Review Article

Successful application of laparoscopic techniques in colorectal surgery and its indications

Patrick T. Delaplain[1,2], Mehraneh Dorna Jafari[2]

[1]Department of Pediatric Surgery, Children's Hospital Los Angeles, Los Angeles, CA, USA; [2]Department of Surgery, University of California Irvine Medical Center, Orange, CA, USA

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

Correspondence to: Mehraneh Dorna Jafari, MD. Department of Surgery, University of California Irvine Medical Center, 333 City Blvd West, Suite 850, Orange, CA 92868, USA. Email: jafarim@uci.edu.

Abstract: Laparoscopic surgery is now widely used for a variety of indications, including both benign and malignant disease in colorectal surgery. There has been an increase in utilization of laparoscopy to treat colorectal pathology over the past decade. This adoption is likely related to the increased comfort among surgeons for laparoscopic surgery, and a growing body of literature that shows equivalent, if not superior, outcomes to open surgery. Many of the same safe practices that are used in open surgery can be applied laparoscopically as well. However, new issues and opportunities for improvement have come along with minimally invasive techniques. While abdominal entry was initially solely based on the location of the surgical target organ, we are now faced with choices regarding the initial entry into the abdomen and creation of pneumoperitoneum. It has also opened the door for early recovery protocols as a large incision is no longer a major determinant of hospital stay. We are also faced with an ever-growing list of indications and novel applications. As surgeons become more facile and instruments become more advanced, approaching emergent indications laparoscopically and avoiding open surgery should become standard of care. However, all of this progress relies on safe techniques, technical expertise and appropriate patient selection.

Keywords: Colectomy; minimally invasive; laparoscopy; colorectal

Received: 25 December 2018; Accepted: 04 January 2019; Published: 16 January 2019.
doi: 10.21037/ales.2019.01.02
View this article at: http://dx.doi.org/10.21037/ales.2019.01.02

Introduction

As the surgical community approaches 40 years since the inception of laparoscopic surgery, it has become the first line approach for many surgical indications. And while it was initially described by Kurt Semm in 1981 for appendectomy, it took a mere 10 years before it was applied to colon resection (1). The incidence of laparoscopic colectomy has been steadily rising and, as of 2015, 60% of cases are now done laparoscopically (2).

General laparoscopic colectomy tips

Entering the abdomen

Though the first surgery didn't take place until much later, inspection of the peritoneal cavity (and the term laparoscopy) have their origins in the early 1900s (3). Perhaps one of the most long-standing and contentious topics with relation to laparoscopy is the method in which initial access and pneumoperitoneum is achieved.

Laparoscopic entry techniques and point of entry are

surgeon dependent, but they can typically be classified into several major categories: closed techniques, open techniques, direct trocar entry and the radially expanding access system. A 2015 Cochrane review looking at laparoscopic entry techniques was limited by low quality data, but it did show a difference in failed entry between open and closed techniques. For every 1,000 patients undergoing an operation, there would be 11–30 fewer failed entry attempts if using an open technique. However, failed entry events were quite rare occurrences in general (0.01–0.3%) (4). Briel *et al.*, in a randomized control study, demonstrated a reduction in rate of failed entry by avoidance of abdominal wall lifting during closed entry (5). Despite no major differences between the techniques, the rates of serious complications are low making it difficult for the available trials to show a difference. Based on the current evidence, it is best for a surgeon to use the technique that they are most comfortable utilizing.

Our general approach is that of closed Veress technique at Palmer's point—2 cm below the subcostal margin in the left midclavicular line. The peritoneal attachment to the rib prevents laxity in this area, regardless of body habitus. Therefore, the depth of Veress insertion should be identical to the abdominal wall thickness. While it is essentially mandatory when there is concern for adhesions to the midline, it is a safe technique under almost all scenarios. We feel that this point of access is ideal for laparoscopic colectomy. By placing the Veress initially at Palmer's point, it allows for insufflation of the abdomen and subsequent optimal port placement. We prefer our camera port to be placed at the midpoint between the xyphoid and pubis after insufflation. Another population that benefits from Palmer's point entry is the obese patient. The presence of a pannus can distort the position of the umbilicus and a periumbilical point of entry could potentially be below the pubic bone. This technique should also be considered in multiparous women whose peritoneum is lax.

While the characteristic "clicks" associated with the different abdominal wall layers is critical for safe placement of the Veress needle, we advocate for the use of both visual and tactile cues when using a closed abdominal entry technique. This combination is important for avoiding vascular and hollow viscus injury. Prior to attempting entry, the abdominal wall thickness of the patient should be estimated either by review of cross-sectional imaging or by physical exam. As mentioned before, if the Veress needle is placed at Palmer's point, the depth of entry should be equivalent to the abdominal wall thickness in that area.

If an injury is suspected, either with return of blood and/or bowel contents; the trocar and/or Veress should not be removed. This will allow for inspection of the trajectory of the injury and allow for possible repair. Upon access to the abdomen from another entry, or exploratory laparotomy depending on surgeon's comfort level, the trajectory of the injury should be assessed and repaired if necessary.

Bowel injury

Inadvertent bowel injury during laparoscopic entry is relatively uncommon (0–7%) in the literature (5-15). However, the rates of bowel injury with manipulation during the course of a complicated case may be much higher. In fact, it has been reported in up to 18% of laparoscopic adhesiolysis cases for bowel obstruction (16). While these injuries are sometimes unavoidable, the key to avoiding complication with bowel injury is to be vigilant and recognize injury early. We prefer to repair these injuries laparoscopically with intracorporeal suturing. Most small injuries (<50% diameter with intact mesentery) can be repaired primarily. Larger injuries or significant injury to the mesentery may require resection and anastomosis. If intracorporeal suture and/or anastomosis is not feasible or is not within the abilities of the operating surgeon, bowel repair can take place at the time of specimen extraction.

Vascular injury

Major vascular injury during laparoscopic surgery is a rare complication but the associated mortality can be as high as 17% (17). These injuries classically involve the aorta, iliac vessels and/or inferior vena cava (18). Trocar or Veress needle placement is the most common cause of vascular injury (19).

While the initial instinct after vascular injury is to convert to an open operation, it may not be the best course of action. The estimated blood loss with conversion after laparoscopic major vascular injury has been reported as high as 3.4 liters (20), which, can be fatal and is associated with high morbidity. However, a review of case reports regarding laparoscopic repair of major vessel injury estimates the loss to be much lower, around 550 mL (21). If applied correctly, many of the same principles of open surgery can be safely applied laparoscopically in skilled hands.

We recommend a stepwise and controlled approach to vascular injury during laparoscopic surgery that starts with immediate recognition of the injury and rapid control

via direct pressure. The key to any vascular injury is immediate control, which can easily be achieved via direct pressure. This is often aided by the introduction of a Ray-Tec into the abdomen to assist with direct pressure. If necessary, additional ports can be placed to help facilitate recognition and immediate control. At this point, if the surgeon is comfortable with laparoscopic technique, further mobilization should be performed to allow for adequate reassessment of the injury and repair. If the surgeon does not feel comfortable with laparoscopic repair, pressure should be maintained, while anesthesia and the surgical team prepare for open laparotomy. The insufflation should be slowly released while maintaining pressure through the trocar. At this point, a laparotomy incision can be made, and open repair can proceed. Again, we emphasize that it is important to maintain direct pressure and control during conversion to avoid massive blood loss. Repair of vascular injury can be done in a controlled fashion with minimal blood loss as the critical step, vascular control, has already been achieved (21).

Dealing with inadequate bowel length

The major issue with reach during laparoscopic colectomy is secondary to inadequate mobilization and/or limitations of reach of the middle colic vessels (22). We advocate a total laparoscopic approach for both left and right colectomy. An intracorporeal approach for right colectomy allows for minimal need for dissection. Performing an anastomosis via direct laparoscopic vision in a left colectomy allows for the ability to ascertain any tension and immediate correction.

If there is inadequate length for an extracorporeal anastomosis after a right-sided resection, a larger or higher location incision may be needed. The most prudent decision may be to consider doing the anastomosis intracorporeally to avoid additional dissection and potential devascularization of the anastomosis. However, if this is not feasible, there are techniques for gaining additional length. During resection of the right colon, it is critical to mobilize the colon off the retroperitoneum, mobilize the hepatic flexure and take down the attachments between right iliac fossa/pelvic sidewall and the terminal ileum. In cancer operations, this mobilization is further facilitated by the high ligation of the ileocolic artery and ligation of the right branch of the middle colic. Further length can also be gained by mobilization of the transverse colon, this can be achieved by separating the distal transverse colon from the omentum (22). The colon mesentery should be mobilized to the middle colics if intact. If the middle colics were divided, then the splenic flexure may need to be mobilized. It should be mentioned that for extracorporeal anastomosis, the surgeon should assess the reach of the colon before choosing the location of the incision. The small bowel and its mesentery should also be dissected and fully mobile.

The location that the blood supply to the colon is ligated can also help facilitate a tension free anastomosis. For cancer operations, the inferior mesenteric artery will have already been taken as part of a complete oncologic resection. However, it can also be ligated at a high level for benign disease to gain additional length. High ligation of the inferior mesenteric vein and scoring the mesentery anteriorly can also gain some needed reach (23). In fact, we encourage anatomical medial to lateral dissection for both benign and malignant pathology.

If all of the above maneuvers have been exhausted and it is still not possible to create a tension-free anastomosis, you are left with essentially three options: completion total colectomy with ileorectal anastomosis, bringing the colon transmesenteric through an avascular window in the ileal mesentery (24), and the Deloyers Procedure.

The Deloyers Procedure is a salvage technique for colorectal or coloanal anastomosis after an extended left colectomy in which a well-vascularized anastomosis cannot be achieved. It involves complete mobilization of the right colon (including division of the right and middle colic arteries and mesentery) and rotation around the preserved ileocolic artery with direct anastomosis between the right colon and the rectum. First described in 1964 by its namesake (25), there have been successful open and laparoscopic case series regarding its use (26,27).

Preoperative considerations

Prophylactic ureteral stenting

Iatrogenic ureteral injury is an infrequent (0.24% to 1.95%) complication in colon resection, but it has been independently associated with longer length of stay, increased costs and increased morbidity (28). Unfortunately, there are no randomized controlled trials addressing the topic and the retrospective data has been conflicting.

Opponents of prophylactic ureteral stents argue that the low incidence of iatrogenic ureteral injury is insufficient to justify the potential complications of placement and the increased cost. This is compounded by the inconsistency in preventing iatrogenic injury (29-33). However, proponents

argue that without stents only 1 in 3 injuries are noted at the index operation and that immediate repair results in improved outcomes (34). So, even if iatrogenic injuries aren't prevented, intraoperative recognition is improved.

This question was again examined more recently using the NSQIP colectomy-targeted dataset and on multivariate analysis the use of prophylactic ureteral stents was associated with lower rate of ureteral injury (35). Based on the culmination of evidence, there is likely a subset of patients that could benefit from prophylactic ureteral stent placement. However, which patients benefit from this intervention has yet to be elucidated.

Bowel preparation

Fecal and bacterial contamination of the colon during colorectal resection has been an area of concern long prior to the introduction of laparoscopy. As such, the routine use of mechanical bowel preparation (MBP) and oral antibiotics has been part of the narrative for colorectal resection since the introduction of a standard preparation by Nichols and Condon in 1971 (36). However, the support of this practice has not always been steadfast.

In the late 1990s and early 2000s, the benefit of MBP came under scrutiny after several studies failed to show protection against post-operative sepsis and even inferred that it might be harmful (37-40). This led some authors to advocate for its complete abandonment (41), and, in fact, the routine use of MBP was discouraged in the 2013 enhanced recovery after surgery (ERAS) recommendations (42). And while the data was convincing regarding the use of MBP alone, subsequent studies looking at both MBP and oral antibiotics would again change the paradigm.

A retrospective review of these patients showed that MBP with oral antibiotics was associated with lower surgical site infections, fewer anastomotic leaks, and a lower incidence of ileus (43). This would later be confirmed with prospective trials, and a meta-analysis looking at 7 RCTs determined that the use of oral antibiotics with MBP reduced infectious complications (44). As such, the most recent ERAS recommendations call for MBP with oral antibiotics before colorectal surgery (45).

Enhanced recovery after surgery (ERAS)

The concept of ERAS, or enhanced recovery protocols (ERP), has been described since 2000 and broadly refers to a multidisciplinary and evidence-based approach to recovery after surgery (46), and this concept was applied to colon and rectal surgery soon after (42,47). The enthusiasm for its continued use in colorectal surgery has been supported by a Cochrane review showing reduced overall complications and length of stay when compared with conventional perioperative management (48). The current iteration regarding colorectal surgery is a collaboration between the American Society of Colon and Rectal Surgeons (ASCRS) and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and was published in 2017 (45).

The ERAS Clinical Practice Guidelines cover a broad array of topics for the preoperative, perioperative and post-operative periods based on available evidence in the literature. At our institution we follow a strict ERAS protocol including early mobilization, a regular diet on post-operative day 0, minimization of intravenous fluids and no narcotics in the post-operative period. This is made possible by careful preoperative discussion with patients about expectations, milestones and discharge criteria—another recommendation of the ERAS guidelines (45).

Emergent laparoscopic surgery

While two-thirds of elective colon resections are now being done laparoscopically (2), a recent look at the NSQIP database showed utilization for emergent indications is limited to around 11% of cases (49). This likely speaks to its difficulty, even for experienced surgeons, secondary to a myriad of factors including: access difficulty, the frequent requirement for extensive adhesiolysis, loss of abdominal domain and abdominal contamination. However, when feasible, laparoscopic surgery seems to have better short-term outcomes than open operations when used emergently (50).

The key to successfully emergent laparoscopic surgery relies primarily on sufficient surgeon experience with laparoscopy and appropriate patient selection. While extensive adhesions, recent laparotomy, bleeding disorders and obesity could all prevent safe laparoscopy, the only absolute contraindications are inability to safely access the abdomen, inadequate visualization and inability to tolerate pneumoperitoneum (51). However, low pressure laparoscopy, such as with AirSeal, may mitigate some of the potential negative effects of pneumoperitoneum. Currently, it is being utilized for obstructing colon cancers, iatrogenic perforations, inflammatory bowel disease and acute diverticulitis (52,53).

Obstructing colon cancer remains a controversial indication, and acute colonic obstruction is still considered by many to be a contraindication to a laparoscopic approach. Data regarding right-sided colon cancers is promising regarding short-term outcomes (54). However, it is still limited to retrospective experiences and data regarding long-term oncologic outcomes is absent. While the use of laparoscopy in left-sided cancers is more widely published, there is still no consensus on its utility (50,55). Regardless, based on the promising early results of the Colorectal Stent Trial (CreST) and the ESCO Trial, stenting as a bridge to elective laparoscopy may become the preferred technique for obstructing colon cancers (56,57).

Perhaps the largest ongoing debate, however, belongs to the management of acute complicated diverticulitis. The ASCRS continues to recommend laparoscopic resection for elective treatment of sigmoid diverticulitis (58), but its use in purulent/feculent peritonitis is less clear. Despite three randomized controlled trials looking at the use of laparoscopic peritoneal lavage, inconsistent results between the trials has prevented its widespread adoption or abandonment (59-61). As such, the ASCRS Clinical Practice Guidelines state that "*operative therapy without resection is generally not an appropriate alternative to colectomy* (58)." And the most recent Cochrane review looking at open *vs.* laparoscopic colectomy in acute sigmoid diverticulitis was inconclusive (62).

Ideally, perforations during diagnostic or therapeutic colonoscopy should be recognized at the time of colonoscopy and treated endoscopically. However, delayed diagnosis or inability to address the injury endoscopically mandates surgical intervention. Though evidence regarding the use of laparoscopy in iatrogenic perforation is limited to small case series, most agree that it is a scenario naturally suited to laparoscopy (63,64). Direct colporrhaphy, segmental resection and bowel diversion are feasible laparoscopically and most injuries are discovered early—limiting bowel edema/dilation, loss of abdominal domain and hostile resection planes.

The routine use of laparoscopy is well accepted for inflammatory bowel disease in the elective setting (65), but data is again limited for emergency cases. Some have shown similar outcomes to open surgery (66), but only one retrospective case series actually showed decreased complications with a laparoscopic approach (67). Despite limited evidence, no studies to date have shown laparoscopy to be inferior.

Regardless of the indication, the decision to approach an emergent case laparoscopically needs to be tailored to the experience of the surgeon and the individual patient. But, avoiding a laparotomy has many advantages including smaller incisions, less pain, reduction in wound complications, reduction in hernias and potentially faster recovery (51).

Regardless of the indication, every emergent case should start with a safe entry technique, typically in the left upper quadrant though the right upper quadrant can be used if the left side isn't advisable. Careful attention must be paid to avoiding injury to the liver if the right subcostal area is chosen. While there are no well-designed studies that show a reduction in injuries with direct optical trocars, they may be advantageous if abdominal entry is expected to be especially difficult (51).

The next major obstacle after abdominal entry is adequate visualization. Patient positioning and the use of gravity is critical to successful visualization. In addition, the omentum is frequently adherent to the area of surgical interest and will need be mobilized and placed caudally above the transverse colon. It will also help to have sponges available and some form of laparoscopic irrigator to keep the field of view as clean as possible. The specific approach, port placement and final steps depend on the indication.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Annals of Laparoscopic and Endoscopic Surgery* for the series "Laparoscopic Colon Surgery". The article has undergone external peer review.

Conflicts of Interest: The series "Laparoscopic Colon Surgery" was commissioned by the editorial office without any funding or sponsorship. Dr. MD Jafari served as the unpaid Guest Editor of the series. Dr. MD Jafari is supported by educational grants from Ethicon, Medtronic and Intuitive. PT Delaplain has no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Jacobs M, Verdeja JC, Goldstein HS. Minimally invasive colon resection (laparoscopic colectomy). Surg Laparosc Endosc 1991;1:144-50.
2. Moghadamyeghaneh Z, Carmichael JC, Mills S, et al. Variations in Laparoscopic Colectomy Utilization in the United States. Dis Colon Rectum 2015;58:950-6.
3. Harrell AG, Heniford BT. Minimally invasive abdominal surgery: lux et veritas past, present, and future. Am J Surg 2005;190:239-43.
4. Ahmad G, Gent D, Henderson D, et al. Laparoscopic entry techniques. Cochrane Database Syst Rev 2015;8:CD006583.
5. Briel JW, Plaisier PW, Meijer WS, et al. Is it necessary to lift the abdominal wall when preparing a pneumoperitoneum? A randomized study. Surg Endosc 2000;14:862-4.
6. Agresta F, De Simone P, Ciardo LF, et al. Direct trocar insertion vs Veress needle in nonobese patients undergoing laparoscopic procedures: a randomized prospective single-center study. Surg Endosc 2004;18:1778-81.
7. Angioli R, Terranova C, De Cicco Nardone C, et al. A comparison of three different entry techniques in gynecological laparoscopic surgery: a randomized prospective trial. Eur J Obstet Gynecol Reprod Biol 2013;171:339-42.
8. Bhoyrul S, Payne J, Steffes B, et al. A randomized prospective study of radially expanding trocars in laparoscopic surgery. J Gastrointest Surg 2000;4:392-7.
9. Cogliandolo A, Manganaro T, Saitta FP, et al. Blind versus open approach to laparoscopic cholecystectomy: a randomized study. Surg Laparosc Endosc 1998;8:353-5.
10. Feste JR, Bojahr B, Turner DJ. Randomized trial comparing a radially expandable needle system with cutting trocars. JSLS 2000;4:11-5.
11. Ostrzenski A. Randomized, prospective, single-blind trial of a new parallel technique of Veress pneumoperitoneum needle insertion versus the conventional closed method. Fertil Steril 1999;71:578-81.
12. Tinelli A, Malvasi A, Guido M, et al. Laparoscopy entry in patients with previous abdominal and pelvic surgery. Surg Innov 2011;18:201-5.
13. Tinelli A, Malvasi A, Istre O, et al. Abdominal access in gynaecological laparoscopy: a comparison between direct optical and blind closed access by Verres needle. Eur J Obstet Gynecol Reprod Biol 2010;148:191-4.
14. Tinelli A, Malvasi A, Mynbaev OA, et al. Bladeless direct optical trocar insertion in laparoscopic procedures on the obese patient. JSLS 2013;17:521-8.
15. Venkatesh R, Sundaram CP, Figenshau RS, et al. Prospective randomized comparison of cutting and dilating disposable trocars for access during laparoscopic renal surgery. JSLS 2007;11:198-203.
16. Behman R, Nathens AB, Byrne JP, et al. Laparoscopic Surgery for Adhesive Small Bowel Obstruction Is Associated With a Higher Risk of Bowel Injury: A Population-based Analysis of 8584 Patients. Ann Surg 2017;266:489-98.
17. Roviaro GC, Varoli F, Saguatti L, et al. Major vascular injuries in laparoscopic surgery. Surg Endosc 2002;16:1192-6.
18. Nordestgaard AG, Bodily KC, Osborne RW, Jr., et al. Major vascular injuries during laparoscopic procedures. Am J Surg 1995;169:543-5.
19. Sandadi S, Johannigman JA, Wong VL, et al. Recognition and management of major vessel injury during laparoscopy. J Minim Invasive Gynecol 2010;17:692-702.
20. Barbosa Barros M, Lozano FS, Queral L. Vascular injuries during gynecological laparoscopy--the vascular surgeon's advice. Sao Paulo Med J 2005;123:38-41.
21. Jafari MD, Pigazzi A. Techniques for laparoscopic repair of major intraoperative vascular injury: case reports and review of literature. Surg Endosc 2013;27:3021-7.
22. Johnson EK. Overcoming Technical Challenges: The Abdomen. In: Ross H, Lee S, Mutch M, et al. Editors. Minimally Invasive Approaches to Colon and Rectal Disease. New York, NY: Springer, 2015;201-11.
23. Kim CB, Bardakcioglu O. Sigmoid Colectomy and Left Hemicolectomy: Laparoscopic Approach. In: Bardakcioglu O. Editors. Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery. Boston, MA: Springer, 2015;109-17.
24. Rombeau JL, Collins JP, Turnbull RB, Jr. Left-sided colectomy with retroileal colorectal anastomosis. Arch Surg 1978;113:1004-5.

25. Deloyers L. Suspension of the Right Colon Permits without Exception Preservation of the Anal Sphincter after Extensive Colectomy of the Transverse and Left Colon (Including Rectum). Technic -Indications- Immediate and Late Results. Lyon Chir 1964;60:404-13.
26. Manceau G, Karoui M, Breton S, et al. Right colon to rectal anastomosis (Deloyers procedure) as a salvage technique for low colorectal or coloanal anastomosis: postoperative and long-term outcomes. Dis Colon Rectum 2012;55:363-8.
27. Sciuto A, Grifasi C, Pirozzi F, et al. Laparoscopic Deloyers procedure for tension-free anastomosis after extended left colectomy: technique and results. Tech Coloproctol 2016;20:865-9.
28. Halabi WJ, Jafari MD, Nguyen VQ, et al. Ureteral injuries in colorectal surgery: an analysis of trends, outcomes, and risk factors over a 10-year period in the United States. Dis Colon Rectum 2014;57:179-86.
29. Bothwell WN, Bleicher RJ, Dent TL. Prophylactic ureteral catheterization in colon surgery. A five-year review. Dis Colon Rectum 1994;37:330-4.
30. Kyzer S, Gordon PH. The prophylactic use of ureteral catheters during colorectal operations. Am Surg 1994;60:212-6.
31. Leff EI, Groff W, Rubin RJ, et al. Use of ureteral catheters in colonic and rectal surgery. Dis Colon Rectum 1982;25:457-60.
32. Nam YS, Wexner SD. Clinical value of prophylactic ureteral stent indwelling during laparoscopic colorectal surgery. J Korean Med Sci 2002;17:633-5.
33. Fry DE, Milholen L, Harbrecht PJ. Iatrogenic ureteral injury. Options in management. Arch Surg 1983;118:454-7.
34. Selzman AA, Spirnak JP. Iatrogenic ureteral injuries: a 20-year experience in treating 165 injuries. J Urol 1996;155:878-81.
35. Coakley KM, Kasten KR, Sims SM, et al. Prophylactic Ureteral Catheters for Colectomy: A National Surgical Quality Improvement Program-Based Analysis. Dis Colon Rectum 2018;61:84-8.
36. Nichols RL, Condon RE. Preoperative preparation of the colon. Surg Gynecol Obstet 1971;132:323-37.
37. Bucher P, Mermillod B, Gervaz P, et al. Mechanical bowel preparation for elective colorectal surgery: a meta-analysis. Arch Surg 2004;139:1359-64; discussion 65.
38. Bucher P, Gervaz P, Soravia C, et al. Randomized clinical trial of mechanical bowel preparation versus no preparation before elective left-sided colorectal surgery. Br J Surg 2005;92:409-14.
39. Santos JC Jr, Batista J, Sirimarco MT, et al. Prospective randomized trial of mechanical bowel preparation in patients undergoing elective colorectal surgery. Br J Surg 1994;81:1673-6.
40. Fa-Si-Oen P, Roumen R, Buitenweg J, et al. Mechanical bowel preparation or not? Outcome of a multicenter, randomized trial in elective open colon surgery. Dis Colon Rectum 2005;48:1509-16.
41. Slim K, Vicaut E, Launay-Savary MV, et al. Updated systematic review and meta-analysis of randomized clinical trials on the role of mechanical bowel preparation before colorectal surgery. Ann Surg 2009;249:203-9.
42. Gustafsson UO, Scott MJ, Schwenk W, et al. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS((R))) Society recommendations. World J Surg 2013;37:259-84.
43. Kiran RP, Murray AC, Chiuzan C, et al. Combined preoperative mechanical bowel preparation with oral antibiotics significantly reduces surgical site infection, anastomotic leak, and ileus after colorectal surgery. Ann Surg 2015;262:416-25; discussion 23-5.
44. Chen M, Song X, Chen LZ, et al. Comparing Mechanical Bowel Preparation With Both Oral and Systemic Antibiotics Versus Mechanical Bowel Preparation and Systemic Antibiotics Alone for the Prevention of Surgical Site Infection After Elective Colorectal Surgery: A Meta-Analysis of Randomized Controlled Clinical Trials. Dis Colon Rectum 2016;59:70-8.
45. Carmichael JC, Keller DS, Baldini G, et al. Clinical Practice Guidelines for Enhanced Recovery After Colon and Rectal Surgery From the American Society of Colon and Rectal Surgeons and Society of American Gastrointestinal and Endoscopic Surgeons. Dis Colon Rectum 2017;60:761-84.
46. Ljungqvist O, Scott M, Fearon KC. Enhanced Recovery After Surgery: A Review. JAMA Surg 2017;152:292-8.
47. Nygren J, Thacker J, Carli F, et al. Guidelines for perioperative care in elective rectal/pelvic surgery: Enhanced Recovery After Surgery (ERAS(R)) Society recommendations. Clin Nutr 2012;31:801-16.
48. Spanjersberg WR, Reurings J, Keus F, et al. Fast track surgery versus conventional recovery strategies for colorectal surgery. Cochrane Database Syst Rev 2011:CD007635.
49. Davis CH, Shirkey BA, Moore LW, et al. Trends in laparoscopic colorectal surgery over time from 2005-2014 using the NSQIP database. J Surg Res 2018;223:16-21.

50. Harji DP, Griffiths B, Burke D, et al. Systematic review of emergency laparoscopic colorectal resection. Br J Surg 2014;101:e126-33.
51. Pedraza R, Haas EM. Emergent Laparoscopic Colorectal Surgery. In: Ross H, Lee S, Mutch M, et al. Editors. Minimally Invasive Approaches to Colon and Rectal Disease. New York, NY: Springer, 2015;303-8.
52. Agresta F, Arezzo A, Allaix ME, et al. Current status of laparoscopic colorectal surgery in the emergency setting. Updates Surg 2016;68:47-52.
53. Mandrioli M, Inaba K, Piccinini A, et al. Advances in laparoscopy for acute care surgery and trauma. World J Gastroenterol 2016;22:668-80.
54. Arezzo A, Passera R, Ferri V, et al. Laparoscopic right colectomy reduces short-term mortality and morbidity. Results of a systematic review and meta-analysis. Int J Colorectal Dis 2015;30:1457-72.
55. Frago R, Ramirez E, Millan M, et al. Current management of acute malignant large bowel obstruction: a systematic review. Am J Surg 2014;207:127-38.
56. Hill J, Kay C, Morton D, et al. CREST: Randomised phase III study of stenting as a bridge to surgery in obstructing colorectal cancer—Results of the UK ColoRectal Endoscopic Stenting Trial (CREST). J Clin Oncol 2016;34:3507.
57. Arezzo A, Balague C, Targarona E, et al. Colonic stenting as a bridge to surgery versus emergency surgery for malignant colonic obstruction: results of a multicentre randomised controlled trial (ESCO trial). Surg Endosc 2017;31:3297-305.
58. Feingold D, Steele SR, Lee S, et al. Practice parameters for the treatment of sigmoid diverticulitis. Dis Colon Rectum 2014;57:284-94.
59. Kohl A, Rosenberg J, Bock D, et al. Two-year results of the randomized clinical trial DILALA comparing laparoscopic lavage with resection as treatment for perforated diverticulitis. Br J Surg 2018;105:1128-34.
60. Schultz JK, Wallon C, Blecic L, et al. One-year results of the SCANDIV randomized clinical trial of laparoscopic lavage versus primary resection for acute perforated diverticulitis. Br J Surg 2017;104:1382-92.
61. Vennix S, Musters GD, Mulder IM, et al. Laparoscopic peritoneal lavage or sigmoidectomy for perforated diverticulitis with purulent peritonitis: a multicentre, parallel-group, randomised, open-label trial. Lancet 2015;386:1269-77.
62. Abraha I, Binda GA, Montedori A, et al. Laparoscopic versus open resection for sigmoid diverticulitis. Cochrane Database Syst Rev 2017;11:CD009277.
63. Agresta F, Michelet I, Mainente P, et al. Laparoscopic management of colonoscopic perforations. Surg Endosc 2000;14:592-3.
64. Bleier JI, Moon V, Feingold D, et al. Initial repair of iatrogenic colon perforation using laparoscopic methods. Surg Endosc 2008;22:646-9.
65. Wu XJ, He XS, Zhou XY, et al. The role of laparoscopic surgery for ulcerative colitis: systematic review with meta-analysis. Int J Colorectal Dis 2010;25:949-57.
66. Marcello PW, Milsom JW, Wong SK, et al. Laparoscopic total colectomy for acute colitis: a case-control study. Dis Colon Rectum 2001;44:1441-5.
67. Seshadri PA, Poulin EC, Schlachta CM, et al. Does a laparoscopic approach to total abdominal colectomy and proctocolectomy offer advantages? Surg Endosc 2001;15:837-42.

doi: 10.21037/ales.2019.01.02
Cite this article as: Delaplain PT, Jafari MD. Successful application of laparoscopic techniques in colorectal surgery and its indications. Ann Laparosc Endosc Surg 2019;4:6.

