Review Article

Development of lymph node dissection in laparoscopic gastrectomy: safety and technical tips

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Abstract: With the accumulation of experience in laparoscopic radical gastrectomy and the progress in surgical instruments, the laparoscopic technique has been widely applied in gastric cancer. Combining previous reports with data from our center, we believe that laparoscopic surgery for gastric cancer is safe and feasible, and its surgery-related complications have an incidence that is not higher, and perhaps even lower, than that of traditional laparotomy. However, the stomach has many anatomical levels and an abundant blood supply; additionally, laparoscopic surgery is relatively difficult. Therefore, understanding the normal gastric peripheral vascular anatomy and variation, selecting an appropriate surgical approach, applying programmed surgical procedures and team cooperation, and paying attention to the details in lymph node dissection are keys to a successful laparoscopic lymph node dissection in gastric cancer.

Keywords: Stomach cancer; laparoscopy; gastrectomy

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In 1994, Kitano, a Japanese scholar, *et al.* reported the use of a laparoscopic radical gastrectomy for early gastric cancer for the first time (1). After more than 20 years of development, laparoscopic radical gastrectomy for early gastric cancer has been accepted as a standard treatment options for stage IA gastric cancer by the new edition of the *Japanese Gastric Cancer Treatment Guidelines*. In 1997, Goh *et al.* (2), for the first time, applied the laparoscopic technique to the treatment of locally advanced distal gastric cancer and achieved good short-term effects, which promoted the expansion of surgical indications of laparoscopic radical gastrectomy from early gastric cancer to early stage of advanced gastric cancer and promoted the use of this technique worldwide (3-6). Increasingly more scholars paid attention to the safety of laparoscopic radical gastrectomy in addition to its long-term effects (7-9). The 7th, 8th and 9th national survey of the Japan Society for Endoscopic Surgery (JSES) showed that with increasing cases of laparoscopic radical gastrectomy for distal gastric cancer (2,671, 3,792 and 6,615 cases), intraoperative complications (3.5%, 1.9% and 1.7%) and postoperative complications (14.3%, 9.0% and 8.2%) decreased every year (10). The interim report regarding a multicenter, prospective and randomized controlled study by the Korean Laparoscopic Gastrointestinal Surgery Study (KLASS) Group demonstrated that the incidence of complications in laparoscopy and laparotomy for early gastric cancer was 10.5% (17/179) and 14.7% (24/163), respectively (P=1.37) (6). The Chinese Laparoscopic Gastrointestinal Surgery Study (CLASS) Group showed no statistical significance in the incidence of postoperative complications between the laparoscopy group and laparotomy group (15.2% *vs.* 12.9%, P=0.285) by carrying out a multicenter, prospective and randomized controlled study on

laparoscopy and laparotomy for advanced gastric cancer (4). Our department retrospectively studied 2,170 cases of laparoscopic surgery for gastric cancer, showing a total incidence of postoperative complications of 13.8%, which was in agreement with the above studies. We concluded that laparoscopic surgery for gastric cancer is safe and feasible after the learning curve, and the incidence of surgery-related complications is not higher, and might be even lower, than that of traditional laparotomy (11). However, the stomach has many anatomical levels and an abundant blood supply; additionally, laparoscopic surgery is relatively difficult. Therefore, the safety and effectiveness of laparoscopic radical gastrectomy are the focus of attention. This paper explored the techniques of laparoscopic lymph node dissection for gastric cancer by combining the experience of our department with the related literature.

Acquisition of normal gastric peripheral vascular anatomy and its variation

Lymphatic networks in each layer of the gastric wall anastomose and connect with each other according to a certain flow direction and generally accompany gastric peripheral vessels and flow to the gastric peripheral lymphatic system. Therefore, lymph node dissection for gastric cancer is also a process of exposing and baring gastric peripheral vessels. Understanding the gastric peripheral vascular anatomy is of great significance for the safe and effective implementation of laparoscopic radical gastrectomy. The blood supply of the stomach is mainly from the celiac artery system, which surrounds the pancreas; thus, the pancreas is the anatomical center for localizing and baring blood vessels. From right to left, there are the right gastroepiploic artery and vein and their branches on the surface of the pancreatic head and its lower edge, celiac artery and its three branches, including the trunk of the splenic artery, left gastric artery and common hepatic artery, which further consists of the gastroduodenal artery, proper hepatic artery and right gastric artery, at the upper edge of the pancreas in the pancreatic body, as well as the left gastroepiploic vessels, splenic vessels and short gastric vessels near the tail of the pancreas. In the process of laparoscopic radical gastrectomy with lymph node dissection, in addition to a detailed understanding and acquisition of the normal anatomical position and pathway of these vessels, their variation should also be always considered. Otherwise, damage and bleeding of variant vessels will be often caused, influencing the operation of the surgery. Our department has performed 3,000 cases of laparoscopic radical gastrectomy; additionally, the gastric peripheral vascular anatomy and variation were summarized, such as different ways of flowing to the right gastroepiploic vein (12), variations in the pathways of the coronary vein (13,14), vascular classification in the absence of the common hepatic artery (15), vascular classification of the splenic lobe (16,17), etc., providing a good anatomical basis for laparoscopic D2 lymphadenectomy for gastric cancer.

Selection of appropriate surgical approaches

The selection of appropriate surgical approaches is the key to a successful laparoscopic radical gastrectomy. Our center roughly divided the process of laparoscopic lymph node dissection for gastric cancer into the dissection of the inferior region of the pylorus, the superior region of the pancreas and the splenic hilum, with different surgical approaches (18-20).

The inferior region of the pylorus—approach of the middle colic vein

The tissue in the fused segment between the lobes before and after the transverse mesocolon (gastric-mesocolic gap) is loose and has no vessels, facilitating the stripping of the anterior lobe of the transverse mesocolon and causing no bleeding. In the separation of the anterior lobe of the transverse mesocolon in the inferior region of the pylorus, this anatomical plane should be selected, and the middle colic vein should be exposed first. Due to the location of the gastric-mesocolic gap on the surface of the middle colic vein, this vein is superficial, and it is easy to differentiate this violet-blue vein from the peripheral adipose tissue. In addition, the right gastroepiploic vein could be exposed along the surface of the middle colic vein to the lower edge of the pancreas; after the separation of the right gastroepiploic vein, the right gastroepiploic artery could be exposed and bared along the surface of the head of the pancreas to the pylorus to clean the lymph nodes under the pylorus.

The superior region of the pancreas—proximal approach of the trunk of the splenic artery

The location of the initial segment of the trunk of the splenic artery is relatively constant and has few anatomical

variations; additionally, the distance from the upper edge of the pancreas is usually the shortest. Therefore, the vessels in this segment are easily exposed after separating the pancreatic capsule. With the splenic artery as the anatomical landmark, the celiac artery, left gastric artery and common hepatic artery could be further exposed towards the right. In addition, based on the data from our department (21), the rate of No. 11p lymph node metastasis was the lowest compared with the other groups in the superior region of the pancreas, and it was less difficult to clean. Accordingly, in the dissection of lymph nodes in the superior region of the pancreas, we entered the posterior pancreatic space in the superior region of the pancreas from the left gastropancreatic fold to expose the trunk of the splenic artery and clean the No. 11p lymph node; then, No. 7, 9 and 8a lymph nodes were successively cleaned from left to right.

The splenic hilum—left approach

The pancreatic capsule at the pancreatic tail is relatively loose and is prone to entering the posterior pancreatic space after separation. At the same time, the separation of the left gastroepiploic vessels could contribute to a better dissociation of the greater omentum, providing favorable conditions for the next lymph node dissection. Therefore, regarding the dissection of lymph nodes in the splenic hilum, we applied the left approach (22); the inferior splenic vessels were exposed as the reasonable operative plane with the pancreatic capsule entering the posterior pancreatic space after separation from the upper edge of the pancreatic tail, and the root of the left gastroepiploic vessels was bared and ligated, the No. 4sb lymph node was cleaned, and then the No. 11d and No. 10 lymph nodes were cleaned along the central part of the trunk of the splenic artery to the splenic hilum, facilitating the resection of lymph nodes at the splenic hilum together with a stomach sample, which was consistent with the principle of radical tumor resection.

Application of programmed surgical procedures and team cooperation

The selection of reasonable surgical procedures and the application of a programmed surgical operation could simplify the surgical process, regulate complex laparoscopic surgery for gastric cancer and improve surgical efficiency; additionally, it is easy to make this method popular and teach this method. Taking laparoscopic spleen-preserving splenic hilar lymph node dissection as an example, based on the completion of more than 500 cases of laparoscopic surgery for gastric cancer, our center developed a laparoscopic spleen-preserving splenic hilar lymph node dissection method in January 2010 and summarized a set of surgical procedures for laparoscopic splenic hilar lymph node dissection *in situ*, which was called "Huang's three-step maneuver" (22). First, lymph node dissection in the inferior splenic pole is conducted by exposing the inferior splenic vessels along the pancreatic tail using an ultrasound knife, baring and separating the root of the left gastroepiploic vessels and then separating 1–2 short gastric vessels; second, lymph node dissection in the trunk of the splenic artery, is carried out by cleaning the No. 11d lymph node along the central part of the trunk of the splenic artery to the splenic hilum and baring the middle splenic vessels and 2–3 short gastric vessels; Third, lymph node dissection in the upper splenic pole is performed by baring the upper splenic vessels along the upper splenic pole and separating the last short gastric vessel, and then, lymph node dissection in the splenic hilum is completed. The team cooperation, in which the assistant surgeon actively cooperates with the surgeon to expose the surgical region by specific pull and exposure during the surgery, greatly reduces the difficulties of the complicated surgery, contributing to the possibility of a standardized laparoscopic D2 lymph node dissection for advanced gastric cancer.

In the team cooperation, the assistant surgeon and the laparoscope holder are vital to the surgery. The assistant surgeon should hold an intestinal clamp in the left hand and a nipper in the right hand lightly and flexibly to cooperate with the surgeon and form a better local tension by "carrying", "topping", "pushing" and "bearing". The flexible application of a suction device by the assistant surgeon can not only eliminates blood, effusion, fog and titanium clip, keeping the surgical field clean but also replaces the partial functions of the nipper to pull tissue and expose gaps, act as a stripper to assist cleaning, and apply pressure, expose and stop bleeding. At the same time, the influence on the surgical procedure caused by frequently changing the apparatus is avoided. The laparoscope holder should be familiar with the surgical procedures and the habits of the surgeon to provide a clear and stable sight for the surgeon and the assistant surgeon, which is also a guarantee for a successful laparoscopic surgery. The laparoscope holder can choose different anatomical landmarks in different regions as the visual reference plane, with vessels and organs requiring protection placed horizontally and vessels and

organs requiring separation placed vertically, which could assist the surgeon to choose the correct anatomical plane and reduce accidental injury to important blood vessels. In the dissection of the splenic hilum and other narrow regions, the included angles of the four apparatus of the surgeon and the assistant surgeon are small, easily leading to sheltering from observation by the apparatus, namely "the effect of chopsticks". Then, the laparoscope holder can quickly adjust the observation angle by rotating the optical fiber and lens to obtain the optimum surgical field.

Paying attention to the details in lymph node dissection (23)

Paying attention to the details in lymph node dissection could improve the surgical efficiency, reduce unnecessary damage and bleeding, and make the surgery more enjoyable. For a more successful lymph node dissection, more ideal exposure of the surgical field, avoidance of frequent changes in the surgical position and repeated clamping of the diseased gastric wall are necessary to adopt a certain strategy of lymph node dissection. Using total gastrectomy as an example, dissection is conducted in the following order: "No. 6→No. 7, 9, 11p→No. 8a, 5, 12a→No. 1, 3→No. 4sa→No. 10, 11d→No. 2"; this order could connect each gastric peripheral lymphatic tissue requiring clearance from the bottom to the top and follows the principle of "en bloc resection" to the maximum degree. During lymph node dissection, clamping too many tissues at once should be avoided, and cutting and separation should be performed by the "nibbling up" method step-by-step to reduce wound exudates. In the process of solidification and cutting by an ultrasound knife, extreme tension should be avoided to prevent vascular breaking before solidification and cutting, which may result in uncontrollable bleeding. The non-functional surface of the ultrasonic knife should always be close to the important vessels and organs requiring protection, such as the gastric wall, duodenal wall, pancreas, spleen, etc. During the excitation of the ultrasonic knife, the functional surface should be within the visual field of the surgeon, which is also an important factor for avoiding damage and bleeding. In addition, vessels without a clear path should be as far away from the distal end of the heart as possible. The direction of the vessels should be clarified first, and then separation is considered. Moreover, blindly cutting vessels must be avoided to prevent unnecessary damage. We believe that the preoperative determination of the distribution of gastric peripheral vessels through 3D-CT vascular remodeling can greatly reduce the surgical difficulty and time, decreasing the incidence of vascular injuries and increasing the surgeon's confidence in the laparoscopic lymph node dissection (17).

For the dissection of enlarged lymph nodes, it is important to find the correct anatomical plane. Separating the plane too high might result in entering lymph nodes, leading to bleeding of the lymph nodes. Finding spaces on the surface of vessels and separating the bottom of the lymph nodes close to the surface of vessels can contribute to the achievement of the complete removal of lymph nodes. Lymph nodes are usually crisp; the assistant surgeon can expose the anatomical spaces by pulling the superficial fascia of lymph nodes. However, enlarged lymph nodes should not be pulled directly by clamping to avoid bleeding and tumor spread. Stopping the bleeding of lymph nodes using the ultrasound knife is not only difficult to coagulate but also often leads to greater bleeding. Treatment for lymph node bleeding with little influence on the surgical field is unnecessary. The correct anatomical plane should be detected, and complete lymph node dissection at the root of the lymph nodes is necessary, which is followed by natural cessation of bleeding. When bleeding affects the exposure of the surgical field, pressure could be applied using pledget to stop the bleeding. When bleeding greatly influences surgical procedures, the left gastric artery should be found first and ligated, reducing the amount of bleeding.

In summary, laparoscopic surgery for gastric cancer is safe and feasible; however, standardized laparoscopic radical gastrectomy with lymph node dissection is relatively difficult. Understanding the normal gastric peripheral vascular anatomy and variation, selecting an appropriate surgical approach, applying programmed surgical procedures and team cooperation, and paying attention to the details in lymph node dissection are keys to successful laparoscopic radical gastrectomy with lymph node dissection.

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Footnote

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

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