERD after LSG when they concomitant repair of hiatal hernia (HH) during the LSG operation (69). Preoperative evaluation of hiatal defects and repair of it during the LSG is recommended (70). For the small hiatal defect which is easily missed during preoperative panendoscopy examination, can be revealed and repaired easily when the surgeon remembers to exam the crura during LSG procedure and dissects left crura during dissection angle (66).

Why we need more in addition to LSG about diabetes resolution

LSG was once considered a restrictive procedure, but this presumption has recently come under scrutiny (71). It is found to be involved in "restriction", "absorption" and "hormone change". "Foregut" and "Hindgut" theories, recently even the midgut, can somehow give us possible explanations of LSG results. LSG resect the fundus of stomach where ghrelin is the main hormone to be secreted, which dramatically diminished and also increase the counter-hormone "obestatin" level in the early postoperative time (72). The counter-reaction of ghrelin and obestatin combined with decreased leptin may cause body to reduce appetite and utilize blood glucose effectively (73). Also postoperatively 1 year-follow up showed increase of CCK which also play a role in LSG on weight loss and sugar control (42). Up-regulated secretion of incretins (GLP-1, PYY) , the glucose-dependent insulin enhancer, which were elevated while rapid delivery of partially digested food into distal intestine, combines with other changes mentioned above are important reasons to improve glucose tolerance after LSG (73-76).

Reduction of digestion was due to combination of restriction, the "appetite suppressive" effect from resection of the ghrelin-rich fundus, faster gastric emptying and decreased gastric acid secretion (77,78). Hormonal changes of LSG included antidiabetic effects of GLP-1 and PYY (79,80), which are not seen with the purely restrictive procedures like gastric banding. According to these studies, LSG can achieve satisfied body weight loss and T2DM resolution results. Otherwise, it is still inferior than LRYGB, which involves more physiologic mechanism of bypassing duodenum and proximal jejunum. To achieve better T2DM resolution, add foregut exclusion to sleeve gastrectomy (sleeve plus) might be an essential modification.

Sleeve plus: LDJB-SG

LRYGB and BPD-DS are procedures with higher rates of T2DM remission and long-term complications (81). The aim of metabolic surgery is to produce remission of T2DM with more physiological aspects and minimal morbidity and mortality. In our center, LDJB-SG (*Figure 3*), a novel surgical procedure was invented as a proposed technique for treatment of T2DM to reach the goal of metabolic surgery (82).

Operative techniques

Under general anesthesia, a 5-port laparoscopic surgery was used to access the abdominal cavity. We then performed a standard sleeve gastrectomy with endostaplers. After ensuring hemostasis, a stay suture was placed at the distal end of SG for counter-traction and better visualization of the first part of the duodenum. Two centimeters distal to the pylorus, we did the dissection of the duodenum. For firing the stapler, we need to use a tape to place for traction after the dissection of duodenum. We transected duodenum 2 cm from the pylorus, taking care not to injure the common bile duct (CBD), pancreas, and major vessels in the area. And then we measured 2–300 cm of the jejunal loop from the ligament of Treitz. We then performed side to side isoperistaltic, totally hand-sewn, one layered duodeno-jejunal anastomosis with absorbable sutures. After the anastomosis, we placed one anti-torsion suture in the antrum and upper jejunum, 4 cm proximal to the duodenojejunostomy. We then repaired the Peterson defect with a continuous non-absorbable suture. We put one Jackson-Pratt drain behind the duodenojejunal anastomosis reaching the sleeve and end the procedure (82).

Advantages of LDJB-SG

Exclusion of duodenum may ease the abnormal glycemic control and insulin resistant. Scientists found proximal bowel diversion, which was done on rat models, would not decrease food intake or weight loss but may improve diabetes instead. As previous elucidation, that's the reason why LSG only resolved partial T2DM. Rubino *et al.* demonstrated when bypassing duodenum and proximal jejunum, amelioration of T2DM will occur without any change on food intake, body weight, malabsorption, or nutrient delivery to the hindgut (83).

LDJB-SG has higher satisfied T2DM resolution rates than LSG (remission rate for 1 year follow up: 62% *vs.* 32%) (84). For diabetes patients, surgery preserving the pylorus may cause delaying gastric emptying and then reduce postprandial glucose excursions (85,86). LDJB-SG is a good option for revision when intractable dumping syndromes happened after LRYGB (87). LDJB-SG also eliminates the risk of remnant gastric cancer, an important issue in Asia where gastric cancer is very common (88). Based on our experience, the resolution of co-morbidities was similar in both LDJB-SG and LRYGB for BMI <35 kg/m^2 T2DM patients at postoperative 1 year. LDJB-SG has longer operative time and length of stay than LRYGB, however, it has no inferior rate than LRYGB on postoperative one-year improvement of body weight loss, fasting plasma glucose and %HbA1c. The level of HOMA-%B at 12 months was even significantly higher in the LDJB-SG than in the LRYGB (89). However, further studies on change of gut hormones and long-term results compared with RYGB, LDJBSG is still needed to be investigated in the future.

Conclusions

LSG has gradually taken place LRYGB as the main bariatric surgery in the world. And sleeve plus surgery, such as LDJB-SG, will become the main surgical procedure in treating obesity with T2DM, because of better resolution than LSG, but less complications than LRYGB.

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Footnote

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Laparoscopic pancreaticoduodenectomy

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Abstract: Laparoscopic procedures have become an important part of minimally invasive surgery for pancreatic disease. However, due to the complex anatomic location and numerous reconstructions, laparoscopic pancreaticoduodenectomy (LPD) still remains one of the most challenging procedures even for the experienced laparoscopic surgeons. Owing to the evolution in laparoscopic technology and instrumentation within the past decade, LPD is beginning to gain wider acceptance. In contrast to the traditional open procedures, LPD has been showed to improve perioperative outcomes, such as less blood loss, decreased postoperative pain, shorter hospital stay and faster recovery. According to our experience, LPD has the same indications as the open procedures, including the cases with SMV or PV been invaded. However, abundant experience in open surgery and strict laparoscopic technique training are still play an important role in this procedure. Here we propose the posterior approach, and sum up the dissection processes as "Three axis and four visual fields". In order to shorter the operative time, vessels should be taken as the axis, dissection should be performed from the distant towards the portal and every visual field should be made full use of. However, prospective RCTs of LPD are still absence. We are looking forward to adding more surgeons to promote LPD, working together to identify its superiority and long-term advantages over the open counterpart and making it become the gold standard for the treatment of periampullary diseases.

Keywords: Laparoscopic pancreaticoduodenectomy (LPD)

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Introduction

Laparoscopic procedures have advanced to represent the new gold standard in many surgical fields, also it has become an important part in minimally invasive surgery for pancreatic disease. Laparoscopic pancreaticoduodenectomy (LPD) was first described by Gagner and Pomp in 1994 (1), and more series began to describe this new technique in the following years (2-10). However, due to the complexity of the procedure, such as the retroperitoneal location of the pancreas, close relationship with blood vessels [superior mesenteric artery and vein, portal vein (PV), hepatic artery (HA), etc.] and the technical difficulty of three reconstructions, LPD remains to be one of the most challenging procedures even for the experienced laparoscopic surgeons.

Fortunately, owing to the evolution in laparoscopic technology and instrumentation within the past decade, LPD is beginning to gain wider acceptance. As reported in the literatures (11-13), compare to the traditional open counterpart, LPD has been showed to improve perioperative outcomes, such as less blood loss, decreased postoperative pain, shorter hospital stay and faster recovery. But there still some problems blocking the popularization of this technique, including longer operation time, higher expense, uncertain of the long-term advantages and so on.

Definitely, LPD is an attractive and also challenging procedure to surgeons. Abundant experience in open pancreaticoduodenectomy and strict laparoscopic technique training are the foundation to promote the process, and covering the learning curve is the only way to master this complex procedure.

According to our experience, we propose the posterior approach, and sum up the dissection processes as "Three axis and four visual fields". They are, common hepatic artery (CHA)-HA [gastroduodenal artery (GDA)] axis, superior mesenteric vein (SMV)-PV axis, superior mesenteric artery (from far and near) axis and distal gastric and pancreatic neck region, Treitz ligament region, descending duodenum region, hepatoduodenal ligament region. In order to shorten the operative time, vessels should be taken as the axis, dissection should be performed from the distant towards the portal and every visual field should be made full use of.

However, prospective RCTs of LPD are still absence. We are looking forward to adding more surgeons to promote LPD, working together to identify its superiority and long-term advantages over the open counterpart and making it become the gold standard for the treatment of periampullary diseases.

In the following sections, we will share our experience about LPD in detail, including the managements throughout the perioperative period.

Patient selection and workup

According to our experience, LPD has the same indications as the open procedures, including benign periampullary diseases, distal common bile duct cancer, ampullary carcinoma, duodenal carcinoma, pancreatic head carcinoma, and even the cases with SMV or PV been invaded, but at the very beginning period, patient selection should be very cautious, and distal common bile duct or ampullary diseases seemed to be more appropriate.

Most of the time, the cases easy to resect are always difficult to reconstruct, such as the small tumor in the pancreatic head. On the other hand, the cases difficult to resect are always easy to reconstruct, such as the obvious obstructive jaundice case with dilation in both bile duct and pancreatic duct. Sometimes the patient of ampullary carcinoma might be both easy to resect and reconstruct as well. Of course, the case of pancreatic head carcinoma with vessel invasion would be difficult to resect or reconstruct.

Before the operation, routinely blood tests (CA19-9, CEA and AFP, liver function, IgG4, etc.) are performed, which would be initially helpful to understand the general situation, identify benign or malignant mass, and determine whether preoperative biliary drainage is needed or not.

A variety of imaging modalities are used to assess the resectability of the tumor, such as CTA and MRCP, which would help to estimate the relationship of the tumor with the major vessels, dilation of bile duct and pancreatic duct. More attentions should be paid to vascular variation, especially allotropic hepatic right artery originated from superior mesenteric artery. Endoscopic ultrasonography (EUS) would be needed in some of the complex cases. Also PET-CT would be useful in finding the metastasis.

Pre-operative preparation

Perform the biliary drainage pre-operation for 10–14 days if total bilirubin is higher than 300 μmol/L, which might greatly reduce the intraoperative tissue edema and wound exudation when total bilirubin is reduce to below 100 μmol/L).

Intestinal preparation would be needed before the operation.

Other pre-operative preparations are in accordance with the other abdominal surgeries.

Equipment preference card

We are in favor of harmonic scalpel, LigaSure combined with bipolar coagulation to implement most of the processes.

Laparoscopic ultrasound would be of great help in locating the small lesion and determining the surgical margins.

Other frequently used equipments and instruments include energy platform, golden finger hook, Endo-GIA, etc.

Procedure

After successful general anesthesia with tracheal intubation, disinfect the surgical area and spread aseptic towel routinely.

Place the patient in a supine, straddle and reverse Trendelenburg position. Usually five trocars are needed for this complex procedure. The surgeon stands between the patient's legs, two assistants stand on each lateral side of the patient and take turns to hold the laparoscope.

Enter the abdomen through an infraumbilical approach and then thoroughly explore the abdomen to exclude metastasis. Sometimes intraoperative ultrasonography is performed to locate the small tumor and assess its resectability. And most of the time, suspension of the ligamentum teres hepatis is helpful for surgical exposure.

Then, create an opening in the gastrocolic omentum using technique of choice (harmonic scalpel, or LigaSure.), continue the division proximal and distal along the surface of the transverse colon until a sufficiently large window has been developed. After confirming the resectability of the tumor, divide the stomach with the laparoscopic linear stapler and expose the pancreas and CHA. Mobilize upper margin of the pancreas (harmonic scalpel, or unipolar electric coagulation hook), encircle and tape CHA and dissect the lymph nodes around (No. 8), then divide and cut GDA. Continue to encircle and tape HA towards the hilar, dissect the lymph nodes (No. 12) and identify PV just under HA.

After mobilizing the inferior margin of pancreas and identifying SMV by following the middle colic vein and the gastrocolic trunk as they drain directly into the SMV in close proximity, encircle and tape SMV and carefully protect the transverse mesocolon throughout the operation when dissecting the inferior border of the pancreas. Enter the avascular plane between the neck of pancreas and the SMV, bluntly mobilize and create a post-pancreatic tunnel upwards until the upper margin of the pancreas. There should not be any collateral veins entering the anterior surface of the SMV from the substance of the pancreas. Tape the pancreas to avoid injury to the vessels in the following process.

Next, reflect the transverse colon cephalad, identify and fully divided the Treitz ligament on the left side until the inferior vane cava (IVC) is coming into view. Then divide the upper portion of the jejunum about 10 cm away from Treitz ligament with a linear stapler, and separate the proximal jejunum from the mesojejunum with LigaSure or harmonic scalpel. The horizontal part of duodenum should be mobilized as much as possible from the left side of the abdomen, which would be of much help to the following procedures.

Mobilize the hepatic flexure downward to expose the duodenum, perform a Kocher maneuver, by incising the peritoneum lateral to the duodenum in the avascular plane. Reflect the duodenum and head of the pancreas medially so as to expose inferior vena cava, left renal vein and the origin of superior mesenteric artery.

Traverse the pancreas slowly by using harmonic scalpel or electrocoagulation. It is important to identify the pancreatic duct and cut it with a sharp scissors. Complete hemostasis of pancreatic stump would be helpful in preventing postoperative bleeding.

Pass the divided jejunum to the right side and begin to separate the pancreatic uncinate process from SMV and SMA. Here three layers should be dissected in turn. The first layer is composed of loose tissue, where a branch of uncinate process from SMV could be separated and cut, remember to preserve the gross first jejunal branch if possible. The second layer is a dense fibrous tissue, in which inferior pancreaticoduodenal artery should be handled, and allotropic hepatic right artery may be found in this layer too. Finally there is also a loose tissue of the mesentery of uncinate process. It is important to identify the origin and termination of any anomalous vessel here before division, because an aberrant right HA may occasionally arise from SMA. And then continue dissection along the sheath of SMA, upwards to the posterior of hepatoduodenal ligament (No. 12).

After fully skeletonization of the hepatoduodenal ligament, separate the gallbladder from the liver and divide the bile duct on hepatic duct level, remove the whole specimen and finish the resection processes.

Use either a transverse incision just above the synchondroses pubis or a middle incision in the upper abdomen to take out the specimen is feasible. Close the incision, irrigate the abdomen and get ready for reconstruction.

Pull the proximal jejunum to the right side through the rear part of the mesenteric vessels. Duct to mucosa anastomosis is the most traditional method used for the pancreaticojejunostomy, usually 4-0 prolene is chosen for the suture of posterior layer (continuous or interrupted), but for the especially brittle and soft pancreas, interrupted sutures maybe more suitable. A pancreatic stent is inserted and the duct to mucosa anastomosis is fashioned with 5-0 prolene sutures. Then the anterior layer is completed with the 4-0 prolene or barbed sutures, either continuous or interrupted suture is OK.

Make an end-to-side hepaticojejunostomy distal to the pancreaticojejunostomy, and make sure that there is no tension between the two anastomoses. In most cases, 5-0 PDS or 4-0 barbed suture is used for the running suture, but sometimes biliary stent and interrupted suture might be needed if the bile duct is too small (D <5 mm).

Gastrojejunostomy is performed using a laparoscopic linear stapler or running suture with 3-0 barbed sutures, but for the pylorus-preserving procedure, the stapler is

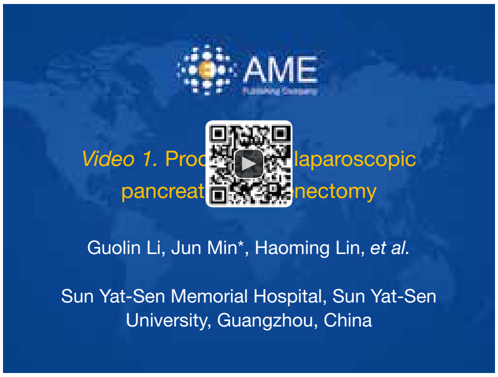

Figure 1 Procedure of laparoscopic pancreaticoduodenectomy (14). Available online: http://www.asvide.com/articles/1220

obviously not an ideal choice according to our experience.

After the reconstructions, two double-lumen drainages are emplaced, one in the hepatorenal recess, just posterior to the hepaticojejunostomy, and the other posterior to the pancreaticojejunostomy. The tips of the two drainages cross each other might be very useful in case of any postoperative leakage.

If you want to know more about the detail procedures of LPD, please pay attention to *Figure 1*.

Role of team members

(I) Jun Min (surgeon);
(II) Rufu Chen (surgeon);
(III) Guolin Li (surgeon);
(IV) Haoming Lin (surgeon);
(V) Jun Cao (surgeon);
(VI) Jinxing Wei (surgeon);
(VII) Zehua Huang (theatre nurse);
(VIII) Qing He (physician of ICU);
(IX) Shuling Peng (anesthetist);
(X) Qingfang Han (trainee).

Post-operative management

Reasonable analgesia is especially important for postoperative recovery, and it is better to "Be on time" than "Be on demand".

Maintaining unobstructed drainage and preventing localized hydrops would be the most important things for the pancreatic surgery after operation, and perform Ultrasound examination at any time if needed.

Conventionally check the amylase of each drainage daily for at least three days after the surgery. If the result is obviously abnormal, have a double check or prolong the time for testing until it return to normal.

The drainages will stay for four or five days, remember to confirm the drainages are unobstructed and there is few hydrops in the abdomen before removing them.

Gastric tube would be taken out 3–5 days after the surgery when gastrointestinal function gradually recovers, it is better to clamp the tube for a couple of hours before taking out.

Finally, pay more attention to perioperative nutritional support and maintain body weight stable and body fluid balanced would help to faster recovery. Do not forget to use somatostatin through intravenous pumping for 3–5 days.

Tips, tricks and pitfalls

(I) Vessels should be taken as the axis, dissection should be performed from the distant towards the portal, which is more conducive to grasp the anatomical planes and at the same time simplify the dissection of hepatoduodenal ligament.
(II) Made full use of every visual field, and avoid repeated exposure or manipulation.
(III) Suspension of the ligamentum teres hepatis is helpful for surgical exposure.
(IV) Familiar with the anatomy and blood supply of the pancreatic head and duodenum.
(V) Pay more attention to vascular variation, especially allotropic hepatic right artery originated superior mesenteric artery.
(VI) The horizontal part of duodenum should be mobilized as much as possible from the left side of the abdomen, until reaching the right side of the inferior vena cava, which would help to perform the Kocher maneuver.
(VII) Management of uncinate process is the most critical technology in LPD, during which the following three layers should be showed: (i) loose tissue containing branch of uncinate process from SMV; (ii) dense fibrous tissue in which inferior pancreaticoduodenal artery and allotropic hepatic right artery may be found; (iii) loose mesentery of uncinate process.
(VIII) Reverse-stitch technique would be helpful for the reconstruction of hepaticojejunostomy.
(IX) Tension and lack of blood supply will always contribute to the leakage.

(X) Remember that the knot too tight may increase the risk of pancreatic fistula.
(XI) It is harmful to stay the tubes too long; and it is also not a good idea to place as much tubes as possible.

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Footnote

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Management for a complicated biliary stricture after iatrogenic bile duct injury

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Abstract: Bile duct injury (BDI) remains to be a serious complication of biliary surgery. Biliary stricture is likely to occur in cases without proper management of BDI, may be causing such severe complications as repeated strictures, cholangitis or impairment to liver function. Here, we reported a 69-year-old man with a one-more-year history of recurrent cholangitis caused by iatrogenic BDI. The patient underwent a reconstruction of choledochojejunostomy, with liver quadrate lobectomy, and hilar cholangioplasty. The procedure was difficult, but the recovery was smooth. Only through comprehensive pre-operative evaluation and meticulous intraoperative manipulate, the technical challenge of re-operation for complicated biliary stricture after BDI should be easily addressed.

Keywords: Bile duct injury (BDI); complicated biliary stricture; choledochojejunostomy

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Introduction

Due to being a severe complication, bile duct injury (BDI) is still a challenging issue for biliary surgeons. Over the past decades, the literatures reported incidence of major BDI after laparoscopic cholecystectomy (LC) is about 0.3–0.5% (1-3). Recently, a prospective cohort study showed that complexity of referred BDI and rate of associated vascular injuries have increased over time (4). BDI may cause not only biliary stricture for cases without effective and timely management, even result in severe complications such as recurrent cholangitis and impairment to liver function, but also high morbidity and mortality, impaired quality of life, and substantial financial burdens to patients and society (1,5). Depending on the type of injury, optimal management of BDI is achieved with a multidisciplinary approach, including endoscopic, percutaneous, and surgical interventions (6). Here, we present a case of management for complicated biliary stricture after iatrogenic BDI.

Patient selection and workup

In March, 2014, a 69-year-old man was referred to us with a one-more-year history of recurrent jaundice and fever after LC. He underwent LC for cholecystolithiasis with chronic cholecystitis in November 2012. One month later, the man was re-admitted for severe jaundice. Considering the iatrogenic BDI caused by the primary operation (more information was unknown), he underwent Roux-en-Y choledochojejunostomy. Since then, he received several interventional measures, including percutaneous transhepatic biliary drainage (PTBD), percutaneous balloon balloon angioplasty, as well as percutaneous transhepatic cholangioplasty, with two biliary drainage tubes for left and right hepatic duct separately, trying to relieve repeated jaundice and high fever. However, the patient's condition had no significant improvement and even his weight loss of about 15 kilogram.

Pre-operative work-up included magnetic resonance

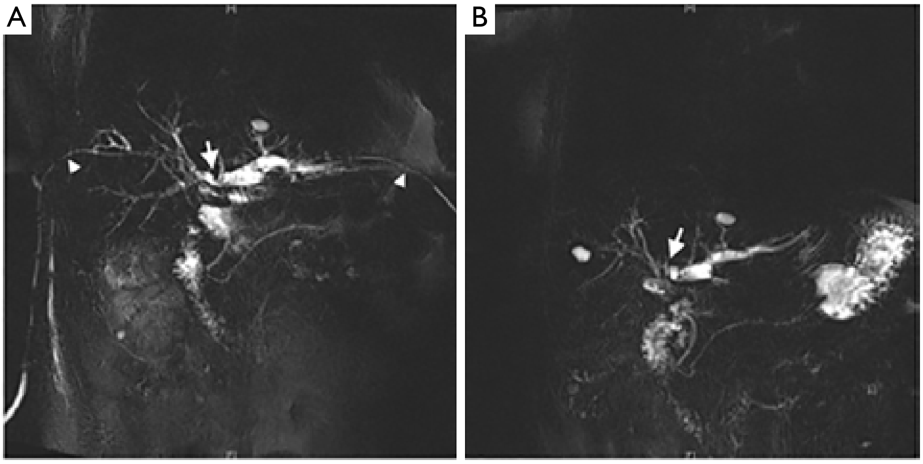

Figure 1 Magnetic resonance cholangiopancreatography (MRCP) shows bile duct injury (BDI) stricture at hilar bile duct (white arrow) with dilation of the intrahepatic bile duct (more obvious in the left) and two tubes of percutaneous transhepatic biliary drainage (PTBD) (white triangle).

cholangiopancreatography (MRCP) and computed tomographic angiography of the liver and biliary tract. MRCP showed stricture at hilar bile duct and dilatation of intrahepatic bile duct (*Figure 1*). Following a thorough discussion of treatment options and associated benefits and risks with the patient, we decided to proceed with a reconstruction of choledochojejunostomy. Risks and complications of the procedure included biliary leak, cholangitis, bleeding, anastomotic strictures, biliary cirrhosis, and the need for further surgeries.

Pre-operative preparation

Prior to the procedure, complete blood count, liver function test, coagulation function test, and cardiopulmonary function assessment were ordered (all normal) in addition to a full physical examination and patient history. Antibiotics were administered in that sequence no more than 30 minutes prior to the incision. Appropriate consent was obtained from the patient per our institutional protocol.

Equipment preference card

- ❖ Water knife;
- ❖ Bile duct probes;
- ❖ Fine catheter;
- ❖ 4–0 Vicryl suture;
- ❖ 5–0 Prolene suture;
- ❖ Self-retaining wound retractor.

Procedure

The operative procedure is demonstrated in *Figure 2*. The patient was placed in the supine position. After general anesthesia was induced, a Foley catheter was placed. Through the original incision, a down L-shaped incision below the right rib edge was made. Dense adherence was found in the area of biliary-enteric anastomosis, which was 40 cm away from enteric-enteric anastomosis. Part of the right and quadrate lobe of liver (about 4 cm × 4 cm) was marked and removed. Then, bile duct above the anastomosis was separated by water knife. After finding the original anastomosis, the bile duct was confirmed by a puncture. Part of the anterior wall of the bowel was incised. Anastomotic scar hyperplasia was significantly associated with stenosis. It was found that left and right hepatic was interrupted, and anastomosis of left hepatic duct almost closed.

Bile duct wall was separated from the liver tissue until opening the diameter of right hepatic duct to 2 cm, and the left to 2.5 cm. Due to the confluence of left and right hepatic duct to be adhered scar tissue, it was reshaped into an “8” shape with satisfaction. After exploration of the bile duct again, it was confirmed that the secondary bile duct was clear, and the hepatic duct of right posterior lobe was opening at the beginning of left hepatic duct. Two small stones, diameter of about 0.3 cm, was removed from bile duct, after cleaning with saline via fine catheter. After trimmed the scars of the anterior wall of the bowel, the bile

Figure 2 Video demonstrating the reconstruction of choledochojejunostomy for biliary stricture after bile duct injury (BDI) (7).
Available online: http://www.asvide.com/articles/1415

duct jejunum anastomosis was sutured by 4–0 Vicryl and 5–0 Prolene intermittently. Hereafter, PTBD drainage tubes was removed. The outlet of left hepatic drainage tube was sutured with satisfaction. For the purpose of anti-reflux, the original intestinal anastomosis was suturing about 5 cm paralleled.

Total operative time was about 7 hours. Blood lose during the operation was about 200 mL. Two units of red blood cells and 200 mL of plasma was transfused Intraoperative.

Post-operative management

Following the procedure, the patient was admitted to the surgical intensive care unit for 24 hours observation and return to the regular wards. Postoperative evolution was uncomplicated and the patient was discharged on the 21st postoperative day. Two years after operation the patient was well and subsequent follow-up examinations did not reveal any symptoms of bile duct stricture.

Tips, tricks and pitfalls

- Treatment principles for BDI including restoring normal anatomical relationship of biliary system, retaining normal function of Oddi's sphincter, maintaining the normal pathways of bile circulation, prevention of biliary stricture and reflux cholangitis. A reasonable individual treatment program should be developed according to the timing, location, scope and extent of BDI;
- If the BDI did not recognized until weeks after the primary operation, bile duct stricture might be formed due to repeated inflammation or multiple manipulations. Residual bile duct would become shorter, or even buried in the scar tissue;
- Due to the anatomical variation and deep location, right posterior hepatic duct more likely to be omitted. Preoperative PTBD angiography can not only contribute to the diagnosis, but also provide a guidance for intraoperative intubation via the PTBD sinus to facilitate finding the right hepatic duct. Ultrasound-guided puncture and intraoperative contrast-enhanced ultrasound, by which injection of contrast agent into the target bile duct to determine the drainage area of the bile duct, also would help to find the right hepatic duct;
- During dissecting hilar plate, which should be along the hilar to the right, the most difficult step is to expose and reshape the proximal bile duct. If necessary, removal of hepatic quadrate lobe would facilitate the search of intrahepatic bile duct. According to the actual situation, other ways also can be taken, such as incision of anterior transhepatic approach, as well as transverse portion of left hepatic duct approach;
- The key step of biliary tract reconstruction is dissection and reshape of hilar bile duct. Dissection should be along with the liver surface, via both left and right approach, to open the omentum hole. The method of "duct-to-mucosa" should be applied for biliary-enteric anastomosis as far as possible;
- The biliary supporting tube is not routinely placed, although it helps avoid the occurrence of anastomotic leakage and biliary stricture. We generally removed the tube 3 to 6 months post-operation, depending on intraoperative condition of the bile duct, the cholangiography and electronic choledochoscopy results after surgery, as well as general condition of the patient.

Discussion

A commonly accepted classification describing the type of BDI has not been available yet (8). Bismuth classification and Strasberg classification (an expansion of the Bismuth system), is currently the most widely used classification system for BDI. However, both of them still mainly based on the anatomical site of the BDI, with many limitations, such as not considering additional vascular involvement, and the type of injury factors (9). Moreover, no existing classification system takes into account all therapeutic and prognostic implications (10). Therefore, it is necessary to develop a new classification system according to the following conditions, such as not only anatomical site of the bile duct tree injury, but also type of injury factors, lesion characteristics, and prevention strategies.

Depending on the type of injury, percutaneous, endoscopic, and surgical interventions may account for the management of BDI. Percutaneous intervention is usually performed under ultrasound or radiological guidance, including abscess drainage, transhepatic biliary drainage, dilation of bile duct strictures and stent placement to maintain ductal patency, as well as management of complications from previous interventions. Although a randomized clinical trial showed that metallic stents should be considered an appropriate option in patients with benign biliary strictures and a bile duct diameter 6 mm or more (11). However, our experience does not recommend the use of metallic stents for biliary strictures in BDI patients because it does not improve the onset of recurrent cholangitis.

Surgical interventions are eligible for BDI patients with large lateral defects in major ducts, strictures refractory to percutaneous or endoscopic treatment, and nearly all complete transactions and ligations (6). Roux-en-Y hepaticojejunostomy is the best treatment option for most major BDI, and provides excellent long-term outcomes overall when the procedure is performed in tertiary referral center (2), or by an experienced hepatobiliary surgeon (10,12). It is worth noting that liver transplantation would be the last choice for BDI patients who developed biliary cirrhosis, and even liver failure (13).

The importance of timing of surgical repair for the outcome is controversial. It is still not clear whether the injury should be repaired immediately or a delayed repair is preferred. A retrospective study, 640 cases involved, was conducted to compare the results of immediate, early and late surgical repair for BDI sustained during a cholecystectomy. It was concluded that the best timing to repair a BDI was beyond 45 days (late repair group) and the best results could be expected in the hands of experienced hepatobiliary surgeons with bilio-enteric repair in the form of the Roux-en-Y hepaticojejunostomy (14). In another analysis of factors associated with successful surgical reconstruction, it was found that eradication of abdominal infection, complete cholangiography, use of correct surgical technique, and repair by an experienced biliary surgeon were the most important variables, whereas the timing of reconstruction was not independently significant (15).

For the case presented here, the patient underwent a second operation to reconstruct the biliary system in less than a month after the first LC, and resulted in severe post-operative complications. The patient did not achieve satisfactory outcomes till underwent the last surgical management more than one year after the original iatrogenic injury. This indicates that the choice of making an early repair is a difficult task and should be undertaken by an experienced hepatobiliary surgeon to offer the patient the best chance of a cure (16). Another retrospective analysis conducted by our team found that the timing of reconstruction depended on the downtrend of serum bilirubin levels and the control of inflammation, generally from 4 to 6 weeks after percutaneous or endoscopic interventions (17), which was similar to some other reports (18,19).

Some patients may develop complications of anastomotic and biliary strictures after Roux-en-Y hepaticojejunostomy for BDI. Reconstruction is often undergone after fully exposure of the anastomic area and assessment of the biliary anatomy with an electronic choledochoscopy if available. According to our experience, if strictures and inflammation are limited in the anastomic and extrahepatic area, a vertical incision and a horizontal suture are preferred in order to construct a 2–3 cm wide anastomosis. Moreover, a complete resection of strictures and a new hepaticojejunostomy are recommended, when those spreads to higher bile duct. Sometimes, dissection of the hilar plate or partial hepatectomy is needed to expose the normal bile duct (17). For this patient, considering extensive adhesion, complete resection of former anastomosis and a new Roux-en-Y hepaticojejunostomy was performed.

In some patients with complex BDI involving disruption of proximal bile duct (involving hepatic confluence) and injuries associated with concomitant vascular damage, partial hepatectomy is required (20). It has reported that two main groups of BDI patients require liver resection: those with an injury-induced liver necrosis necessitating early intervention, and those in whom hepatectomy is indicated for treatment of liver atrophy following long-term cholangitis (21). In our experiences, hepatectomy is not a standard procedure in surgical treatment of BDI. However, in some complex injuries, it should be considered to help the exposure of normal bile duct, even if there has no evidence on liver necrosis or lobar atrophy and fibrosis. According to literatures, hepatic resections in patients with

BDI can be performed successfully with low mortality, although with significant morbidity, and with excellent long-term success (21). As showed in this case, removal of hepatic quadrate lobe would facilitate the search of intrahepatic bile duct.

Conclusions

It should be noted that biliary reconstruction for BDI is a challenging surgical procedure even in the hands of experienced hepatobiliary surgeons. Endoscopic and percutaneous interventions may be performed for definitive treatment or as adjuncts to surgical management. Only through comprehensive pre-operative evaluation and meticulous intraoperative manipulate, the technical challenge of reconstruction for complicated biliary stricture after BDI should be easily addressed.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Minimally invasive surgical management of chylothorax complicating esophagectomy

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Contributions: (I) Conception and design: L Bonavina; (II) Administrative support: E Asti; (III) Provision of study materials or patients: E Asti, S Siboni; (IV) Collection and assembly of data: E Asti, S Siboni; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: Chylothorax is a rare complication of esophagectomy associated with increased morbidity and mortality. Prophylactic thoracic duct ligation is generally recommended during transthoracic esophagectomy, but despite this strategy chyle leak can occur. A possible explanation is that in up to 40% of individual the anatomical route of the thoracic duct is anomalous. A two-week wait and see policy with total parenteral nutrition and pleural drainage appears to be justified in patients with a chyle output of less than 1,000 mL per day. The introduction of video-assisted thoracic surgery has offered a safe and effective therapeutic alternative in these patients. We recommend primary en-bloc stapling of the thoracic duct through a right thoracoscopic approach in the semi-prone position.

Keywords: Esophagectomy; chylothorax; thoracic duct; cisterna chyli

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Chylothorax is a rare complication of esophagectomy which may be associated with metabolic, immunologic, and respiratory impairment, and increased postoperative mortality. A recent systematic review including 9,794 patients submitted to esophagectomy for cancer during the past three decades showed a 2.6% incidence of chylothorax (range, 0.9%–9%). Use of neoadjuvant therapy and squamous carcinoma type were the leading predisposing factors based on a Cox-regression analysis. Two-third of patients underwent reoperative surgery at an average of 23 days after esophagectomy, and the reported mortality rate at 30-day was 1.6% (1).

Surgical anatomy

Chyle flows from the bowel lymphatic vessels to the cisterna chyli, and then through the thoracic duct, to ultimately empty near the junction of the left internal jugular and subclavian veins in the neck. Between 1,500 and 2,000 mL of chyle is drained by the venous system every day. An iatrogenic lesion of the thoracic duct is apparently more frequent during a transthoracic rather than a transhiatal esophageal resection (2). In most individuals, the thoracic duct arises from the cisterna chyli; in the chest, the duct is located between the azygos vein and the aorta, posterior to the esophagus. On computed tomography the cisterna chyli may resemble a retro-crural lymph node; in about 15% of patients it may be visualized by magnetic resonance at the level of L1–L2 vertebral bodies (3). Early division of the thoracic duct into two or more branches is present in up to 40% of the cases, and also the intrathoracic course of the duct before entering the left subclavian vein is variable. Since iatrogenic injury of the thoracic duct is infrequently recognized at operation, primary duct ligation during transthoracic esophagectomy has been recommended in order to prevent accidental lesions and subsequent chylous fistula (4).

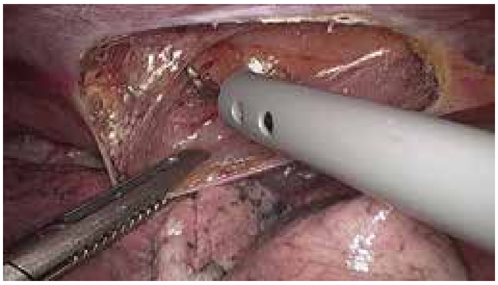

Figure 1 Right thoracoscopic view in the semi-prone position. The supradiaphragmatic area corresponding to the thoracic duct is dissected free from the aorta.

Diagnosis

The diagnosis of chylothorax can be straightforward based on the typical milky appearance of fluid in the chest drain. However, in the fasting postoperative patient at bedside, a high-volume output from the drain or a recurrent pleural effusion may be the only sign of chyle leak. In these patients, assessment of triglyceride levels in the pleural fluid and a cream test per os or through the nasogastric tube can confirm the diagnosis. When chylothorax is diagnosed after removal of the chest drain and return to oral feeding, the patient can present with dyspnea and pleural effusion with the typical milky appearance. More rarely, atypical clinical presentation with severe hemodynamic instability secondary to a mediastinal chylocele may occur (5).

Management

Early surgical reoperation in patients with chylothorax has been advocated to reduce postoperative morbidity and mortality. This strategy is based on the evidence that depletion of T cells may occur within a week of chyle drainage despite best supportive care (6). However, given the fact that a chylous fistula can heal spontaneously, a two-week wait and see policy and conservative therapy with total parenteral nutrition and pleural drainage appears to be justified in patients with a drain output of less than 1,000 mL per day (7,8). Continuous suction drainage is necessary to prevent lung collapse and fibrin formation, and to accurately measure the rate of leakage. A non-fat, high protein diet can also be effective in reducing chyle flow, but addition of medium-chain triglycerides is necessary (9). It has been shown that thoracic duct sealing occurs faster with total parenteral nutrition rather than with enteral nutrition (10). Somatostatin and its analogue octreotide have been used in conjunction with other modalities for the conservative management of chylothorax (11,12), but no conclusive evidence of efficacy has emerged.

In patients with failure of medical treatment, ligation of the thoracic duct is mandatory. A two week time interval before surgical reintervention is reasonable to allow healing of the intrathoracic anastomosis and possibly reduce the trauma of an early trans-thoracic reoperation. A gastrografin swallow study or an upper digestive endoscopy should be performed before reoperation to make sure that no concomitant anastomotic problems exist that may need to be addressed at the same time. The classical surgical approach for ligation of the thoracic duct is through a right thoracotomy (13). Occasionally, a direct transabdominal approach to the cisterna chyli can be considered. Cream should be administered per os or through a nasogastric tube 4–6 hours before surgery to identify the site of the leak. If the duct is not clearly visible, mass ligation of the tissue between the aorta, azygos vein and spine should be performed.

Lampson (14) first showed that chylothorax could be controlled by supra-diaphragmatic ligation of the thoracic duct. Brinkmann and colleagues recently reported on 906 patients undergoing transthoracic esophageal resection and routine duct ligation at a single institution. Chylothorax occurred in 17 (1.9%) patients, and 15 of them underwent rethoracotomy and repeat duct ligation. Conservative therapy was preferred for two patients with a leak below 1,000 mL per day. Two deaths occurred among patients undergoing reoperation, giving an overall 90-day mortality of 11.7% (15).

Despite the satisfactory outcomes and the marked reduction of hospital mortality, the propensity to early surgical reintervention in patients with chylothorax has been tempered in the past by the morbidity associated with thoracotomy. The advent of video-assisted thoracic surgery has offered a safe and effective therapeutic alternative in these patients. The thoracoscopic procedure for duct ligation can be performed in the left lateral decubitus using an angled 30-degree scope and three trocars. More recently, the thoracoscopic approach has been successfully performed also in the prone or semi-prone decubitus position (16) (*Figure 1*). After carefully pushing the gastric tube away from the spine, the injured duct releasing chyle in the posterior costophrenic angle is identified. Clips and sutures can be initially used to seal the thoracic duct, but occasionally this may prove unsuccessful (*Figure 2*). An alternative and safe approach consists of encircling *en bloc*

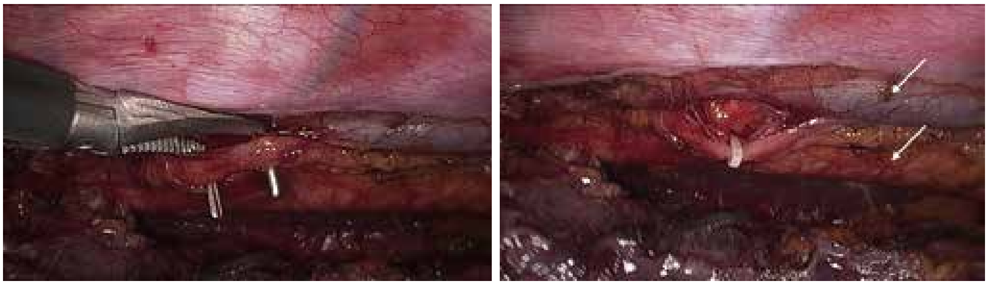

Figure 2 The thoracic duct has been isolated (left image) and clipped with Hemolock (right image).

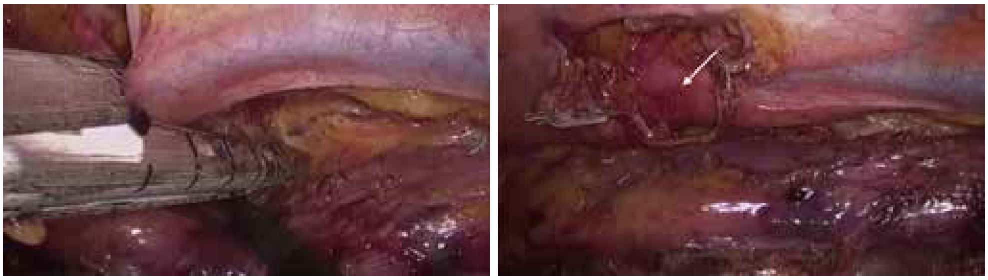

Figure 3 After *en bloc* dissection of the periaortic tissue including azygos vein and thoracic duct, an endostapler with 45 mm vascular cartridge is applied and fired. Arrows indicate the azygos vein (upper) and the aorta (lower).

the azygos vein and the periaortic fat tissue between the spine and the gastric tube using a conventional right-angled clamp. Subsequent application of a single blue cartridge of an articulating endostapler is generally effective in sealing the leak (2) (*Figure 3*).

In patients in whom previous transthoracic attempts at duct ligation have failed, a direct transabdominal approach to the cisterna chyli through laparotomy or laparoscopy can be a reasonable option (5,17,18). The gastric tube crossing the diaphragmatic hiatus should be displaced toward the left side, and multiple suture ligations of the cisterna chyli and the origin of the thoracic duct at its origin are performed transhiatally along the right side of the aorta.

In conclusion, routine thoracic duct ligation should be performed at the time of trans-thoracic esophagectomy in an attempt to decrease the incidence of chylothorax. Reoperation for chyle leakage after esophagectomy should be performed early in the postoperative period since a prolonged conservative strategy is unlikely to be successful in the majority of patients and may be life-threatening. We recommend primary stapling of the thoracic duct en-bloc with the periaortic tissue through a right thoracoscopic approach in the semi-prone position.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Stapled hemorrhoidopexy: no more a new technique

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Abstract: Hemorrhoidal disease affect between 4.4% and 36.4% of the general population. The common symptoms are: bleeding, prolapse, pain, discharge, itching and hampered anal hygiene. There is no correlation between specific symptoms and anatomic grading. Apparently severe looking hemorrhoids can cause relatively few symptoms. Open hemorrhoidectomy, as described by Milligan, has been accepted worldwide as the best choice for treatment of symptomatic hemorrhoids. In 1998, Longo proposed a procedure for hemorrhoidectomy with minimal postoperative pain, no perianal wound requiring postoperative wound care and a relatively short operative time. His technique presented a new notion for treating hemorrhoids as he proposed circumferential rectal mucosectomy that results in mucosal lifting (anopexy). His aim was not excision of the hemorrhoidal tissue but rather restoring anatomical and physiological aspects of the hemorrhoidal plexus. The grading system described by Goligher, is the most commonly used and is based on objective findings and patient history. Stapled hemorrhoidopexy is performed for grade III and IV, for grade II in case of major bleeding. In lithotomy position and spinal anesthesia and after taking all aseptic precautions, the procedure of stapled hemorrhoidectomy was performed according to Longo's technique. After this surgical procedure, the need to manually reduce prolapse will have been cured in approximately 90% of patients and the overall preoperative symptoms will be much reduced in the great majority. There should be no anal pain. Bowel habits should have returned to a normal pattern without urgency. One year follow-up or longer 11% of patients had remaining or recurrent prolapse, the reintervention rate is about 10%.

Keywords: Stapled hemorrhoidopexy; hemorrhoids; anal canal diseases; coloproctology; gastrointestinal surgery

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Introduction

In the literature, there are several theories describing the causes of the hemorrhoidal disease. Some believe that it is primarily a disease of the veins in line with the varicose veins in the esophagus. A morphological and functional failure of a sphincter mechanism coordinating the filling and drainage of the anorectal vascular cushions may be the cause (1). Another hypothesis is that the disease is caused by a weakening of the collagen support in the anal canal where the submucosal collagen fibrils degenerates with sliding mucosa during defecation or physical activity as a result (2). A third theory suggests an increased arterial flow to the vascular plexus (3). Constipation and bowel habits with straining are associated with the hemorrhoidal disease (4,5). The hemorrhoidal disease affects the general population between 4.4% and 36.4% (6,7). Physiologically hemorrhoids are anal cushions that can become symptomatic through prolapse and bleeding. When they become symptomatic you may occur secondary symptoms: pain, pruritus and mucus loss. Often it is not found correlation between the presence of hemorrhoids and the clinical symptoms (6,8). The common symptoms are: bleeding, prolapse, pain, discharge, itching and hampered anal hygiene. There is no correlation between specific symptoms and anatomic grading. The presence of a severe hemorrhoidal prolapse can cause poor symptomatology (2), while the presence of normal anal cushions may be associated with important clinical symptoms that can cause great anxiety in patients. In this last case, the socioeconomic and cultural factors play an important. A few attempts to create a symptom score have been made, but a validated symptom score is not available at the moment. History should include toilet habits, stool frequency, stool consistency and difficulties in rectal emptying. Dietary habits in terms of fiber intake should be assessed. Milligan *et al.* in 1937 proposed the open hemorrhoidectomy for the treatment of symptomatic hemorrhoids, since then this surgical technique was the most practiced and accepted in the world (9,10). Despite its effectiveness, this technique is associated with postoperative pain for the presence of open wounds in a sensitive area and that require local therapy. For these reasons, the technique is not well accepted by patients and different approaches have been advocated from time to time (7,11). In the past years, several studies (9,11,12) have modified the anatomy and physiology of hemorrhoids underlying some important pathogenetic aspects. These findings are also the rational basis of a totally new surgical approach in the treatment of hemorrhoidal disease. In 1998 Longo proposed what sounded, at the time, like an ideal solution: a procedure for hemorrhoidectomy with minimal postoperative pain, no perianal wound requiring postoperative wound care and a relatively short operative time (13). His technique presented a new notion for treating hemorrhoids as he proposed circumferential rectal mucosectomy that results in mucosal lifting (anopexy). His aim was not excision of the hemorrhoidal tissue but rather restoring anatomical and physiological aspects of the hemorrhoidal plexus (14). As early as 2001, there were several studies to confirm that stapled hemorrhoidopexy is a safe procedure that is associated with a shorter operative time, low postoperative pain, shorter hospital stay and a more rapid return to normal activities of daily living than other surgical techniques (15). Several subsequent randomized controlled trials and reviews confirmed these findings, with some studies claiming that stapled hemorrhoidopexy is the most effective and safe procedure for hemorrhoids (16). Based on these early successes and the expected interest in new procedures that might reduce postoperative pain, stapled hemorrhoidopexy has acquired a considerable popularity (17) with a reputation as a safe and effective alternative approach for the treatment of hemorrhoids (18). There have been recent calls for further randomized trials to investigate the long-term outcomes of stapled hemorrhoidopexy. Whether such trials are now practical is debatable. Given the proven short-term benefits of the stapled technique, it is possible that clinicians and patients will be reluctant to randomise to open surgery. Long-term follow-up data is already beginning to emerge (19-23), and perhaps future research efforts might better be engaged in undertaking a comprehensive cost-effectiveness analysis, incorporating both hospital and community costs. The latest evidence on stapled hemorrhoidopexy suggests that it is a technique that is finally coming of age and establishing itself as a credible alternative to conventional hemorrhoidectomy. It is probably most suited to the treatment of grade III, and perhaps circumferential grade II, hemorrhoidal prolapse. Controversy remains regarding its role in large volume and grade IV prolapse, due to increased rates of recurrence. Until this is resolved, it is unlikely that stapled hemorrhoidopexy will attain acceptance as the preferred "gold standard". In comparison, the fate of conventional hemorrhoidectomy appears somewhat uncertain, accepting that it will continue to have a role in specific circumstances. It is likely that "patient's choice" will ultimately determine its survival or otherwise, and will be driven by how acceptable postoperative pain is in the era of modern surgical technology.

Patient selection and workup

Treatment of the hemorrhoidal disease and assessment of treatment outcome must be based on a uniform grading. Investigation in different positions is described, lithotomy position, left lateral position (Sims) position, sitting on a toilet chair and photo documentation with the patient standing or sitting. Grading is dependent on the position of the patient examined. The prerequisite for a proper grading is standardized examination conditions, or at least, a description of the position during examination. The grading system described by Goligher, is the most commonly used and is based on objective findings and history (24):

(I) Grade I: no prolapse, vascular cushions in the anal canal visualized by endoscopy;
(II) Grade II: prolapse during defecation, but spontaneous reduction;
(III) Grade III: prolapse during defecation, which need

Figure 1 Grade III hemorrhoids.

Figure 2 Grade IV hemorrhoids.

manually reduction;

(IV) Grade IV: persistent prolapse irrespective attempt to reduce the prolapse.

Clinical examination can be performed in different positions. The patient can be placed in the prone position, on the left side with knees bent to his chest, or in the knee-elbow position. The inspection will evaluate the perianal skin and anus closure. At this stage, grade IV hemorrhoids will already be visible. The strain can be highlighted hemorrhoids of grade II and III as spontaneous prolapse. Subsequently, digital rectal exam will evaluate the functionality of sphincter anus. Grade II–IV hemorrhoids may be appreciated as tense-elastic cushions. The instrumental exams includes colonoscopy and defecography; the first is performed both in women than in men, especially in the case of bleeding and family history of malignant disease, the second is useful in women and optional for men. This latest exam helps the surgeon to exclude the presence of rectal prolapse, rectocele, edrocele and uro-gynecological pathologies associated. Surgery is performed for grade III and IV (*Figures 1,2*), for grade II in case of major bleeding. Absolute contraindications are the presence of abscess, gangrene, anal stenosis and complete rectal prolapse.

Pre-operative preparation

Preoperatively, the patient is subjected to blood and urine tests, chest X-ray and electrocardiogram. These tests are normally done a few days prior to surgery. These exams are performed prior to admission. The anti-platelet drugs such as aspirin should be discontinued three days before the surgery, while the anticoagulants should be replaced with subcutaneous heparin seven days before. For spinal anesthesia, dietary restrictions vary. The patient must observe fasting after midnight, it is tolerable 2 hours before take, with a little water, antihypertensive and antidiabetic drugs. It would be better perform this type of surgery in the hospital and not in outpatient. Admission occurs on the same day of the surgery and after the anesthesiologist examination the patient is given the informed consent form that must be well understood and signed. Two or three hours before surgery, a low enema is practiced to eliminate solid stool that could reduce the view of the operating field. Finally, a sedative is administered before surgery.

Equipment preference card

- Team: two surgeons, two nurses.
- Procedure: stapled hemorrhoidopexy.
- Anesthesia: spinal.
- Antibiotic prophylaxis: single dose of prophylactic antibiotic, cephalosporin 2 g (monocef), was given intravenously 2 h before the procedure.
- Position: lithotomy.
- Skin preparation: wash with iodopovidone solution (5 min).
- Equipment: suction apparatus, headlamp (available), urinary catheter, minor instrumentation set, 10 cm × 10 cm gauzes, 1 stapler (special sterile kit consisting of a circular stapler, 33 mm, a circular anoscope with dilator and a suture anoscope), lubricating solution, long gauze for the final buffer.
- Suture: 2-0 prolene for pursestring, 3-0 polygalactine for hemostasis along staple line.
- Other equipment: one precision scale to weigh the surgical specimen.

Figure 3 Lithotomy position.

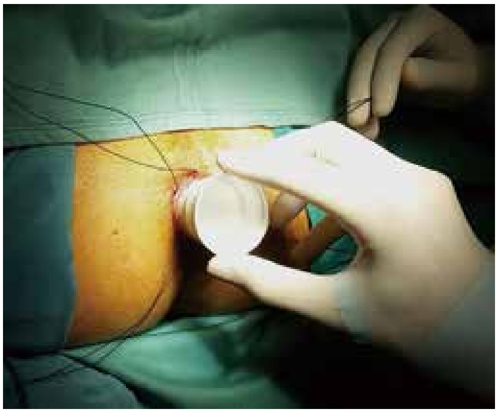

Figure 4 Insertion of the obturator to gently dilate the anal sphincter.

Procedure

The patient can be placed in the lithotomy position, jack knife position or on the left side with knees to chest, it is generally preferred the lithotomy position (*Figure 3*). All patients receive antibiotic prophylaxis before induction of anesthesia. The same way as open hemorrhoidectomy, different types of anesthesia can be chosen, local, spinal or general can be used, and the choice depends on the surgeon's preferences. Urinary catheter is positioned in all patients. After disinfection of the surgical field, stapled hemorrhoidopexy is performed with Longo's technique. The anal canal is manually dilated, with subsequent insertion of the obturator (*Figure 4*). Obturator is extracted and placed inside the circular anal dilator, and simultaneously inserted into the anal canal. After obturator removing will observe the placement within the external hemorrhoidal prolapse (*Figure 5*). Anal dilator is positioned correctly when the inside edge past the dentate line. This will help prevent damage to the dentate line and the

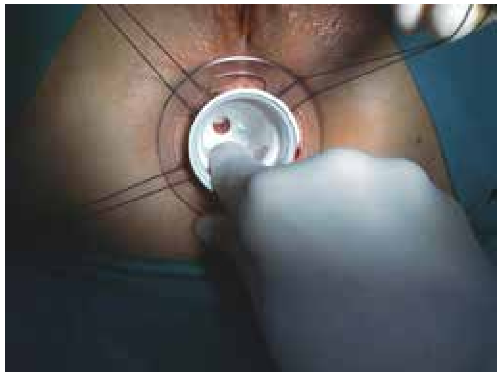

Figure 5 Insertion of circular anal dilator with obturator which is then removed.

Figure 6 The circular anal dilator is fully affixed to the perineum with three to four sutures (0 silk).

internal sphincter. Externally anal dilator is provided with four slits through which is firmly fixed to the perianal skin with four silk staples (*Figure 6*). Inside the anal dilator is positioned anoscope, the surgeon rotates the anoscope and manufactures a circumferential purse string of 2-0 prolene. The correct height for the suture is at 2 cm from the apex of hemorrhoids, and it must include only mucosa and submucosa (*Figure 7*). At each rotation, the anoscope must be extracted and inserted again to avoid the rolling of the mucosa with consequent asymmetry of the purse-string. At the end, while tightening the suture is inserted a finger inside to check its circumferential integrity. At this point the open circular stapler is introduced in such a way that the anvil goes beyond the suture line. The suture is tightened and closed with a surgical knot around the stem of the stapler and the two ends of the suture thread are pulled through the lateral casing slits. The ends of the suture are

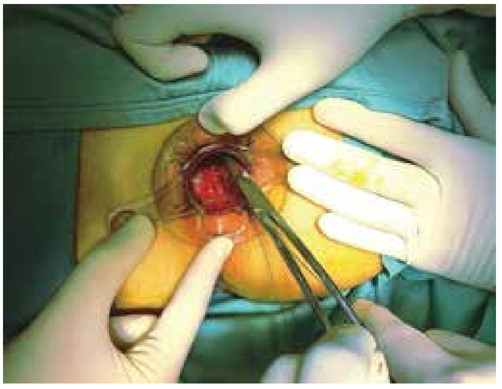

Figure 7 Prolene circumferential purse string.

Figure 8 Closure of the stapler and fired.

Figure 9 Surgical specimen.

knotted externally or fixed using a clamp. Pulling slightly and constantly the terminal portion of the suture the stapler is tightened so as to favor the entry of the tissue inside the casing. Once the casing reaches the half of the anal dilator the stapler should be pushed into the anal canal and completely closed. The stapler is aligned to the longitudinal axis of the anal canal, and after releasing the block it is fired. The closure must be maintained for 30 seconds to aid in hemostasis (*Figure 8*). In females posterior vaginal wall was

Figure 10 Operating team.

checked before firing the stapler to prevent entrapment. The stapler was then one turn anticlockwise opened to its maximum and gently withdrawn. The staple line should be well checked for possible bleeding that can be corrected with surgical staples of polyglactin 3-0. At the end of operation, anal canal was packed with gauze dressing which was removed in the morning after surgery. The circular sample can be sent for histopathological analysis (*Figure 9*).

Role of team members

The team consists of four persons (*Figure 10*): (I) the surgeon who performs the surgery; (II) assistant (surgeon or trainee surgeon) that helps in aspiration and maintain the correct position of the instrumentation and then draw up the histology; (III) the instrumentalist nurse prepares the surgical site and assists the surgeon with the correct surgical instruments; finally, (IV) a second circulating nurses for all that can occur during surgery and in conclusion cleans instrumentation.

Post-operative management

Patients normally eat the next day. On the same day they remove the urinary catheter and the gauze pad. For the evaluation of postoperative pain it is useful to use the VAS scale (0 indicates no pain; and 10, maximum pain). The pain can be estimated at 12 or 24 hours after surgery and at discharge. Pain therapy consists of a basic analgesia (paracetamol or ketorolac) on request. At discharge the patients receive a laxative syrup to be taken once a day for 15 days and the basic analgesia. Generally the average hospital stay is 2–3 days. The follow-up consists of a patient interview and physical examination to 15 days, 1 month, and 2 months after surgery.

Tips, tricks and pitfalls

After its description, some surgeons have had serious complications, but this was due to technical errors and a short learning curve. This technique is simple but needs to be applied properly. It is important that the technique is transmitted by an experienced surgeon, and including at least 25 interventions as primary surgeon. Another important aspect is the indication for surgical treatment of hemorrhoidal disease. Postoperative bleeding depends on the attention that the operator dedicated to the control of hemostasis, in 1–2% of cases may need reoperation. The cases of stenosis of the staple line are rare but may require dilations. If there is a partial dehiscence of the staple line can suffice observation. The externalized staples should be removed because they can give granulomas that bleed easily and cause prolonged postoperative pain. Compared to open hemorrhoidectomy in 30–40% of the stapled hemorrhoidopexy occurs a defecatory urgency. An answer to this could be that the suture line engages a sensitive area of the lower rectum, but it will resolve spontaneously within the first week.

Some serious complications have been described in the literature: *tearing of the rectal wall* may be due to a purse string too high or irregular, excessive tensile force during the closure of the stapler may also be responsible; irregular or high purse string may also be responsible for the *obliteration of the rectal lumen*; *rectovaginal fistula* can occur in women when the bag in the front wall is too deep and during the closure of the stapler is not checked the posterior vaginal wall; resection of the internal anal sphincter could happen if the purse string is too low, so that the internal sphincter will be pulled into the case of the stapler and partially or totally resected.

Other rare but serious complications: some patients 3–5 days after surgery have intense *pelvic pain*, this symptom often requires the use of benzodiazepines and morphine; rare reports have described some cases of *necrosis* of the staple line and *Fournier's gangrene* of the anus; moreover, also some cases of pelvic emphysema extended to the retroperitoneum have been described. Despite the rarity of these severe complications may occur and are difficult to explain to the patient that has suffered. To date more than 4 million stapled hemorrhoidopexy have been performed worldwide with complications in very low percentage, the most serious events are rarer. For success in this type of surgery it is essential to give adequate information to the patient and perform the surgery with proper technique.

In conclusion this technique is feasible and easily reproducible, the reduction of the hemorrhoidal prolapse occurs in approximately 90% of patients with moderate postoperative pain. After a few days or at most a few weeks bowel habits return to a normal pattern without urgency. However, approximately 40% of patients may have occasional symptoms such as involuntary gas passage and soiling. After one year or longer 11% of patients may present remaining or recurrent prolapse, the reintervention rate is about 10% including a second stapled hemorrhoidopexy, open hemorrhoidectomy, excision of symptomatic skin tags, or rubber band ligation.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Diagnostic laparoscopy in abdominal trauma patients

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Abstract: Abdominal trauma might be blunt or penetrating type. In some situations, radiological imaging methods might be insufficient for diagnosis, where diagnostic laparoscopy (DL) might be necessary. DL enables us to make a direct visualization of intra abdominal organs, to see any injury if present and decide if laparotomy is necessary or not. DL can be performed under either general or local anesthesia. Its advantages are minimal invasiveness, easiness-to-use, direct visualization of organs and primary laparoscopic repair chance if possible. Two-dimensional view and difficulty in visualizing of all surfaces of organs are among its disadvantages. Intra abdominal irrigation and analysis of the irrigation fluid also give indirect clues. At the end of DL, intra abdominal drain placement and follow up of drainage content can be done.

Keywords: Laparoscopy; trauma; surgery; liver; splen; injury

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Introduction

Trauma is an important and emergent surgical entity which we may see frequently in daily routine. It might be seen in forms of work or home accident, fall-down from height, traffic accident etc. Single organ trauma like falling on one hand or multiple organ traumas which are generally more common or whole-body trauma may be seen. A single trauma to abdomen because of a fist blow may be seen. A good history taking is important in trauma patients to understand the characteristic of trauma. The information of the traumatized part of abdomen and type of the trauma, blunt or penetrating, guides us to make a diagnosis. It is important to decide if intra abdominal organ injury is present or not and if surgery is necessary or not in case of intra-abdominal organ injury. Misdiagnosis might lead to unnecessary surgery. Every unnecessary surgical operation might result in increased mortality and morbidity risk. Radiological modalities to understand if any intra abdominal organ injury is present or not, are available. But these modalities might not be present in every hospital, not be available at that time period or need a preparation period where we do not have time and need immediate diagnosis. Under these circumstances, surgeon has to make an urgent decision. Again, in spite of using radiological imaging, a certain diagnosis cannot be made, still surgeon has to decide and make the diagnosis certain. Diagnostic laparoscopy (DL) is an alternative method in such situations (1-3).

Patient selection and workup

DL can be used for diagnosis in blunt or penetrating intra abdominal trauma. It is an invasive method which is valuable in diagnosis where non-invasive methods are insufficient or cannot be used. Ideally, it is performed in operation room under general anesthesia but, also can be performed at bed-side and under local anesthesia. It can be used to see if any solid or hollow organ or mesentery injury is present in blunt injury cases. A strong abdominal trauma might not result in solid organ injury but mesenteric tear and bleeding because of being crushed between blow and vertebral body. This may be seen as an intra abdominal fluid collection on CT, but, lacerated area might not be seen. DL is both diagnostic and treatment method, by using which hemostasis and primary repair can be provided, in such situations. Also, possible associated intestinal wall crushing or laceration can be assessed. When the degree of injury or severity of active bleeding of solid organ due to blunt abdominal trauma cannot be assessed well, DL can be preferred. If injury is mild or/and hemorrhage is not active, thus, follow up and medical treatment are the preference, DL can be repeated during follow up period. If hollow organ injury is suspected in blunt abdominal trauma, DL can also be preferred. Penetrating trauma might be either stab or gunshot injuries. Stab injuries might be with knife, rapier etc. Gunshot injuries might be with single or multiple bullets, and lead. Stab wounds generally have a straight wound trace but, in some situations, because of multiple to-and-fro movements of the knife, multiple traces in a single stab wound might be present which should be reminded. Gunshot wounds might have either a straight or strange traces because bullet might change direction within the body. For lead wounds, it might be difficult to assess traces as so many lead penetrations are present. DL can be used to see presence of any intra abdominal penetration, if so, any organ injury and, in presence of organ injury, to decide whether laparotomy is necessary or not. The trace and intra abdominal access of a penetrating trauma might be understood by exploring the wound under local or intravenous sedation anesthesia. But, sometimes, wound exploration may be difficult and has a high complication risk. For example, penetrating injuries of inguinal region can be explored but, here, there are tissues, femoral arterial and venous structures within the inguinal canal. If wound trace of this area goes towards upward, i.e., intra abdominally, DL can be performed to see intra abdominal penetration, intactness of peritoneum, presence of preperitoneal or retroperitoneal hematoma, and, if present, size of hematoma (4-10).

Pre-operative preparation

As DL is an invasive procedure, it necessitates a pre-operative preparation. Intravenous access should be provided, vital parameters should be monitored. Hemogram, biochemical parameters, PT, INR and blood group should be ordered pre-operatively. Either general or local anesthesia under which DL is performed, the patient should be consulted by and it should be talked about the procedure to the anesthesiologist. However, if there isn't enough time to complete blood test and the surgeon feels DL to perform immediately, he/she should consult the patient with the anesthetist and, during the procedure, while inserting trocar into intra abdominal cavity, the surgeon should be very careful to prevent bleeding and to provide hemostasis.

Equipment preference card

Laparoscopic equipment is necessary for DL which is composed of monitor, light source, insufflator, camera system, and the equipment should have mobile trolley system. Laparoscopic surgical tools such as sterile Veress needle, trocars, dissectors, endoclench and retractors are also necessary for intra abdominal access and exploration.

Procedure

DL can be performed in operating room (OR) or at bedside under either general or local anesthesia. Ideally, it should be performed in OR and under general anesthesia to explore intra abdominal cavity properly. We explain DL performed in OR first: as conversion is possible following DL, preparation should be as if laparotomy is performed. The patient is placed on operation table, abdominal hair is shaved, abdominal skin is scrubbed with 10% povidone iodine solution and patient is covered with sterile covers. Abdominal fascia is accessed by making an infra umbilical 1–1.5 cm skin incision. The edges of incision, thus fascia, are hanged up with two forceps. If the patient is obese one and this maneuver is insufficient to suspend the fascia, then fascia is grabbed with Kocher's forceps on both side of medial line and hanged up. If there is no history of previous abdominal operation or umbilical hernia, the Veress needle is inserted into abdominal cavity and physiologic saline sterile water is administered through its lumen which flows into the abdominal cavity because of negative pressure gradient if you access properly. Then, CO_2 pneumoperitoneum of 10 to 12 mmHg of pressure is formed through Veress needle. Normally, when insufflation is begun, intra abdominal pressure gets increased slowly beginning from the level of 3 to 5 mmHg as long as gas inflow keeps go on. If a pressure of 10 to 12 mmHg or more is seen at the beginning of insufflation, Veress needle might not be in intra abdominal cavity but in preperitoneal area. So, the surgeon must care that abdominal insufflation occurs properly. Then, 10 mm trocar is inserted into abdominal cavity by using the same fascia hanging maneuver. Videoscope is entered through the trocar and intra abdominal exploration begins. In cases with previous intra abdominal operation or umbilical hernia, trocar can be placed by using open technique. On exploration, intra abdominal blood because of major organ injuries like liver and splenic lacerations, free fluid mixed with intestinal content because of intestinal injury, clear fluid due to urine of perforated urinary bladder might be observed. The degree of bleeding may be assessed on direct observation. The surgeon may decide conversion to laparotomy observing major organ or actively bleeding major arterial injury. Laparoscopic hemostasis can be tried in minor bleeding. If any active bleeding or pathology cannot be detected or a negligible amount of blood is present in intra abdominal cavity, then, blood is aspirated and its origin is searched. If intestinal content is present, intestinal injury and perforation is the case and its repair either laparoscopically or by laparotomy depends on experience on laparoscopy and preference of the surgeon. If presence of intra abdominal urine is suspected, sterile physiological sterile saline water or diluted methylene blue can be administered into the urinary bladder through a urinary catheter and intra abdominal fluid can be observed per operatively. Reverse Trendelenburg position is useful for better visualization of urinary bladder. If urinary bladder injury is still unclear, then an urologist should consult the patient per operatively. If there is no pathological finding at first, then laparoscopic systemic exploration is begun. Abdominal wall and diaphragm are carefully explored. As the abdomen is insufflated, peritoneum is stretched and a tear or laceration of it can be seen more easily. All the free surfaces of liver is tried to be explored and, if needed, second and/or third trocars are placed; inferior surface of the liver is explored by the help of a liver retractor. It is searched if there is any fluid or not between liver and diaphragm or liver and abdominal wall. Splenic surfaces and parasplenic area are also searched for any injury, blood and fluid collection. Anterior surface of stomach and duodenum are explored by retracting the liver. Right and left paracolic gutters are explored. Beginning from caecum, entire colon must be explored. Small intestine and pelvic organs should also be explored. Omentum is retracted upward over colon and small intestine is grabbed with atraumatic bowel forceps and all surfaces of small intestine are explored. Ridiculous care should be taken not to make an iatrogenic injury during exploration. The exploration can be made easier by deviating of operation table to the right side, left side, Trendelenburg or reverse Trendelenburg positions, as needed. If the surgeon considers it necessary, intra abdominal cavity can be irrigated; the irrigation fluid is centrifuged and evaluated under microscope. Detecting intestinal content on this examination is a clue of small bowel perforation. Abdominal cavity is commonly irrigated with physiological saline solution; dextrose-containing solutions are not used as they are good mediums for microorganism proliferation. Physiological saline solution of 1 liter can be administered, aspirated and analyzed. Complete irrigation of all compartments can be achieved by changing position of operation table. Also, localized irrigation of certain compartments can be done by placing a Nelaton catheter in that anatomical region, irrigating with a certain amount of saline solution (for example 100 mL) and taking of sample fluid for analysis. For example, a Nelaton catheter is placed by liver through a trocar and irrigation and suction is done. These local irrigations give information about that anatomic region, not others. The surgeon can locally irrigate other areas if necessary. Completing DL, the surgeon might place a Nelaton catheter through one of the trocar port and use it for drainage content follow up. In situations where general anesthesia can't be used, DL can be performed under local anesthesia. Still, the patient should be consulted by an anesthesiologist pre-operatively. Anesthesiologist can help the surgeon by administering intravenous sedating drugs. The patient should be monitored during this procedure, too. Following local anesthesia, infra umbilical skin incision is made and fascia is reached. We prefer open trocar entry technique in our practice. A 15 mm median incision on fascia and peritoneum is made and trocar is entered into abdominal cavity. A minimum insufflation should be done as a usual insufflation might result in severe abdominal pain due to peritoneal stretching. Unfortunately, minimum pneumoperitoneum use need restricts optimum visualization of intra abdominal cavity and brings the risk of skipping some important pathological findings. Intra abdominal access under local anesthesia might be easy in slim patients but obese patient might not tolerate the procedure. After DL, a Nelaton catheter can be placed into abdominal cavity through trocar port and watched for any pathological drainage (4,7,9,11).

Role of team members

DL is of a team-work. The procedure needs help of anesthesiologist and an experienced nurse on laparoscopy who helps the surgeon during performing it. As a second or third trocar placement, hence more hand tool use, might be needed during DL, thus, the nurse should able to use videoscope. Entire laparoscopic equipment should also be ready to use during the procedure.

Pre and post-operative management

Antibiotic prophylaxis and parenteral fluid replacement should be done pre-operatively. If there isn't any pathology on DL or any complication in early post-operative period, oral fluid intake can be started in early post-operative period, provided that gastro intestinal functions are returned and general condition of the patient is well. Post-operative analgesics provide patient comfort.

If a drain tube has been placed into abdominal cavity, drainage content can be watched. If surgeon desires, intra abdominal cavity irrigation might be repeated through drain tube with physiological saline and this irrigation fluid may be analyzed in laboratory.

Tips, tricks and pitfalls

Recently, DL is needed less than that of yesterday. Innovations and development in radiological methods have an important role on this decrease. But, still, when radiological imaging cannot ascertain the diagnosis or is unavailable, DL is needed. DL performed at optimum conditions satisfies the surgeon and give direction to the treatment. Its disadvantage is its 2 dimensional view. Another one is its limits to view all surfaces of the intra abdominal organs. Though it hasn't got a 100% of diagnostic value, its minimal invasiveness is an advantage. Direct visualization of the organs and drain placement chance if needed are its other advantages.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Prevention and management of hemorrhage during a laparoscopic colorectal surgery

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Abstract: Laparoscopy is believed to play an important role in the treatment for colorectal cancer and is now extensively applied across the world. Although the safety and feasibility of laparoscopic colorectal surgery has been verified by several randomized controlled trials, intraoperative hemorrhage is still a challenge for clinicians, which could lead to conversion to laparotomy or increased mortality. In this article we discuss the strategy for prevention and management of hemorrhage in laparoscopic colorectal surgery in terms of anatomy and surgical skills.

Keywords: Hemorrhage; laparoscopy; colorectal

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Introduction

Laparoscopic techniques have been widely used in the surgical treatment of gastrointestinal tumors. In particular, the feasibility of laparoscopic surgery for colorectal cancer has been well documented in a number of prospective, randomized, and controlled clinical studies. Among them, the laparoscopic radical resection of colorectal cancer has been recognized by the US National Comprehensive Cancer Network (NCCN) as an optional therapy. In fact, the laparoscopic radical operation for rectal cancer has an obvious advantage of being minimally invasive. While achieving minimal invasive and radical resection are the main targets of surgeries for tumors, safety is the foundation and prerequisite of a successful surgery. For beginners, performing a laparoscopic colorectal surgery in a safe and reliable way is the only way to success.

One of the most important and notable surgical complications is intraoperative hemorrhage. In particular, severe bleeding is one of the major complications of some laparoscopic colorectal surgeries and also one of the major causes of conversion to laparotomy.

Severe intraoperative bleeding is often caused by the injury of major blood vessels. The main causes of intraoperative hemorrhage include: (I) inadequate knowledge of the anatomical courses of the vessels under laparoscope; (II) poor identification of anatomic layers; (III) lack of correct and effective traction and effective exposure of visual field; and (IV) lack of cooperation among skillful team members. During the surgery, the operator must be able to identify the anatomic courses of vessels under the laparoscopic view and carry out correct and effective traction, so as to effectively expose the surgical field, obtain good surgical view, and thus prevent any possible injury of any vessel. This proposes higher requirements on the operator, the first assistant, and the camera holder,

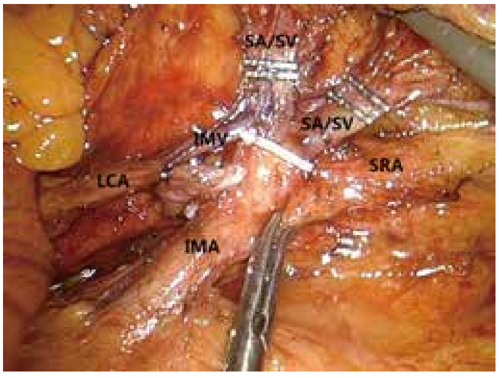

Figure 1 Blood vessels in rectum and left colon. IMA, inferior mesenteric artery; IMV, inferior mesenteric vein; LCA, left colic artery; SRA, superior rectal artery; SA, sigmoid artery; SV, sigmoid vein.

especially close cooperation and good teamwork. The operator must perform separation and dissection in correct anatomic layers to avoid vascular injury and bleeding.

As a young surgeon who is now able to independently carry out laparoscopic radical surgery for colorectal cancer, I had some experience in encountering intraoperative hemorrhage and also have seen or heard much from my mentors and peers, which I would like to share in this article.

Prevention of hemorrhage in a laparoscopic colorectal surgery

Identifying the appropriate anatomical landmarks

Surgeries in rectum or left colon: during the laparoscopic radical treatment of rectal cancer, left colon cancer, and sigmoid colon cancer, the vessels (mainly inferior mesenteric vessels and their branches) to be handled during the surgery are relatively simple. The inferior mesenteric artery (IMA) originates at the midway between the abdominal aorta at the level of the duodenum and the aortic bifurcation and then courses towards the left lower side, showing slight bulge and beating. The inferior mesenteric vein (IMV) is purple in color under laparoscope; it leaves the IMA and arises alone, with its medial landmark being the ascending part of the duodenum and the peritoneal folds of the duodenum and jejunum and the head-side landmark being the lower edge of the pancreas. A key skill for laparoscopic exposure of IMA and IMV is as follows: the assistant pulls the inferior mesenteric vascular pedicles towards the left upper side vertically, so as to form a triangle operating window with the abdominal aorta. By doing so, the unnecessary vascular injury and intra-abdominal hemorrhage can be avoided. During the dissection of the inferior mesenteric vessels, the operator uses a HIFU to complete technical actions such as picking, pulling, isolating, and separating, so as to skeletonize the vessels. This enables both lymph node dissection and prevention of bleeding. Meanwhile, the direction of HIFU energy surface should be carefully adjusted to avoid any vascular injury or bleeding. Meanwhile, during the division of the IMA root, the relationship between IMA and IMV and that between IMA and its branches [including left colic artery (LCA) and sigmoid colon artery] should be taken into consideration. In general, when IMA is closer to the root, it has a longer distance away from IMV. Therefore, when IMA is transected at its root, it will be less likely to injure IMV, left colon vessels, or sigmoid vessels. During the left colon vessel-preserving D3 radical treatment for rectal cancer or the superior rectal artery (SRA)-preserving D3 radical treatment for left colon cancer, a good knowledge of this anatomic feature will be particularly useful for the protection of vessels (*Figure 1*).

Right colon surgeries: the anatomic layers encountered during a right colon surgery are far more complex than those for left colon, rectum, and sigmoid colon; meanwhile, there are more anatomic variations in the arteries of the right colon. In fact, surgeries involving right colon are featured by a large number of variations. The right colon vessels, in particular the vein, have relatively more anatomic variations. While the ileocolic vein has a relatively fixed position and course, the right colic vein, middle colic vein, and gastrocolic common trunk often have variations. It has been reported that the frequencies of occurrence of the gastrocolic trunk and middle colic vein were 69% and 85%, respectively, whereas the frequency of the absence of right colon vein could be up to 57%; furthermore, the frequency of the right colon artery ranges only 20–30%. The branches of gastrocolic trunk also have many variations (*Figure 2*), which include the typical three-branch type (i.e., right colic vein, right gastroepiploic vein, and anterior superior pancreaticoduodenal vein), two-branch type (right colic vein and right gastroepiploic vein), and even variation that the right colic vein directly connects the superior mesenteric vein (SMV). The presence of these variations dramatically increases the risk of bleeding during a laparoscopic surgery for right colon lesions. In particular, during the handling of the common trunk, since this vessel has short and thick

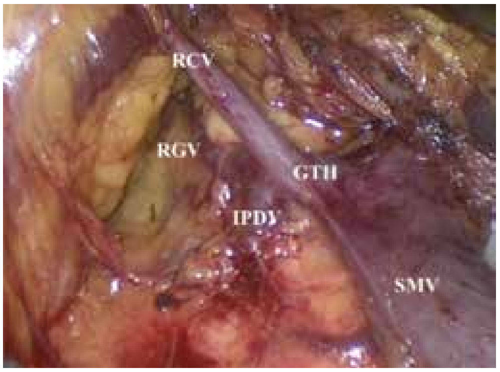

Figure 2 The classic three-branched anatomic appearance of gastrocolic common trunk.

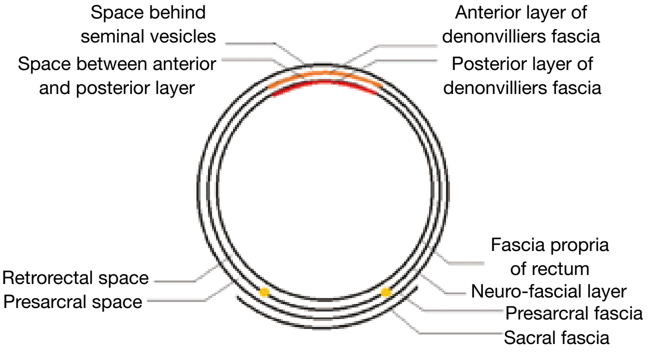

Figure 3 Schematic diagram of the anatomic layers during a rectal surgery.

anatomic structures and crispy texture, excessive traction may tear the common trunk and thus lead to bleeding; even worse, improper management can cause fatal bleeding of SMV; in contrast, inadequate traction can also result in poor exposure of anatomic layers, thus leading to bleeding. Therefore, at the beginning of the surgery, it's better to use ileocolic vascular pedicles as the anatomic landmarks; then, divide the colonic mesentery at its lower edge to open a window, which enables the operator to further search for the right retrocolic space (RRCS) and then trace and dissect the SMV along the ileocolic vessels. SMV is the main line during the surgical anatomy of the whole right colon. Dissect mesenteric adipose tissue on its surfcace to completely expose SMV; along the SMV, the dissection moves upwards to expose the branches of the arteries and veins at its right side. The ligation and transection of these branches not only are less likely to cause bleeding and meanwhile ensure the thorough D3 lymph node dissection. The same skill can be applied during searching for the common trunk and its branches, so as to adequately dissect and expose these vessels. The common trunk is often located within the range from the lower edge of pancreatic head to the line 2 cm upper from the lower edge of pancreatic head. Thus, the lower edge of the pancreatic head can also be used as one of the landmarks during searching for common trunk in a laparoscopic right colon surgery.

Entering the correct anatomical layers

Along with research advances in the local anatomy of the colorectal regional under laparoscope, it has been well documented that the Toldt's space is a vessel-free space located between mesorectum/mesocolon and prerenal fascia (PRF). Due to the continuity of PRF, it is a mutually intersecting anatomic layer that can be used as a surgical plane during the colorectal surgery. There are only two substantive obstacles: the inferior mesenteric vessels and the lateral ligaments of rectum (may include middle rectal artery). For the rectum, this plane is initially seen as the retrorectal space, which extends towards its tail side till the S4 level, at which the mesorectum and the neuro-fascial layer merge into the rectosacral fascia (Waldeyer fascia). During the operation this fascia must be divided before entering the presacral space behind it (*Figure 3*). For the left colon, this plane extends upwards to form the left retrocolic space and the transverse retrocolic space (TRCS), till the lower edge of the body and tail of the pancreas; in the right colon, it is seen as the RRCS and the TRCS. In addition, the intermembrane space (IMS) between the posterior layer of the great omentum and the top of the transverse mesocolon can communicate with the RRCS via the posterior side of the root of transverse mesocolon; therefore, IMS must be entered during the dissociation of transverse mesocolon in a left/right colon surgery. In addition, IMS can be entered by extending towards the head side in the RRCS/left retrocolic space, so as to completely resect the transverse mesocolon (*Figure 4*).

In the clinical settings, a medial approach is recommended during the entering of the proper anatomic layers. During a rectal surgery, the assistant lifts the inferior mesenteric vascular pedicle and the mesenteries of rectum and sigmoid colon towards the abdominal side and meanwhile expand and tighten the mesenteries, thus producing adequate tension. Thus, with the sacral promontory as the starting landmark, the operator cut open the mesenteries towards

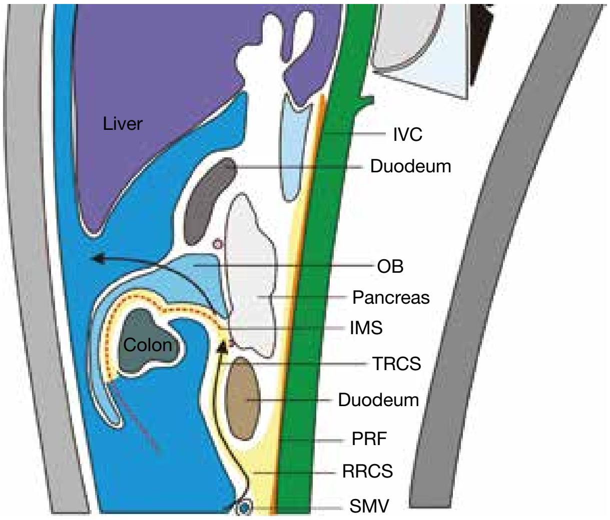

Figure 4 Schematic diagram of the anatomic layers during a colon surgery. RRCS, right retrocolic space; TRCS, transverse retrocolic space; IMS, intermensentric space; PRF, prerenal fascia; RPS, retroperitoneal space; EPS, extraperitoneal space.

the head side. Due to the atomization effect of HIFU, the space behind the rectum and the sigmoid colon naturally appears. Then, toward the tail side the retrorectal space can be gradually extended, and then the rectal fascia can be broken through to reach the presacral space; towards the head side the root of the IMA can be reached for further lymph node dissection. In this correct layer, it can be found that the proper rectal fascia wraps the fat inside the mesorectum and gently hangs down, which is smooth and thin under the endoscopic light source. After the inferior mesenteric vessels are handled, the dissection continues towards the head side till the space behind the left colon. Thus, during the left colon surgery, the same strategy can be applied to find the proper space behind left colon, so as to avoid that the application of lateral approach may lead to the entering of the excessively deep layer or even the posterior side of left kidney. Similarly, the medial approach can also be applied during a right colon surgery. As described above, the mesenterium can be cut open at the lower edge of the ileocolic vascular pedicles; then, the RRCS is entered and extended towards the head side. The duodenum and pancreatic head can be used as landmarks successively to make sure that the right space has been extended. Similarly, it can be found that the posterior lobe of the right mesocolon also holds the fat inside the mesentery and gently hangs down, which is smooth and thin. The dissection continues towards the head side to reach the TRCS and the IMS, so as to finalize the dissociation of transverse mesocolon. Towards the lateral side it can reach the peritoneum.

In summary, both sharp and blunt separation can be carried out in such a proper vessel-free surgical plance, which is a key strategy for preventing severe bleeding in abdominal or presacral cavity during a surgery.

Management of hemorrhage in a laparoscopic colorectal surgery

If severe bleeding occurs during operation, the bleeding site should be controlled as soon as possible. In this process, the operator must keep calm; meanwhile, it is equally important that the assistant and camera holder provides calm response and cooperation. Severe bleeding often has a serious impact on the laparoscopic vision, including brightness and sharpness. The "eyes" of the operator depends on the actions of the camera holder. Often a camera holder is a doctor with lowest qualification; when bleeding occurs, his performance has important impact on the operator's operations in stop bleeding. Thus, teamwork is particularly important. The camera holder must be trained to know how to avoid the impact of pulsatile bleeding on the camera, how to keep the vision clear, and how to put the main surgical field at the center of the camera. The assistant shall thoroughly expose the surgical field by adequate traction and/or effective suctioning, so that the operator can use the left hand to cooperate with the right hand to stop bleeding. For bleeding caused by vascular injury, under the active cooperation of the assistant, the operator can use the instrument in left hand to oppress or clamp the vessel firstly; then, based on the diameter of damaged blood vessel, electro-coagulation, titanium clamps, HIFU, Ligasure, absorbable clips, or large plastic clips may be applied for hemostasis; if necessary, suture ligation may be applied for hemostasis. Same as hemostasis in conventional surgeries, clamping without clear visual field should be avoided; instead, it should be performed after the bleeding has been controlled. If condition allows, the bleeding vessel can be adequately dissociated and exposed before clamping, so as to leave sufficient space for operation and thus achieve proper hemostasis. Remember: once bleeding occurs during surgery, there are limited chances for successful hemostasis. Thus, bleeding should be effectively stopped during each operation. For oozing blood (e.g., presacral hemorrhage), the bleeding may be controlled by compression firstly, followed by sunctioning of the remained blood and clearing of the visual field; finally, hemostatic gauze or bone screw may be applied for hemostasis. In most cases, hemostasis can be completed under laparoscope. Injury of a large blood vessel may lead to massive bleeding in the abdominal cavity; in such cases, conversion to celiotomy should be arranged immediately. Blind pursuit of laparoscopic surgery may miss the chances of hemostasis and therefore should be avoided.

Prevention and treatment of anastomotic bleeding

Anastomotic bleeding during a colorectal surgery (especially the surgeries for rectal cancer) is one of the severe compliations early after surgery. In most cases it occurs after surgeries for low rectal cancer. In fact, the anastomotic bleeding often occurs immediately after intraoperative anastomotic operation; however, since the bleeding is obscure, the condition will not be found until the patient is transfered to the ward. According to our experience, for patients with low rectal cancer, the intestinal canal at the distal end of the tumor shall be skeletonized as thoroughly as possible before it is transected. When a cutter & stapler or a circular stapler is applied, the stapling shall be maintained for about 15–20 s to ensure the sufficient compression and closure of the vessels inside the tissue before the transection of the intestinal canal, which can minimize the potential risk of bleeding.

Furthermore, after the anastomotic operation is completed, the intraoperative endoscopic examination is clinically meaningful for the assessment of anastomosis: it enables the early detection and timely management of anastomotic bleeding and proactively eliminates any potential bleeding, thus minimizing the risk of postoperative anastomotic bleeding. According to our experience, after the anastomotic operation is completed, the condition around the anastomosis should be carefully observed during the intraoperative endoscopic examination. If anastomotic bleeding is found, the accumulated blood should be suctioned off firstly; then, appropriate management is provided, which includes intraoperative endoscopic hemostasis using titanium clips or electrocautery unit; alternatively, suturing under direct vision may be performed to stop bleeding in the ultra-low anastomosis, so as to reduce the occurrence of postoperative anastomotic bleeding. Any active bleeding must be handled immediately; delayed treatment may lead to postoperative bleeding, which might require a second hemostasis treatment.

The management strategy of postoperative anastomotic bleeding is as follows: for minor hemorrhage, conservative treatment is preferred, along with the close observation of the bleeding volume and the patient's general condition; for major hemorrhage or in patients with unstable hemodynamics or in patients who are unresponsive to conservative treatment, non-conservative treatment should be applied. There are three specific endoscopic hemostatic therapies: spraying a haemostatic agent; electrocoagulation; and use of hemostatic clips. The endoscopic hemostatic approaches have many advantages: direct vision of the bleeding site; assessment of bleeding volume; small trauma; fewer complications; and avoiding prolonged hospital stay and saving treatment costs due to a second surgery. Many surgeons also believed that endoscopic techniques are safe and effective in treating anastomotic bleeding after a surgery for rectal carcinoma and proposed that an endoscopic hemostatic approach is preferred before a second hemostatic surgery.

When endoscopic hemostasis is applied, the patient's general condition should be carefully observed to ensure that the operation can be performed as quickly as possible when the vein is cut open and fluid replacement is performed for volume maintenance. During the operation, the accumulated blood and blood clots in the intestinal cavity should be suctioned off to improve the visual field inside the intestinal cavity; then, the bleeding site should be carefully searched for to allow appropriate hemostatic treatment. A small amount of oozing blood may exist at the anastomosis; in such cases, endoscopic spraying of epinephrine may be performed to stop bleeding; alternatively, an electro-coagulation hemostasis method may be applied, during which thermal coagulation may contribute to tissue edema and compress the blood vessels, thus achieving the hemostatic effect. For a larger amount of oozing blood or pulsatile bleeding, spraying of adrenaline should be followed by clamping with titanium clip, particularly for bleeding from a naked blood vessel or a small artery.

For surgeons, while surgical complications can not be completely avoided, there are still chances for reducing the incidence. Intraoperative hemorrhage can be caused by a variety of factors, among which anatomy, operations, and teamwork are most important. Laparoscopic colorectal surgeons must have solid knowledge on the key laparoscopic anatomic landmarks of colon and rectum and the natural anatomic layers under laparoscope and meanwhile grasp the basic operational skills required in a laparoscopic colorectal surgery. Furthermore, the surgeons should also be familiar with the prevention and management of various complications, including hemorrhage. During this process, the operator should never forget that teamwork is equally important in performing a successful laparoscopic colorectal surgery. It is for sure that the quality of laparoscopic colorectal surgeries will be constantly improved and the complications will be reduced if we strictly follow the surgical specifications, introduce new techniques in a balanced way, and continue to strengthen the technical training and learning.

Conclusions

Intraoperative hemorrhage is a common complication in colorectal surgery that needed to be identified and managed as soon as possible. It requires the surgeon to have a sound comprehension of the anatomy of colon and rectum, qualified laparoscopic operation skills, a calm mind and good teamwork.

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