Right Hemicolectomy and Ileocecectomy: Laparoscopic Approach

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Joseph C. Carmichael and Michael J. Stamos

Introduction

In this chapter, we will review the laparoscopic technique to perform a right hemicolectomy and ileocecectomy. There are many variations to this technique, and we will simplify the operation by dividing it into seven basic steps. A laparoscopic medial to lateral approach will be utilized to illustrate the seven steps of a right hemicolectomy. Alternatives to the medial to lateral approach including inferior to superior approach and lateral to medial approach will also be reviewed. Hand-assisted laparoscopy, single-port laparoscopy, and robotic surgery will be covered here but will be reviewed in more detail in other chapters of this book. In closing, a few difficult scenarios and complications will be discussed, and tips and tricks for dealing with them will be reviewed.

Background

The first published report of a laparoscopic right hemicolectomy for cancer occurred in 1991 [1]. Since that time, laparoscopic surgery has been demonstrated to offer several specific advantages for patients in randomized controlled clinical trials including less blood loss, shorter hospital stay, less postoperative pain, a lower incidence of perioperative morbidity, and earlier return of bowel function [2, 3].

Despite the documented advantages, the adoption of laparoscopic techniques in colorectal surgery has progressed much more slowly than in other areas of surgery. In fact, a review of 121,910 colorectal resections performed in American hospitals in 2009 revealed that only 35.41 % of procedures were completed laparoscopically [4]. In comparison, the utilization of laparoscopic techniques in bariatric surgery became widespread in a much shorter period of time. In 1998, 2.1 % of all bariatric surgeries were performed laparoscopically. By 2002, the utilization rate was documented at 17.9 % [5]. In 2004, 76 % of all gastric bypass procedures were performed laparoscopically [6].

The reasons for failure to adopt laparoscopic techniques in colon and rectal surgery are multifactorial. In a Canadian review of laparoscopic colorectal surgery, only half of surgeons even attempted laparoscopy. The surgeons cited lack of adequate operating time and formal training as the main reasons why they did not offer laparoscopic approaches to their patients [7]. It has also been demonstrated that the learning curve to acquire laparoscopic colectomy skills is significant [8]. In a review of 4,852 cases performed by surgeons who possessed advanced open colorectal surgery skills but were self-taught laparoscopic colorectal surgeons (no history of structured training in laparoscopic colectomy), the learning curve was estimated to be between 87 and 152 cases [8].

Laparoscopic right hemicolectomy seems to play an important role in surgeons gaining a foothold in the acquisition of complex laparoscopic colectomy skills, as it appears to be less technically challenging than left colectomy or proctectomy. In a review of 900 patients undergoing laparoscopic colectomy, the rate of conversion to open surgery in patients undergoing laparoscopic right colectomy was 8.1 % versus 15.3 % in patients undergoing laparoscopic left colectomy [9]. Left colectomy was an independent predictor of conversion to open surgery. The learning curve was estimated to be 55 cases for laparoscopic right hemicolectomy versus 62 for left-sided resections. In the setting of a structured, colorectal surgery residency (fellowship), the learning curve is estimated to be much shorter [10]. Performing more than 10 laparoscopic right colectomies and more than 30 laparoscopic left colectomies provided the vast majority of fellows with the ability to be very comfortable performing them in their practice [10]. The simpler nature of laparoscopic

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J.C. Carmichael, MD (✉) • M.J. Stamos, MD
Department of Surgery,
University of California, Irvine, Orange, CA, USA
e-mail: jcarmich@uci.edu; mstamos@uci.edu

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right hemicolectomy may also explain why from 2007 to 2009 surgeons performed 34.1 % of right colectomies laparoscopically versus fewer than 10 % of rectal resections laparoscopically [11].

Laparoscopic colectomy offers many benefits to our patients, but the procedures are technically challenging and the learning curve is steep. Evidence would suggest that laparoscopic right hemicolectomy skills are easier to acquire early in one's learning curve and could be an excellent place to begin moving forward in developing one's laparoscopic colectomy skill set.

Room Setup and Positioning

The controversy on how best to accomplish a laparoscopic right hemicolectomy begins as soon as the patient enters the operating room. Some authors advocate the lithotomy position because the operative surgeon may stand between the legs during division of the mesentery and mobilization of the ascending colon (Box 5.1). The lithotomy positioning also allows for intraoperative colonoscopy and possible EEA stapling in the event that pathology not identified preoperatively, such as ileocolonic fistula, is identified. Alternatively, the patient is placed in the supine position with the left arm tucked at the side so that surgeon and assistant may both comfortably stand on the patient's left side. The supine position is simpler for the operating room staff and does not seem to inhibit the conduct of the operation. The risk of peroneal nerve injury associated with the lithotomy positioning is also avoided.

Box 5.1. Tip
Use lithotomy positioning if there is a possible need to verify target lesion via colonoscopy and potential of using a transanal EEA stapler.

A single laparoscopic display monitor is all that is necessary and should be placed on the patient's right side. In older laparoscopic towers, the monitor sat on top and surgeons become used to constantly looking up during surgery. With modern flat-screen boom-mounted laparoscopic displays, this practice should be abandoned and the monitor should be placed directly opposite the surgeon at eye level. The monitor should be repositioned during the case to always directly face the surgeon and remain perfectly perpendicular to the surgeon's line of site.

In the ideal situation, insufflation tubing, bovie cautery wires, energy device wires, and laparoscopic camera wires should all be passed off the table over the patient's right shoulder. Long sterile, disposable instrument pockets should be taped to the right and left side for the various laparoscopic instruments. The procedure demands some extreme patient positioning, and the patient should be well fixed to the operating room table. The patient can be placed on soft foam or egg crate that is fixed to the table. This helps to create a "friction hold" between the patient's back and the table when using steep Trendelenburg and should minimize pressure points where nerve injury might occur. Padded straps are placed around the patient's thighs and chest so that there is no sliding with extreme table tilt.

Port Placement and Extraction Sites

Ideally, the laparoscopic ports should be separated by 10–12 cm. Initially, a trocar (5 mm or 12 mm depending on the camera chosen) is placed in the center of the abdomen via Veress needle, Hasson, or optical trocar technique. It should be equidistant from the pubic symphysis and the xiphoid process. Various port placements are possible around a central camera port, which is usually enlarged vertically as the most common extraction site and subsequent extracorporeal anastomosis. The typical four-port technique involves three additional 5 mm "working" ports, which are most commonly placed in the left lower quadrant (LLQ) L1, lower midline (LM) L2, and left upper quadrant (LUQ) L3. The LM port is placed 10–12 cm below the umbilical port. The LLQ port is placed equidistant between the umbilical port and the lower midline port (Box 5.2). Finally, the LUQ quadrant port is placed. To facilitate the passage of an endoscopic stapler or for intracorporeal suturing, the LLQ port can be enlarged to a 12 mm port (see port configuration in Fig. 5.1) (Box 5.3).

Box 5.2. Tip
Visualize the epigastric vessels and place the LLQ port laterally. It should be moved medially to the vessels for morbidly obese patients.

A less invasive technique preferred by one of the authors utilizes an LLQ port L1, an LUQ port L2, and an upper midline (UM) port L4 only (all 5 mm). Extraction and anastomosis can then be accomplished through a far lateral right-sided incision (outside the rectus sheath) for an extracorporeal anastomosis. An off-midline, muscle-splitting incision carries the advantage of a reduced incidence of extraction site hernia. In addition, the extraction and anastomosis may be carried out with less colonic mobilization. An alternative site for extraction is a low transverse Pfannenstiel incision, which also carries a low risk of hernia formation and an improved cosmetic result. However, this approach often requires an intracorporeal anastomosis. Intracorporeal anastomosis can be accomplished by placing a 12 mm port at an LM location to divide the colon and ileum and to perform a stapled

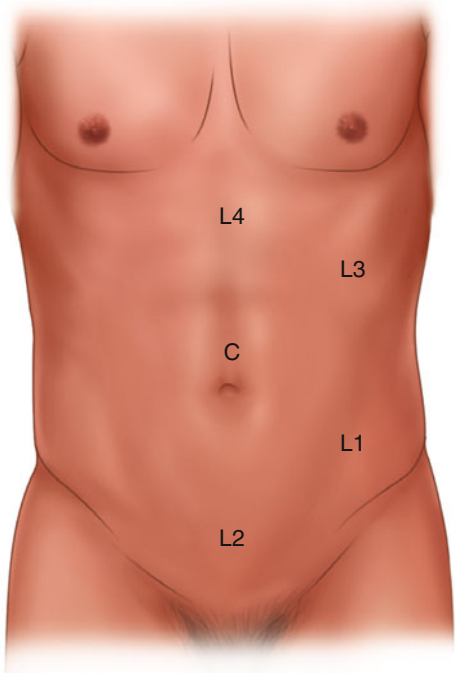

Fig. 5.1 Port configuration. *C* 5 or 12 mm camera port. *L1* 5 mm or 12 mm (for stapler) working port right hand. *L2* 5 mm working port for left hand. *L3* 5 mm assistant port (not utilized for three-port technique). *L4* 5 mm port as alternative to L2

Box 5.3. Tip
The 4-port technique allows optimal exposure, but a 3-port technique is using the L1 and L2 trocars for the surgeon only without an assistant port.

anastomosis, which is then incorporated into the incision for extraction after completion.

Operative Steps (Table 5.1)

Exploratory Laparoscopy

The primary surgeon and assistant both stand on the patients left side: the surgeon toward the feet and the assistant toward the head. The liver and peritoneal cavity are examined for evidence of metastatic disease, a step often facilitated by moderate reverse Trendelenburg position (Box 5.4). The bed is then tilted in a left-side down position, and the small bowel is swept to the left side of the abdomen. The ileum should lie in the pelvis. The greater omentum is lifted over the transverse colon. Some Trendelenburg position may now be necessary to keep the transverse colon out of the operative field. It has been said that "surgery of the right colon is surgery of the duodenum," and the importance of this statement cannot be overstated. It is at this point in the case that the 2nd portion (descending portion) of the duodenum may already be visible through the right colon mesentery (see Fig. 5.2).

Table 5.1 Operative steps and degree of technical difficulty

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy	1
2. Identification and ligation of the ileocolic vessels	3 (medial to lateral) 4 (lateral to medial)
3. Dissection of retroperitoneal plane and identification of the duodenum	3 (medial to lateral) 4 (lateral to medial)
4. Mobilization of the right colon and terminal ileum	2
5. Mobilization of the proximal transverse colon and hepatic flexure	4
6. Identification and ligation of the middle colic vessels	6
7. Extracorporeal anastomosis, closure, and (alternative) reinspection	2
Intracorporeal anastomosis	6

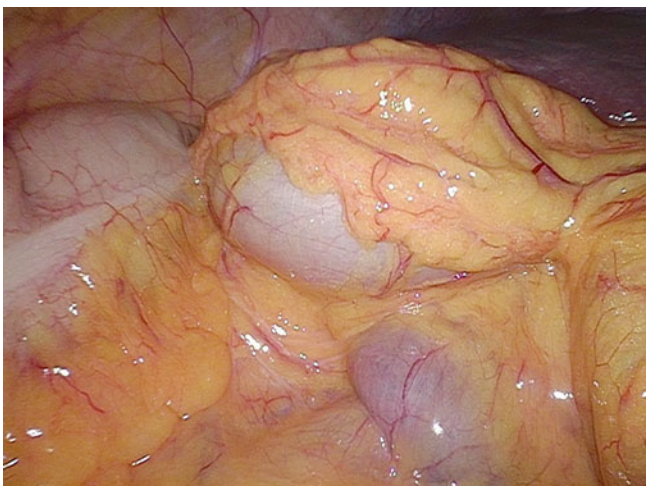

Fig. 5.2 Right colon and duodenum

Box 5.4. Tip
The degree of Trendelenburg versus reversed Trendelenburg positioning depends on the ability to retract the omentum and transverse colon cephalad and the small bowel either cephalad or into the pelvis.

Identification and Ligation of the Ileocolic Vessels

The surgical assistant holds the laparoscope in the left hand and a laparoscopic bowel-grasping instrument in the right hand. The assistant grasps the colonic mesentery medial to the cecum and elevates it toward the right lower quadrant anterior abdominal wall. This will elevate the ileocolic

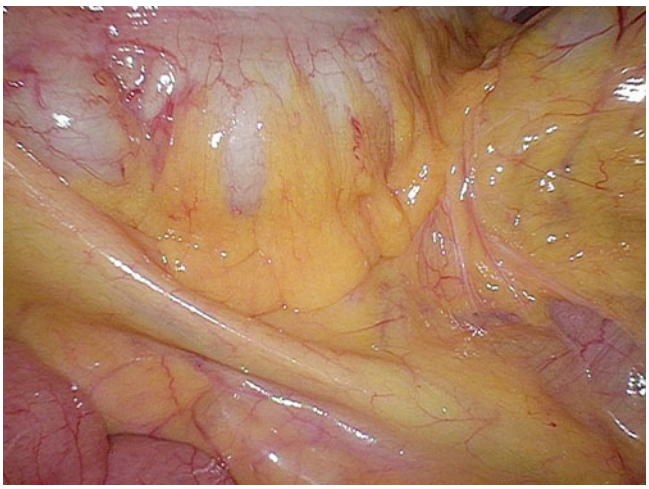

Fig. 5.3 Ileocolic pedicle under tension with cecum elevated

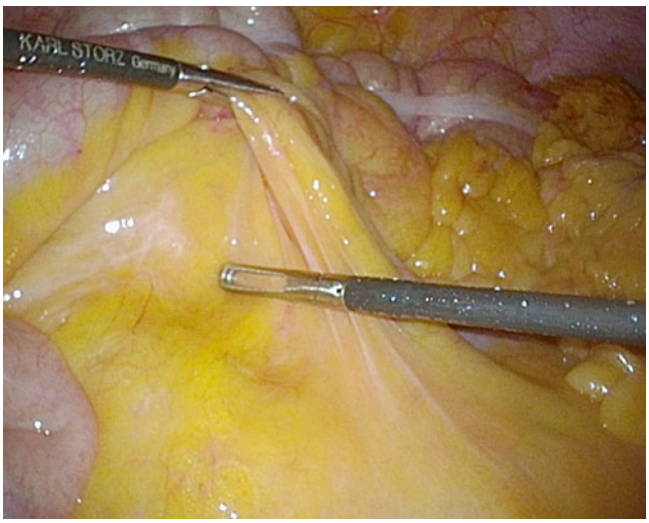

Fig. 5.4 Ileocolic pedicle under tension with mesentery elevated

pedicle and allow its identification. The ileocolic artery and vein arise off the superior mesenteric artery and vein. When the assistant properly elevates the right colon mesentery, the ileocolic pedicle can be easily visualized running in a straight line toward the cecum (see Figs. 5.3 and 5.4 and Box 5.5).

Once the ileocolic pedicle is elevated, the peritoneum along its base is sharply incised or scored with hook cautery (see Video 5.1). The surgeon accomplishes this maneuver by using a laparoscopic grasper in the left hand and a laparoscopic scissors or hook cautery in the right hand. Alternatively, with the three-port technique omitting the assistant's port, the surgeon grasps the cecum or its mesentery to allow traction toward the abdominal wall of the right upper quadrant. The peritoneum can be incised sharply with scissors, and no cautery is necessary if the peritoneum alone is opened. Monopolar hook cautery can also be used to the same effect. The use of bipolar cautery in this area tends to fuse the tissues together rather than allow them to open for the dissection (Box 5.6).

Box 5.5. Caveat
Ensure that the ileocolic pedicle is not mistaken for ileal branches of the small bowel mesentery. Alternatively, the "bare area" of the ascending colon mesentery next to the duodenum can be identified and incised first.

Box 5.6. Tip
Incise the peritoneum proximal enough within the mesentery to avoid injuring the ileal branch of the ileocolic pedicle and use blunt dissection parallel to the pedicle to avoid bleeding.

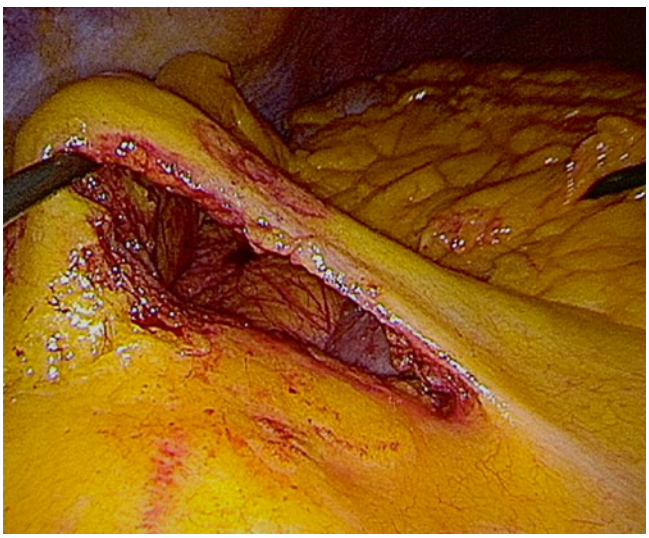

Fig. 5.5 Ileocolic pedicle prior to transection with windows created and duodenum dissected off

Just cephalad to the ileocolic pedicle, the mesenteric window is obvious and can be opened sharply. The peritoneum anterior to the ileocolic vessels is opened. It is generally not necessary to individually isolate the ileocolic artery and vein prior to vascular ligation, but the pedicle should be widely dissected and care should be taken to clearly identify the duodenum prior to ligation (see Fig. 5.5). In case of a lateral to medial approach, this is typically already accomplished.

Vascular ligation may be accomplished with a variety of energy devices such as a 5 mm LigaSure, ENSEAL, or

Box 5.7. Tip
The vessel sealer may be used through whatever port allows a perpendicular seal to avoid bleeding and an endoclip or endoloop should be immediately available for potential bleeding control.

THUNDERBEAT (Box 5.7) (see Video 5.1). While the assistant continues to elevate the cecum and transverse colon, the energy device is typically used in the surgeon's left hand through the LM port L2. Relaxation of the tension before energy application is an essential maneuver to avoid bleeding due to incomplete seal or tissue trauma. A bowel grasper is in the surgeon's right hand through the RLQ port L1 as a safety tool to quickly occlude the previously dissected ileocolic pedicle base in case of bleeding. With proper attention to tissue tension, this should rarely be necessary. Some surgeons prefer to use clips on the proximal side of the pedicle, which then need to be individually dissected and isolated. Alternatively, the laparoscope can be moved to one of the 5 mm ports, and an Endo GIA may be used to divide the pedicle with a vascular staple load through the central 12 mm camera port or utilizing a 12 mm port for any of the working ports (see Video 5.2).

Dissection of the Retroperitoneal Plane and Identification of the Duodenum

Once the peritoneum is opened at the base of the ileocolic vessels, the retroperitoneal tissue is swept down off of the elevated right colon mesentery in a medial to lateral or inferior to superior approach. The entire 2nd and 3rd portions of the duodenum with the adjacent pancreatic head are exposed and no cautery is used around it (Box 5.8). The retroperitoneal plane is developed further laterally and superiorly. The assistant is generally holding a 30° laparoscope, and the lens may need to be turned to face upward during this dissection (Box 5.9). The assistant is also retracting and tenting up the ascending colon by placing a grasper below the ascending colon and mesentery (see Fig. 5.6). This retroperitoneal plane is extended to the right abdominal sidewall and cephalad beneath the hepatic flexure. The dissection is completed once the lateral peritoneum is reached (see Video 5.3). It is not necessary to dissect and identify the right ureter in routine cases if the correct avascular line of dissection is followed. The same plane is dissected in a lateral to medial approach by rolling over the cecum and ascending colon medially instead similar to a more familiar open approach.

Box 5.8. Tip
Look for changes in the fat color to distinguish between retroperitoneal fat and colon mesentery, use blunt dissection in sweeping motions, use the entire dissecting instrument, and use adequate counter traction.

Box 5.9. Caveat
Be very gentle around the duodenum and pancreatic head to avoid bleeding from the trunk of Henle.

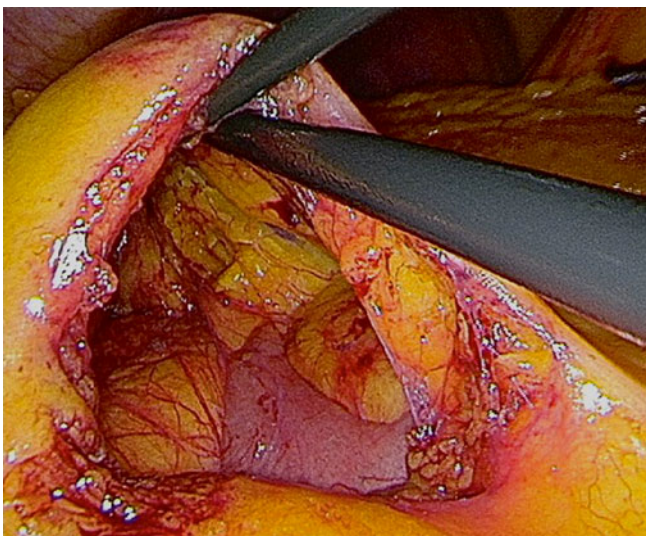

Fig. 5.6 Ascending colon retracted upward and mesentery dissected off retroperitoneum medial approach

Mobilization of the Right Colon and Terminal Ileum

The patient is now placed in a steeper Trendelenburg position, and the ileum that had been resting in the pelvis is elevated to expose the base of the ileal mesentery. In thin patients, the right ureter may be visible through the peritoneum, but does not need to be dissected and visualized if the correct avascular line of dissection is chosen. The assistant will hold the camera and retract the ileum toward the upper abdomen with a laparoscopic grasper. The surgeon uses laparoscopic scissors to sharply incise the peritoneum caudal to the base of the cecum and terminal ileum.

The assistant or surgeon grasps the appendix and cecum and retracts it toward the left upper quadrant. The surgeon divides the lateral attachments of the ascending colon with an energy device (LigaSure, ENSEAL, THUNDERBEAT) or with electrocautery (scissors or hook cautery) in the left

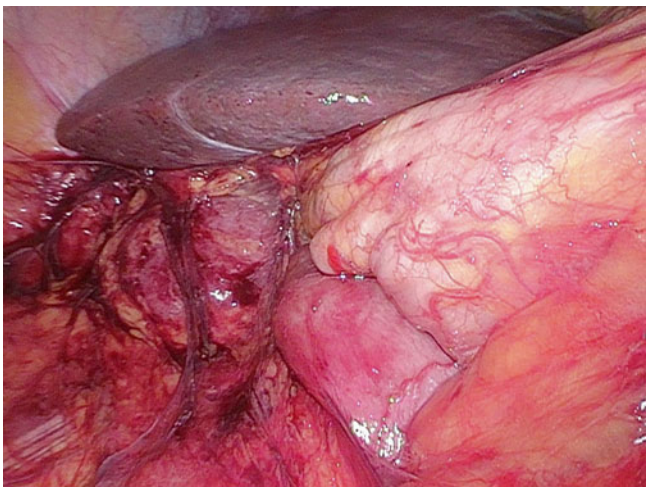

Fig. 5.7 Mobilized colon with visible retroperitoneum and duodenum from lateral approach

hand through the LM port L2. The surgeon's right hand through the LLQ port L1 retracts the cecum and ascending colon by either grasping and pulling it medially and cephalad or pushing it medially close to the line of dissection (see Videos 5.4 and 5.5). Care is taken to stay anterior to Gerota's fascia during this mobilization (see Fig. 5.7). An avoidable mistake in laparoscopic right hemicolectomy is to mobilize posterior to Gerota's fascia toward the liver (Box 5.10). In a medial to lateral approach, the peritoneum is taken down very easily as the plane of dissection is quickly connected to the previous retroperitoneal dissection that was established earlier during the medial approach. To divide the lateral attachments of the distal right colon/hepatic flexure, it may be necessary to place the patient in reverse Trendelenburg position.

The mobilization of the terminal ileum is important for an adequate reach of the ileum for an extracorporeal anastomosis (Box 5.11) (see Video 5.5). Occasionally the ileum may be adhered deep in the pelvis, which may necessitate adequate adhesiolysis. This may be facilitated by steep Trendelenburg positioning and placement of small bowel loops out of the pelvis into the upper abdomen. This allows better visualization of the peritoneal line that needs to be incised between the small bowel mesentery and the retroperitoneum.

Box 5.10. Caveat
Divide the lateral attachments as close as possible to the cecal and ascending colon wall to avoid injury to the ureter/gonadal vessels and to stay in the right plane of dissection

Box 5.11. Tip
Check for adequate mobilization of the ileal mesentery before progressing with the mobilization of the ascending colon.

Mobilization of the Proximal Transverse Colon and Hepatic Flexure

Once the right colon is fully mobilized along the lateral attachments, it is time to mobilize the hepatic flexure. Usually, the surgeon and assistant switch positions at this point with the surgeon now standing to the right of the assistant (both on the patient's left side) (Box 5.12). The surgeon holds a bipolar cautery device through the LUQ port L3 (LigaSure, ENSEAL, THUNDERBEAT) in the right hand and an atraumatic grasper in the left through the LLQ port L1. The assistant holds the camera in the right hand and an atraumatic grasper through the LM port L2 in the left. The transverse colon is retracted caudally, and the proximal duodenum will be seen inferior to the gallbladder fossa. It may be rarely necessary for the assistant to grasp the gallbladder and elevate it to improve visualization of the hepatic flexure. In morbidly obese patients, an additional trocar may be necessary to retract the liver cephalad. If this additional trocar is needed, it can be placed at the intended extraction site to minimize incisions (see Video 5.6).

Box 5.12. Tip
Depending on the planned distal resection margin, the hepatic flexure and proximal transverse colon can be taken down from a lateral approach by continually rolling over cecum and ascending colon medially and cephalad without the need to enter the lesser sac first from a medial point of dissection.

Occasionally not enough counter traction can be achieved by only pulling the transverse colon caudally (Box 5.13). The surgeon then switches instruments, retracting the omentum or gallbladder and liver cephalad with the right hand and utilizing the left hand for dissection and division of the omentum and hepatocolic ligament while the assistant is pulling the transverse colon or hepatic flexure caudally.

Box 5.13. Tip
Always allow enough traction and countertraction between transverse colon and omentum to enter the lesser sac more easily.

The greater omentum and hepatic flexure are divided with an advanced energy device. It is important to be critically aware of the location of the duodenum, transverse colon, and middle colic vessels during this maneuver. In addition, the ascending colon and transverse colon may be tightly tethered together by omentum. Division of the omental attachments between the ascending colon and transverse colon will help with this and the specimen extraction.

Identification and Ligation of the Middle Colic Vessels

In patients with more distal cancers (hepatic flexure/proximal transverse colon), the right branch of the middle colic vessels or entire (high ligation) middle colic trunk may require division (Box 5.14). It is very important that adequate mobilization of the transverse colon be performed prior to any attempt at specimen extraction. The middle colic vessels may be approached in one of two ways depending on the length and thickness of the mesentery. After division of the greater omentum, distracting the transverse colon caudally and anteriorly will identify the middle colic vessels (see Figs. 5.8 and 5.9). At this point, a plane may be developed under the middle colic vessels, and they can be divided from a medial and cephalad approach (see Video 5.7). Alternatively, the middle colic vessels may be exposed from inferiorly. The transverse colon is retracted up toward the liver and tenting the mesentery with two graspers holding the proximal and distal transverse colon (see Fig. 5.10). Upon visual confirmation of the vessels, they can be then isolated and ligated (see Video 5.8).

Box 5.14. Caveat
Be very gentle while mobilizing the proximal mesentery of the proximal transverse colon in the lesser sac to avoid injury and significant bleeding from the pancreaticoduodenal vein.

Extracorporeal Anastomosis, Closure, and Reinspection

After complete mobilization of the colon and ileum, with division of the ileocolic pedicle and middle colic vessels as necessary, the surgeon is ready to perform the ileocolic anastomosis. The more popular extracorporeal anastomotic technique will be reviewed first. A laparoscopic Babcock should be placed on the cecum or appendix to facilitate extraction. The extraction site incision can be made in the midline by extending the supraumbilical camera port cephalad, or if a right upper quadrant port site was chosen, this can be extended laterally and the peritoneum entered

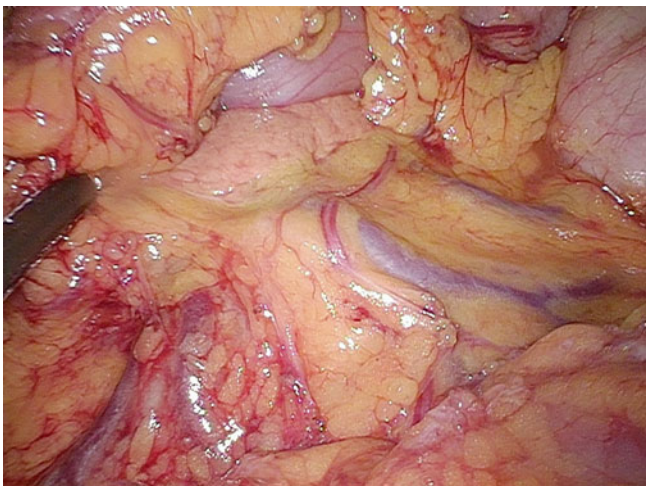

Fig. 5.8 Visualization of middle colic vessels from cephalad approach

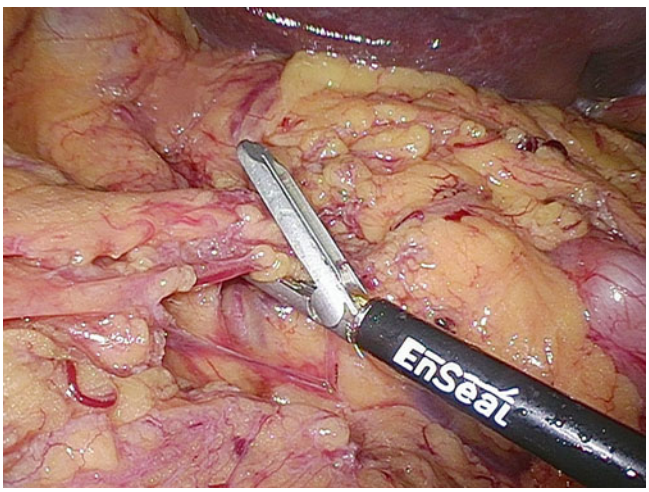

Fig. 5.9 Visualization and division of middle colic vessels from cephalad and medial approach

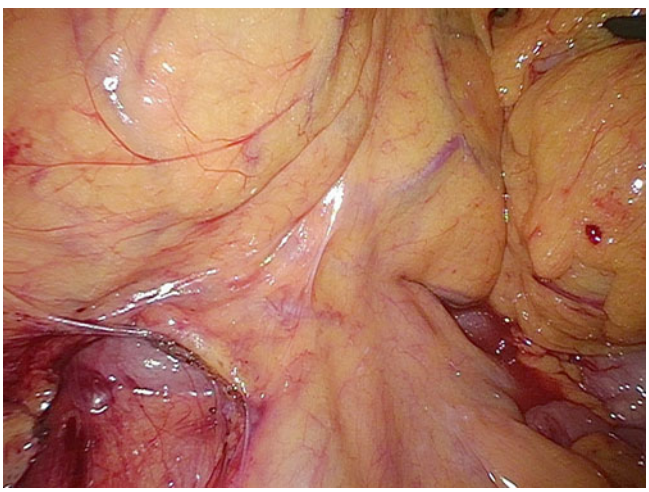

Fig. 5.10 Visualization of middle colonic vessels from caudal approach

in a muscle-splitting technique. A small or medium Alexis wound retractor is inserted and the specimen extracted. A linear 75 mm × 3.5 mm stapler is used to divide the ileum and the transverse colon. Any remaining ileal and transverse colon mesentery is divided with the bipolar electrocautery device. The ileum and colon are most commonly anastomosed in a standard side-to-side fashion. The end staple line is opened at the antimesenteric corner on both the ileum and colon. A 75 mm × 3.5 mm linear stapler is inserted into the ileum and colon and fired creating a side-to-side antimesenteric anastomosis. The common enterotomy is closed with a single firing of a 60 mm × 3.5 mm TA stapler. 3-0 Vicryl Lembert reinforcing sutures may be placed at either the entire TA staple line or the staple line corners if desired. After completion of the anastomosis and a glove and instrument change, the fascia of the extraction site can be closed and reinspection of the peritoneal cavity performed if desired.

Intracorporeal Anastomosis

Intracorporeal anastomosis is a challenging but potentially advantageous technique that requires advanced laparoscopic skills to accomplish. The technique will be described in detail in a separate chapter. Theoretical advantages include (1) a reduced surgical site infection rate due to performing the anastomosis away from the skin incision, (2) a possible reduced rate of postoperative adhesions and small bowel obstruction, (3) a shorter abdominal incision and likely reduced postoperative pain, (4) a better visualization of the mesentery during anastomosis to reduce the potential for twisting the mesentery [12], (5) a reduced postoperative ileus due to a decreased requirement for postoperative opioid analgesics, and (6) an ability to extract the specimen from an incision placed at a more cosmetic location (such as a Pfannenstiel incision). Disadvantages to this technique are that it is technically more challenging, has a risk of intra-abdominal fecal spillage, and prolongs the operation.

Outcomes comparing intracorporeal and extracorporeal anastomosis have been mixed. Some studies have found that intracorporeal technique is associated with positive results including reduced postoperative ileus [13, 14], a shorter incision [13, 15], reduced postoperative pain [14], and decreased length of hospital stay [14]. However, these positive results are mixed and, generally, minimally significant except for the improved cosmesis. In addition, these results come from a small group of surgeons with significant experience in intracorporeal suturing. It is questionable whether widespread implementation of intracorporeal anastomosis would reproduce such outcomes. A systematic review of 945 patients failed to demonstrate a difference between intracorporeal and extracorporeal anastomotic techniques in terms of anastomotic leak and mortality, and further randomized clinical trials were recommended [16].

There are many techniques for performing an intracorporeal ileocolonic anastomosis, and what is described here is just one option available to the surgeon. The left lower quadrant port site is enlarged to 12 mm to accommodate an Endo GIA stapler, or a 12 mm port is introduced at the planned site of the extraction. Any remaining mesentery of the terminal ileum at the site of planned division is divided intracorporeally with a bipolar electrocautery device, and the terminal ileum is divided with a 60 mm Endo GIA stapler. Any remaining transverse colon mesentery is also divided, and the transverse colon is divided with a 60 mm Endo GIA stapler. For simple ileocolic resections, the ileum and colon may be aligned in a side-to-side antiperistaltic fashion. For a formal right hemicolectomy, the ileum and colon are aligned in a side-to-side isoperistaltic fashion. This ensures easier insertion of the Endo GIA stapler during anastomosis. A 3-0 Vicryl fixation suture is placed through the colon and ileum to align them together, and the suture is pulled out through the left lower quadrant port site. Small enterotomies are made in the antimesenteric border of the transverse colon and ileum. A 60 mm Endo GIA 3.5 mm load stapler is inserted through the left lower quadrant port into the two loops of intestine with the smaller anvil side in the terminal ileum. The fixation suture that was passed through the left lower quadrant port helps to align the intestine with the stapler. The stapler is fired and withdrawn, creating a side-to-side anastomosis. The common enterotomy is closed with two layers of running 3-0 Vicryl suture in a continuous fashion. The mesenteric defect is not closed. The abdomen is irrigated and the specimen can be removed through a Pfannenstiel incision. The fascia of port sites larger than 5 mm is closed with absorbable suture.

Approaches

Medial to Lateral Approach

The medial to lateral approach is the most commonly utilized technique and follows the steps 1–7 as described above.

Lateral to Medial Approach

The lateral to medial approach is conducted using the same basic seven steps as noted above but in a revised order. In this approach, the order of the steps is 1, 4, 3, 5, 2, 6, and 7. The lateral to medial approach can be used if the anatomy around the ileocolic pedicle is unclear. This approach may also be useful in patients who have a tumor that may not be resectable due to possible involvement of the head of the pancreas. The retroperitoneum can be explored with this technique without committing to colonic resection by preserving the ileocolic pedicle. Finally, if the patient is only in need of

an ileocolic resection for inflammatory bowel disease, then this technique can be used with extracorporeal vascular ligation via the extraction site. The disadvantage of this approach is that the mesenteric mobilization tends to be slower than the retroperitoneal blunt dissection in the medial to lateral approach. In addition, the duodenum is identified late in the procedure, making inadvertent injury more possible.

Inferior to Superior Approach

The order of the steps in the inferior to superior approach would be 1, 3, 2, 4, 5, 6, and 7. This technique can also be used if the anatomy around the ileocolic pedicle is unclear. The retroperitoneal plane is entered early by lifting the ileum and incising the peritoneum where the ileal mesentery is fused to the retroperitoneum. The plane between the ileal mesentery and retroperitoneum can be developed quickly with blunt dissection. It has some of the advantages of the lateral to medial approach in that the retroperitoneum can be completely explored without dividing the ileocolic pedicle and committing to colectomy. It is also a useful technique for ileocolectomy if intracorporeal division of the ileocolic pedicle is to be avoided completely. One disadvantage to this procedure is that the plane may be less clear in obese patients and retraction of the terminal ileum can be difficult in obese patients.

Hand-Assisted Laparoscopic Right Hemicolectomy

This will be discussed and described in more detail in the following chapter. There are numerous port arrangements described in hand-assisted laparoscopic right hemicolectomy [17–19]. In addition, the order of the operation varies from surgeon to surgeon. The hand access port is generally placed in the mid-abdomen in such a position as to allow extraction of the transverse colon for extracorporeal anastomosis. The assistant's role is limited to managing the 30° laparoscopic camera.

There are many arguments for and against hand-assisted laparoscopic right hemicolectomy. Some authors have found that short-term outcomes between hand-assisted and conventional laparoscopic right colectomies are similar and have therefore recommended that the choice should be based on the surgeon's preference and comfort level [17]. Other authors have stated that because there is no difference between the two techniques, the total laparoscopic approach should be preferred [20]. Clear advantages of hand-assisted surgery are that it requires a less skilled assistant and wide retraction of the bowel is easier with a hand in place. Disadvantages of hand-assisted surgery are that the abdominal incision is larger and sometimes visualization is actually more difficult due to the hand being in the field of view.

Special Considerations and Complications

The Reoperative Abdomen

Laparoscopic surgery in patients who have undergone multiple previous open surgical options can pose a significant challenge. The first obstacle to overcome is gaining access to the abdomen. Obviously, previous surgical incision sites should be avoided. Open technique with placement of a Hasson trocar is certainly safe but can be quite challenging in obese patients with a thick abdominal wall. If a percutaneous technique with a Veress needle is desired, the two safest points of placement are the umbilicus and the left upper quadrant at Palmer's point. Lifting of the umbilical fascia for insertion of the Veress needle has been shown to actually increase the distance to the retroperitoneal and intraperitoneal structures [21]. In this technique, a trocar incision is made adjacent to the umbilicus, and a clamp is inserted through the skin incision to grasp and elevate the subcutaneous umbilical stalk. A Veress needle may then be safely inserted. This technique is not advisable if the patient had a prior midline laparotomy however.

Another safe access option is to utilize Palmer's point for percutaneous insertion of the Veress needle. This technique was originally described by the French gynecologist Rahoul Palmer and involves inserting the Veress needle in the left subcostal midclavicular line. This area is less likely to have adhesions to underlying intestine, and the peritoneum is naturally elevated in this location below the ribs.

After safe insertion of the laparoscopic camera, the next challenge of the reoperative abdomen is intraperitoneal adhesions. For the most part, these should be taken down sharply and/or with gentle sweeping. Electrocautery should be avoided due to the risk of bowel injury from thermal energy spread in the tissues. Atraumatic graspers should be utilized to grasp the bowel. When grasping the bowel is necessary, one should remember that grasping a large bite of intestine is less likely to create a traction injury then when grasping a very small bite of intestine. Good visualization is critical and a 10 mm laparoscope may be necessary to achieve this goal. Finally, it is important to remember that dense adhesions may simply require a conversion to open surgery. It has been previously demonstrated that conversion rates to open surgery in laparoscopic colon surgery are acceptable in patients with prior abdominal surgery [22].

Morbid Obesity

The patient with a significant amount of intra-abdominal fat can pose a significant challenge during laparoscopic right hemicolectomy. Obesity has been shown to increase the complexity of laparoscopic resections in inflammatory bowel

disease with increased blood loss, longer operative time, and a higher rate of conversion rates to open surgery [23]. The key difficulty usually comes during the division of the ileocolic vascular pedicle when the thickened mesentery obscures the plane. Good elevation of the cecum toward the right lower quadrant by the assistant is key to elevating this vascular pedicle. In addition, the greater omentum may be tethered to the right colon and be pulling the transverse colon into the field. Early mobilization of the greater omentum off the right colon can be key to opening up the operative field around the ileocolic pedicle. Once the retroperitoneal plane is entered, it may actually separate more easily than in thinner patients.

Crohn's Disease

Laparoscopic surgery for ileocolonic Crohn's disease is also an area with specific challenges. Inflammatory changes may fuse tissue planes together that would normally easily separate with blunt dissection. Inflammation also leads to thickened, foreshortened mesentery that can be both difficult to divide intracorporeally and difficult to extract and divide extracorporeally. Fistulas may necessitate challenging multivisceral surgical approaches that require dissection in at least three abdominal quadrants. Subtle stricturing small bowel disease can be difficult to see during laparoscopy, and preoperative imaging may underestimate the presence of strictures in one-third of patients [24].

However, given all of these issues, laparoscopic surgery for Crohn's disease is certainly possible. In a randomized controlled trial comparing laparoscopy-assisted and open surgery for ileocolonic Crohn's disease, laparoscopy was associated with a lower 30-day postoperative morbidity (10 % vs. 33 %), shorter hospital stay (5 days vs. 7 days), and a lower overall cost at 90 days. The disadvantage of laparoscopic surgery was a significantly longer operative time (115 min vs. 90 min) [25].

Keys to success in laparoscopic Crohn's surgery include good preoperative planning and early recognition when conversion to open surgery is needed. As mentioned above, a lithotomy patient position can facilitate use of the EEA stapler if concomitant sigmoid colectomy is needed for ileocolic fistula.

Locally Advanced Cancer

The presence of locally advanced cancer has previously been identified as adding a high level of complexity to laparoscopic colectomy cases [8]. However, abdominal wall involvement of a cecal or ascending colon cancer need not be a specific contraindication to laparoscopic colectomy. While it probably goes without saying, preoperative planning and CT scan review are critical. The surgery is begun with a medial to lateral approach and the retroperitoneal plane is opened. After the ileum is mobilized, the tumor itself is addressed. Electrocautery is used to score the peritoneum overlying the abdominal wall around the cancer area. Once this extraperitoneal incision is created, the colon is swept medially and the free abdominal wall muscle fibers are taken with bipolar electrocautery. After the abdominal wall dissection has been carried beyond the locally advanced tumor, the colon is elevated and the retroperitoneal dissection plane and extraperitoneal abdominal wall dissection plane are both seen in the same field; these two planes are connected by dividing the intervening tissue with bipolar electrocautery. Great care must be taken to visualize the right ureter if the dissection has proceeded into the retroperitoneum.

Bleeding

Bleeding at the middle colic vessels can be a significant intraoperative complication in laparoscopic right hemicolectomy or open right hemicolectomy. The most common causes are excess traction and unclear anatomy. The important thing to keep in mind is to not make a bad problem worse with a thermal duodenal injury or additional tearing of middle colic veins or the trunk of Henle. A laparoscopic suction irrigator should be used to clear the field with suctioning only as irrigation tends to obscure the view to a greater degree. The patient can be placed in a steeper reverse Trendelenburg position to divert the pooling blood away from the bleeding vessel and improve visualization. If thermal injury to the duodenum is a concern, then avoid bipolar cautery devices and utilize clips.

Enterotomy and Duodenal Injury

Enterotomy and duodenal injury can occur during Veress needle placement, trocar placement, and mobilization and division of the mesentery or with blind insertion of sharp or blunt instruments during the case. There are three important points regarding bowel injury during the case. First, the best "management" of bowel injury involves avoiding injury to begin with. This can be as simple as using safe techniques to insert the Veress needle [21]. In addition, instruments and trocars should be observed as they are placed into the abdomen. Also, avoid unnecessary instrument exchange during the case by utilizing instruments that can serve a dual purpose. For example, some atraumatic graspers are also useful for grasping a suture needle during intracorporeal anastomosis, a bipolar cautery device can be also used for blunt dissection, and scissors can also be used for blunt dissection. Avoiding unnecessary instrument exchange can also shorten the operative time of the case.

Second, if an injury has occurred, it is critical to recognize it during the case. Inspect the abdomen after Veress needle insertion and any blind trocar insertion. Visualize the duodenum before and after ileocolic and middle colic vessel division. If there is a questionable injury that cannot be adequately assessed during laparoscopy, then laparotomy or minilaparotomy is indicated.

Third, it is important to realize that conversion to open surgery is far better than not adequately addressing the issue laparoscopically. For example, if a duodenal injury is identified and the surgeon does not practice intracorporeal suturing regularly, it is best to repair that injury via an open technique. Because the duodenum lies just below the midline extraction site, open suture of the duodenum can be performed without a significant enlargement of the extraction site incision.

Difficulty with Identification of Tumor or Lesion

Prior to any colectomy or proctectomy, it is critical to review the endoscopic report in which the tumor was localized. It is now well established that preoperative endoscopic tattooing of tumors improves intraoperative localization and is associated with shorter operative time and blood loss [26]. It is important to ensure that tumors of the colon were marked with submucosal ink or were found to be adjacent to an obvious landmark such as the ileocecal valve prior to surgery. It is important to not rely on the subjective impression of where the endoscopist thought the tumor was. Colonoscopy reports have been found to be inaccurate in 11.3 % of colectomy patients [27]. Terms such as "hepatic flexure" or "proximal transverse colon" can be very unreliable. If there is any question regarding the tumor location, repeat endoscopy prior to surgery is indicated.

If the lesion cannot be found intraoperatively, it may be necessary to mobilize portions of the omentum off the transverse or ascending colon to achieve better visualization. If visualization is still not possible, intraoperative colonoscopy with CO2 insufflation is indicated and found to assist in the identification of colon tumors intraoperatively [27]. If the patient is supine, intraoperative colonoscopy can be accomplished by moving into a "frog leg" position or a lithotomy position.

Summary

Laparoscopic right hemicolectomy is a challenging procedure with a significant learning curve; however, it may be an excellent place to begin laparoscopic colorectal surgery in terms of degree of technical difficulty. There are many advantages to utilizing laparoscopic techniques for colon and rectal resection. Multiple approaches to minimally invasive right colectomy are available – each with its own risks and benefits.

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