26 The Surgical Management of Colon Cancer

Matthew G. Mutch

Key Concepts

- Complete clinical staging for colon cancer includes a total colon exam; computed tomography of the chest, abdomen, and pelvis; and a serum CEA level.
- The principles of an oncologic resection include a total mesocolic resection, a ligation of the primary vessel at its origin, a wide mesenteric resection with >12 lymph nodes examined, and at least a 5 cm resection margin.
- There is no difference in cancer-related outcomes for open and laparoscopic resections.
- Anastomotic assessment for left-sided anastomosis is associated with a decreased leak rate.
- Surgical resection is the most effective therapy for patients who present with obstruction colon cancers.
- Endoscopic stenting of an obstructing colon cancer is an effective bridge to surgery within 72 h.
- Perforated cancers should be treated with an oncologic resection.
- First-line therapy for patients with metastatic colon cancer and an asymptomatic primary tumor is chemotherapy.

Introduction

Our understanding of the pathogenesis, staging, and management of adenocarcinoma of the colon has evolved greatly over the last decade. Today, it is accepted that colorectal cancers develop via one of three distinct genetic pathways: (1) chromosomal instability, (2) mismatch repair, and (3) CpG island hypermethylation. This increased understanding of the genetics of colorectal cancer development has led to the identification of several putative molecular markers to predict their biologic and clinic behavior. However, pathologic staging using the TNM system remains the most valuable prognostic tool available, with depth of invasion (T stage) and lymph node involvement (N stage) being the best markers to risk stratifying regional and distant metastatic spread, respectively. Preoperative imaging has allowed for more accurate clinical staging and earlier detection of metastatic disease that may impact the treatment of the patient. Advances in chemotherapy have allowed for improved outcomes for patients with selected stage II and stage III and IV cancers. Despite all of these advances, surgical resection remains the cornerstone and most important facet in the management of colon cancer. An intimate understanding of the anatomy of the colon, its vasculature, and the retroperitoneum are critical to performing an appropriate oncologic resection for colon cancer. This chapter will focus on the technical aspects of the principles of an oncologic resection such as the importance of total mesocolic resection, ligation of primary vasculature at its origin, obtaining an adequate lymph node harvest to ensure an examination of >12 lymph nodes, and obtaining appropriate distal and proximal margins for open and laparoscopic resections. Special topics such as laparoscopic colectomy for cancer, management of obstructing and perforated colon cancers, treatment of the primary tumor in the setting of metastatic disease, and the short-term and long-term outcomes for colectomy for cancer will be addressed.

Preoperative Preparation

When preparing to take a patient to the operating room for resection of his/her colon cancer, it is imperative to have a complete understanding of the patient's physiologic status, tumor location, and clinical staging. Being able to provide patients with individualized risk stratification for complications after colorectal surgery is becoming more and more important because of the increasing scrutiny of patient safety and outcomes. The general population in the USA is getting older and has an increasing number of comorbidities, so surgeons will be making more and more challenging decisions regarding the management of patients with colorectal cancer.

S.R. Steele et al. (eds.), *The ASCRS Textbook of Colon and Rectal Surgery*, DOI 10.1007/978-3-319-25970-3_26

Physiologic Assessment

A variety of scoring systems are available for stratifying a patient's risk of perioperative morbidity and mortality after undergoing major digestive system surgery. Each scoring system differs in the included parameters and the outcomes that they measure. The most widely utilized scoring system is the American Society of Anesthesia (ASA) score, but it only provides assessment of an anesthesia complication for a given patient's physiologic status. In contrast, the Physical and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM) and modified Portsmouth-POSSUM scoring systems provide an assessment of the risk of postoperative mortality and morbidity [1]. The scoring system includes 12 preoperative physiologic factors such as age, blood pressure, heart rate, electrocardiogram status, hemoglobin, and electrolytes. It can also be reevaluated in the postoperative period using six additional intraoperative parameters including operative procedure, estimated blood loss, peritoneal contamination, presence of malignancy, and urgency of the operative procedure. However, it has been repeatedly shown that POSSUM and P-POSSUM scores underestimate the risk of morbidity and mortality for patients undergoing major colorectal surgery. In an effort to improve the performance prediction of patients undergoing colorectal resections, a colorectal-specific POSSUM (CR-POSSUM) score was developed [2]. Multiple retrospective and prospective studies have demonstrated improved accuracy with the CR-POSSUM compared to POSSUM and P-POSSUM for predicting mortality after colorectal surgery for a variety of diseases such as cancer and diverticulitis [3, 4]. The CR-POSSUM scoring system has also been validated in multiple health-care systems around the globe such as the USA, the UK, India, Middle East, Caribbean, and Asia [5, 6]. Furthermore, the CR-POSSUM scoring system has improved accuracy in elderly patients defined as >80 years of age when compared to P-POSSUM [7]. There are also suggestions that physiologic health status of an elderly patient is more important than the type of surgery when attempting to predict mortality in this age group. The American College of Surgeons developed a surgical risk calculator using data from National Surgical Quality Improvement Program (NSQIP) to provide patient-specific postoperative risks of various complications. The scoring system is based on over 1.4 million patients with over 1500 unique Current Procedural Terminology (CPT) codes and has performed very well for predicting mortality, overall morbidity, and risk of six specific complications (pneumonia, cardiac, surgical site infection, urinary tract infection, venous thromboembolism, renal failure, and return to the operating room) [8–10]. The NSQIP risk calculator has been shown to underestimate the risk of complications for colorectal resections, and more surgeon- and patient-specific data are needed. However, it remains a useful tool to preoperatively assess morbidity and mortality risk. The risk calculator is available at http://riskcalculator.facs.org.

Tumor Localization

Accurate tumor localization is a critical component of the preoperative assessment of the patient and operative planning. Intraoperative tumor localization can be challenging from several standpoints such a small or early tumor, obese patient, adhesions, laparoscopy, or inadequate tattooing. The utilization of intraluminal anatomic markings for tumor localization is inaccurate, 12–14 % of the time, and may be higher if cecal and rectal tumors are excluded [11]. In other words, the colonoscopy will not accurately locate the tumor 1 out of 7 times. Localization with endoscopic tattooing provides the most accurate method for localization. The tattoo should be placed distal to the lesion and in three separate areas around the circumference of the lumen (Fig. 26.1). A single injection into the mesenteric border or sprayed into the peritoneal cavity may be difficult to identify. Chou et al. reported that endoscopic tattooing provided accurate localization in 94 of 97 (98 %) tumors [12]. This study also examined radiographic methods for tumor localization and found barium enema and CT colonography to be 93 % and 95 % accurate, respectively. Alternatively, endoscopic placement of metal clips at the site of the tumor with immediate plain radiograph (or CT) will localize the tumor with a high degree of accuracy. The ultimate fallback to identify a lesion is intraoperative colonoscopy, ideally using carbon dioxide as the insufflation gas to limit bowel dilatation.

Patients who present with endoscopically obstructing lesions can be effectively evaluated with CT colonography to complete their total colon exam prior to surgery. CT colonography has replaced contrast enema studies in many situations because of improved accuracy in detecting synchronous lesions and often provides better tumor localization. A study of 411 consecutive patients evaluated with CT colonography for incomplete colonoscopy due to a stenosing colorectal cancer and the preoperative CT colonography was compared to the intraoperative and pathologic findings [13]. The study demonstrated a sensitivity of 100 % for detecting

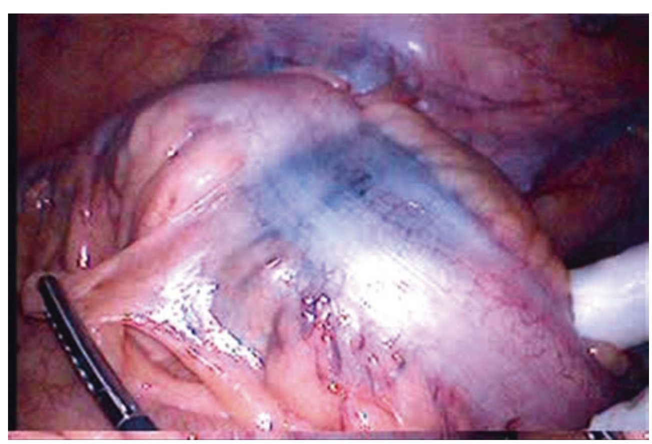

Figure 26-1. Tattoo localization of a sigmoid colon cancer.

proximal synchronous cancers and negative predictive value of 97 % for identifying advanced neoplastic lesions (advanced adenomas or cancers). Other studies have demonstrated similar results [14–16]. CT colonography can safely be used in the acute and subacute settings as demonstrated by Maras-Simunic et al. [17]. They examined 44 patients who presented with signs and symptoms of a large bowel obstruction, and CT colonography was able to accurately identify the cause of obstruction as a cancer in 41 and due to a benign process in nine patients. It was also able to accurately detect two synchronous cancers in this small study population. Therefore, if it is safe and feasible, patients presenting with a distally obstructing lesion (clinically or endoscopically) who have a negative CT colonography can be safely treated with a segmental resection without significant risk of missing of synchronous, proximal lesions.

Surgical Technique

Extent of Resection

The National Comprehensive Cancer Network provides the recommended principles of surgical resection for colon cancer, which include obtaining an adequate proximal margin, distal margin, and lymphadenectomy [18]. Colon cancers tend to grow circumferentially around the lumen of the colon, extend out radially and, to a lesser degree, longitudinally along the bowel. Therefore, a 5 cm proximal or distal margin has always been recommended. This is important to remove all tumors bearing mucosa but also to resect all lymph nodes with potential to drain tumor cells. A retrospective study by Rorvig et al. compared final pathologic stage in resected colon cancer specimens with a tumor margin <5 cm to those with a >5 cm margin. The node positivity rate for tumors with a margin <5 cm was 37 % versus 51 % for a margin >5 cm [19]. This highlights that even though the primary tumor does not grow in a longitudinal fashion, lymphatic drainage can extend in a longitudinal or somewhat aberrant fashion. In order to obtain an adequate lymphadenectomy, the feeding vessel to the resected segment of the colon should be taken at its origin. For example, the ileocolic pedicle should be ligated at its origin on the superior mesenteric artery, and the inferior mesenteric artery should be ligated at the level of the aorta. The goal is to clear all regional lymph nodes and provide a minimum of 12 lymph nodes for pathologic evaluation. The impact of an adequate lymph node harvest and evaluation on the accuracy of pathologic staging is well documented and is addressed in Chap. 34. The concept of high versus low ligation of the primary feeding vessel had been debated throughout the literature. Historical data and recent prospective randomized trials have demonstrated no difference in morbidity associated with high ligation [20–23]. However, the rate of positive lymph nodes along the IMA above the level of aortic bifurcation has been reported to be as high as 8 % and when resected is associated with better disease-free survival [22]. Therefore, to maximize the lymph node harvest and to ensure complete resection of potentially metastatic lymph nodes, the mesentery should be resected with the primary vessel ligated at its origin and at least a 5 cm margin distal or proximal to the tumor.

Mesocolic Resection

The concept of total mesorectal excision (TME), which was popularized by R.J. Heald, also pertains to the resection of the colon and associated mesentery along the appropriate fascial planes. Just as the mesorectum is enveloped in a fascia, the mesocolon also has a visceral fascial plane that separates it from the retroperitoneum (parietal fascia). A serosal surface on the bowel and mesentery excludes the anterior aspect of the mesentery from the perineal cavity. Therefore, a complete mesocolic excision (CME) is the sharp dissection of the visceral fascia from the parietal fascia of the retroperitoneum and central ligation of the primary vasculature. Hohenberger et al. adopted this concept in the mid-1990s and published their results on 1329 consecutive patients [24]. They reported an improvement in 5-year local recurrence and 5-year survival from 6.5 to 3.6 % and 82.1 to 89.1 %, respectively, after adoption of CME plus central ligation of the mesenteric vessels. Subsequent studies have demonstrated several other benefits of CME such as increased lymph node harvest, longer vascular ligation, increased resection of extranodal tumor deposits, and increased upstaging, which led to no differences in morbidity but improved locoregional control and survival [25, 26]. The technical concept of sharp dissection of the colon and mesocolon off the retroperitoneum, excision of the mesentery along the lines of resection, and central ligation of the vasculature is as important to colon cancer as TME is to rectal cancer.

Right Colectomy

Tumors located anywhere from the cecum to the proximal transverse colon can safely be treated with a right colectomy. The basic tenets of resection of a right-sided tumor include full abdominal exploration, full mobilization of the right colon, and hepatic flexure with a mesenteric resection including ligation of the ileocolic and right branch of the middle colic vessels at their origin. The resection can be performed safely and effectively via either an open or laparoscopic approach. Data regarding laparoscopy and colorectal cancer is presented in detail below.

Open Approach

The peritoneal cavity can be accessed with a midline incision or as some surgeons prefer a right-sided transverse incision. Once the abdomen is open, explored, and the tumor is located, the wound should be protected with a wound protector. The first step in mobilizing the right colon is to access the retroperitoneum, which can be accomplished laterally along the white line of Toldt, inferiorly near the cecum, posteriorly under the small bowel mesentery, or superiorly through the lesser sac. Once the retroperitoneum is entered, the mesentery and hepatic flexure are mobilized. The duodenum should be identified and reflected into the retroperitoneum. The omentum associated with the resected colon should be resected as well. With the colon completely mobilized, the vascular pedicles can be ligated. Regardless of the approach used, the step is the same and only their order is different.

Lateral Approach

The surgeon stands on the patient's left side and the first assistant on the patient's right side. The right colon is grasped, and the peritoneum is incised just anterior to the white line of Toldt from the cecum to the hepatic flexure. This allows access to the retroperitoneum or the avascular plane between the visceral and parietal planes of the colon and retroperitoneum. It is important not to violate the mesenteric side of this plane in order to ensure a total mesocolic resection. Under tension, the right colon is separated sharply from the retroperitoneum. The duodenum should be identified and reflected into the retroperitoneum. The cecum is then mobilized off the retroperitoneum, and the posterior attachments of the small bowel mesentery are divided all the way up to the duodenum. This provides the mobility of the small bowel for the anastomosis. With the duodenum safely reflected posteriorly, the hepatic flexure can be mobilized. The surgeon's left hand is placed under the colon and its mesentery and brought out laterally to expose the superior attachments along the inferior edge of the liver. Eventually, the lesser sac is entered, and the lesser omentum is divided. Care must be taken so the plane between the omentum and the transverse colon mesentery is separated, and dissection into the transverse colon is avoided. These two planes are typically fused up to the midline, and beyond this point, the proper lesser sac is entered. After the right colon and hepatic flexure are completely mobilized, the cecum is put on stretch, and the ileocolic pedicle can easily be identified. Since the right colon and its mesentery have been mobilized, there should be bare areas on the cephalad and caudad aspects of the ileocolic pedicle. The peritoneum is incised along the lines of resection for both bare areas allowing isolation of the pedicle so it can be ligated at its origin on the superior mesenteric vessels. The terminal ileal mesentery is divided so that a 5 cm margin on the terminal ileum is obtained. The right branch of the middle colic vessels is identified by elevating the transverse colon mesentery. The pedicle should become evident either by it bowstringing under tension or there should be another bare area where the omentum has been dissected free during the exposure of the lesser sac. The peritoneum should be incised from the distal site of transection of the colon to the base of the pedicle and across the pedicle to the cut edge of the right colon mesentery. The pedicle can then be ligated at its origin. Ileocolic anastomotic techniques will be discussed later.

Posterior Approach

The small bowel is eviscerated and reflected toward the right upper quadrant to expose the posterior aspect of the small bowel mesentery from the ligament of Treitz to the cecum (Fig. 26.2). The peritoneum is incised along this entire length, and the retroperitoneum is entered (Fig. 26.3). The duodenum is readily identified and reflected into the retroperitoneum.

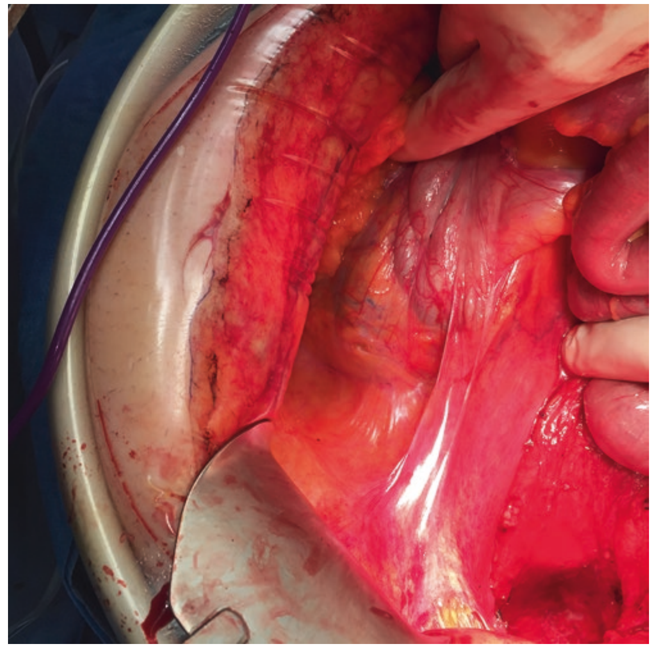

FIGURE 26-2. Exposure of the posterior aspect of the small bowel mesentery for the posterior approach to a right colon.

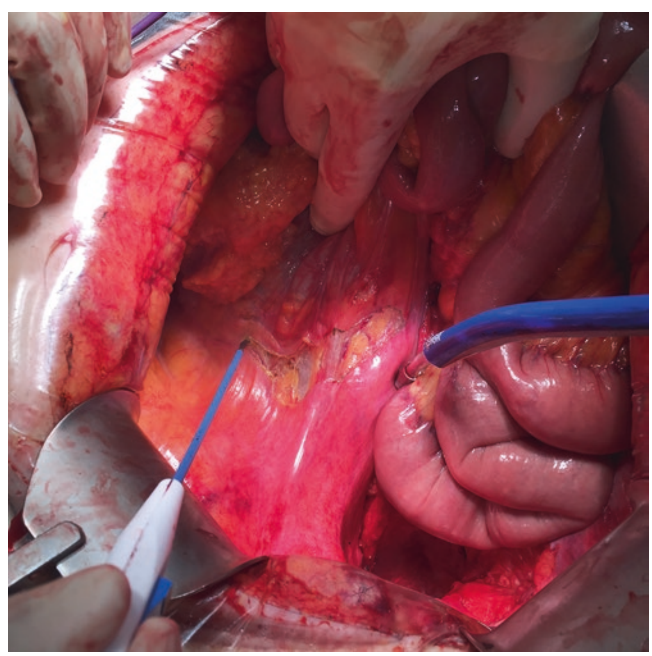

FIGURE 26-3. Entry into the retroperitoneum from the posterior approach to a right colectomy.

The right colon mesentery is elevated off the retroperitoneum out beyond the ascending colon laterally and the transverse colon superiorly. The further this dissection can be performed from a medial-to-lateral direction beyond the transverse colon, hepatic flexure, and ascending colon, the easier the lateral dissection becomes as all that remains are the lateral peritoneal and lesser omental attachments. At this point, starting at the level of the cecum, the surgeon while standing on the patient's left side places his/her left hand under the right colon mesentery and lateral to the colon to expose the lateral peritoneal attachments. These are then divided heading up toward the hepatic flexure. If the dissection is continuing easily, the lesser omentum is separated from the transverse colon mesentery in order to enter the lesser sac. If this plane is difficult to develop, the distal site of transection is identified, and the lesser sac can be entered at this point. This begins by dividing the greater omentum to the level of the colon, and the lesser omentum is bluntly separated from the colon and its mesentery to enter the lesser sac. Once the lesser sac is entered, this plane is developed toward the hepatic flexure. Eventually, the posterior retroperitoneal dissection plane is entered. With the duodenum free, the remaining attachments along the inferior liver can be safely divided. The right colon and hepatic flexure are completely mobilized so the vascular pedicles can be ligated and the mesentery can be resected as described above.

Superior Approach

This dissection begins at the distal site of transection of the transverse colon. This is accomplished by elevating the transverse colon to expose its inferior aspect of the mesentery so the right branch of the middle colon vessels can be identified. It is the first pedicle medial to the bare area of the duodenum and should bowstring under the tension of elevating the transverse colon. The greater omentum is divided up to the transverse colon, and the lesser omentum is separated from the colon and mesentery to enter the lesser sac. As this plane is developed toward the hepatic flexure, the lesser omentum is divided. The stomach superiorly and duodenum posteriorly should be identified and separated from the colon mesentery. Once the lesser omentum or hepatic attachments to the colon are divided beyond the hepatic flexure, the hepatic flexure can be elevated under tension to develop the retroperitoneal plane, identify and free the duodenum, and divide the lateral peritoneal attachments of the right colon. With the peritoneal attachments divided, the remaining colon is mobilized in the same manner as described in the lateral approach. The superior approach is very useful for big bulky or locally advanced tumors of the cecum and proximal ascending colon because it allows for complete mobilization of the colon and mesentery before addressing the site of the tumor.

Anastomosis

The anastomosis can be accomplished via handsewn or stapled techniques. For the handsewn technique, the anastomotic orientation can either be end to end or side to side, and it can be created in a single or double layer of sutures. However, an end-to-end anastomosis is often difficult given the significant size discrepancies between the lumens of the small bowel and colon, so only the side-to-side technique will be presented. For the handsewn technique, the bowel is divided with a stapler or sharply, and the cut edges are closed with an absorbable monofilament 3-0 suture. To close the enterotomy, a Connell stitch is used in a running fashion, and this suture line can be dunked with interrupted Lembert stitches using an absorbable 3-0 suture. The bowel is then oriented in a side-to-side, antiperistaltic fashion. A single-layer anastomosis can be created using an absorbable monofilament 3-0 suture in either a running or interrupted fashion. For a single-layer, interrupted anastomosis, a 6–7 cm enterotomy is created. The first two stitches are placed 180° from each other in the proximal and distal corners, which allows for the "back walls" of the anastomosis to be aligned. With the "back wall" edges of the anastomosis inverted, the next stitch is placed in a bisecting position, and the subsequent stitches are placed in the same bisecting fashion until the "back wall" is complete. For the "front wall" of the anastomosis, sutures are alternately placed at proximal and distal corners until they meet in the middle. The suture is place from an inside out of the first lumen to the outside in of the second lumen. This technique places the knot of the suture intraluminally and inverts the two edges of the bowel. The last stitch will need to be placed in an out-to-in and in-to-out fashion, so the knot is on the outside of the bowel. For a running handsewn anastomosis, two sutures are placed in the middle of the "back wall" of the anastomosis, so one suture will run the anastomosis in the proximal direction and the other suture will run in the distal direction, and after completing the "front wall," the two sutures will be tied together. For the "back wall" of the anastomosis, the suture can be run in an overlapping, baseball-type fashion as the two bowel edges are already inverted. At each corner as the "front wall" of the anastomosis is created, the stitch should be transitioned to a Connell stitch, so the front edges will be inverted as well. For a double-layered anastomosis, the first step is to place the back row of Lembert stitches along the length of the anastomosis. The enterotomies are then made parallel to the Lembert stitches, and the inner layer is created in the same fashion of the running anastomosis described above. The front outer layer of Lembert stitches are then placed once the inner layer is completed.

Stapled anastomoses are most commonly performed in a side-to-side fashion but can also be performed in a side-to-end configuration as well. The traditional side-to-side, stapled anastomosis is created by individually dividing the proximal (Fig. 26.4) and distal limbs (Fig. 26.5) of the bowel with a stapler. The antimesenteric corner of each staple line is then excised, and forks of the stapler are placed into the lumen of each limb of the intestine. The stapler is reassembled and fired with the bowel in an antiperistaltic and antimesenteric fashion (Fig. 26.6). The resulting common enterotomy is reapproximated, so the longitudinal staple lines are offset, which prevents the intersection of more than two staple lines (Fig. 26.7). This common enterotomy can be

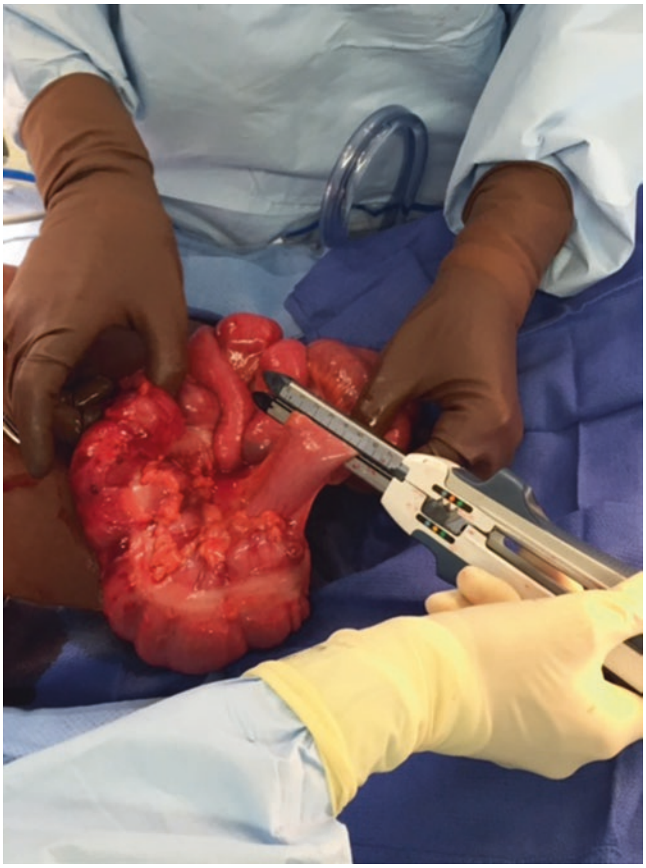

Figure 26-4. Division of the terminal ileum. Courtesy of Howard Ross, M.D.

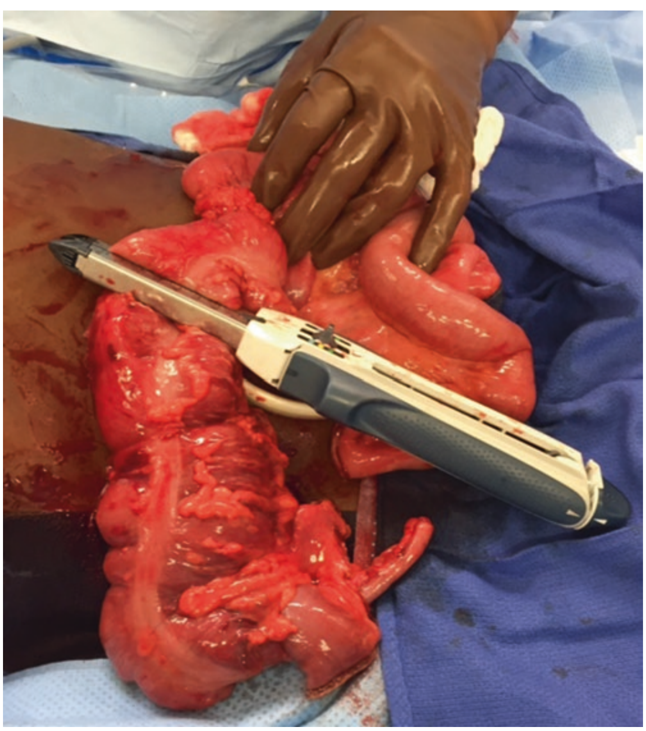

Figure 26-5. Division of the transverse colon. Courtesy of Howard Ross, M.D.

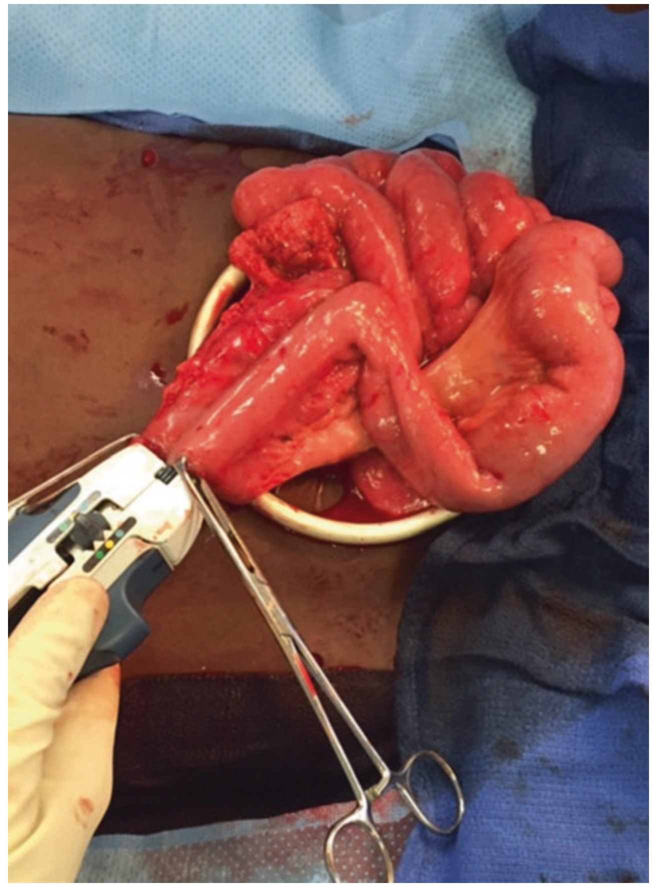

Figure 26-6. Firing of the linear stapler for a side-to-side stapled anastomosis. Courtesy of Howard Ross, M.D.

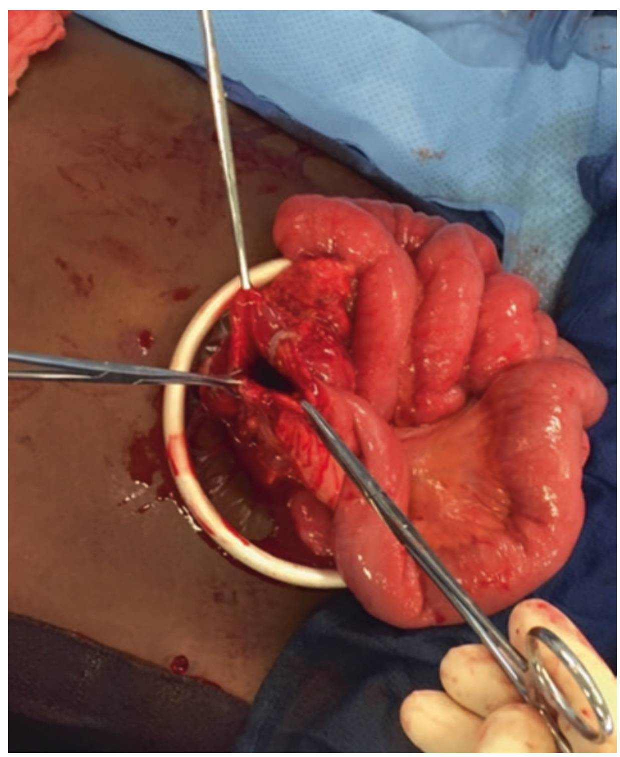

Figure 26-7. Closing the common enterotomy by offsetting the longitudinal staple line. Courtesy of Howard Ross, M.D.

closed with suture or staples (Figs. 26.8 and 26.9). An alternative method for creating the side-to-side anastomosis is not to divide the proximal and distal bowel. Enterotomies are then made on the antimesenteric side at the site of transection. The forks of the staple are then passed through each enterotomy where they are reassembled and fired in an antiperistaltic and antimesenteric fashion. The common enterotomy is once again reapproximated with the longitudinal staple lines offset, and then it is closed with a firing of the stapler that incorporates the proximal and distal limbs of the bowel. This technique saves the use of two stapler loads.

A stapled anastomosis can also be created in a side-to-end fashion. This anastomosis is created with an end-to-end anastomotic (EEA) stapler. The distal limb is divided sharply; a purse string is placed; and the stapler anvil, typically 28 or 29 mm, is placed inside. The proximal limb is also divided sharply, and the stapling cartridge is passed into the lumen of the proximal bowel. It is aligned for the spike to come out through the antimesenteric border. The spike should be positioned proximal enough, so the distal aspect of the circular staple line is at least 4 cm proximal to the cut edge of the bowel. This is important to ensure that the distal strip of the bowel remains viable once the enterotomy is closed. The end enterotomy of the proximal limb is then closed with a linear stapler or can be handsewn.

Laparoscopic Approach

Proper room setup and instrumentation are critical for success. A mechanical bed is essential, so the patient can be placed in extremes of positions to maximize the use of gravity for retraction and exposure. The patient needs to be safely secured to the bed, and there are a myriad of techniques to accomplish this such as bean bags, nonskid pads, or shoulder braces. Placing the patient in stirrups has the advantage of allowing the assistant or surgeon to stand between the legs, which allows for visualization in the direction of the dissection and minimizes working against the camera angle. Instrumentation is up to the surgeon's preference, but the use of atraumatic graspers is recommended. There are several energy devices available such as monopolar cautery, bipolar vessel sealers, and ultrasonic sealers that can be used for dissection and ligation of appropriate vessels. With regard to port placement, there are no hard-set rules, and they should be based on the surgical approach and surgeon's preference (Fig. 26.10a, b). Laparoscopic colectomy is a multi-quadrant procedure, so placement of the camera port as to maximize visualization is important. The most optimal place for the

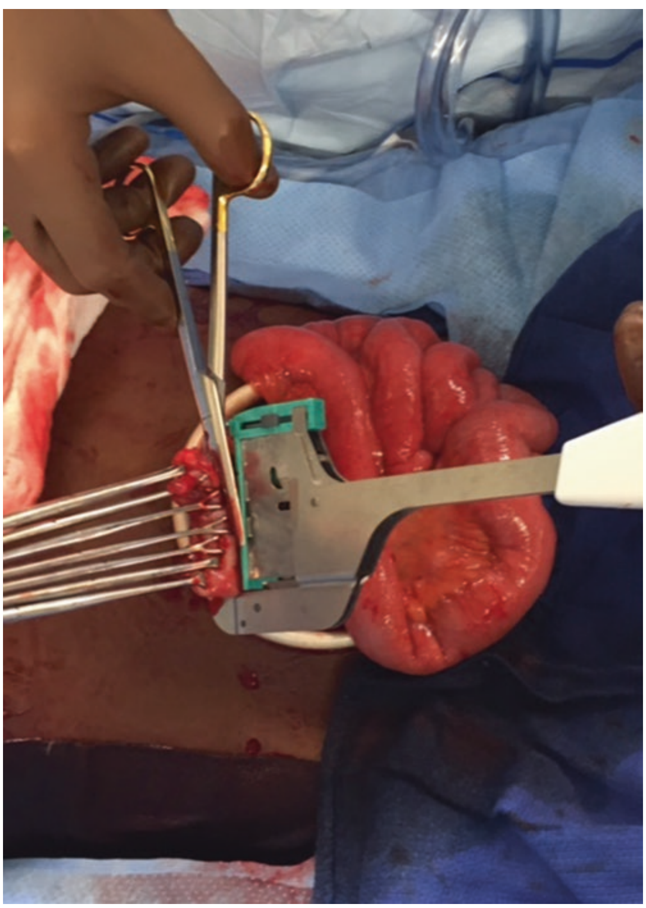

Figure 26-8. Closing the common enterotomy for a side-to-side anastomosis. Courtesy of Howard Ross, M.D.

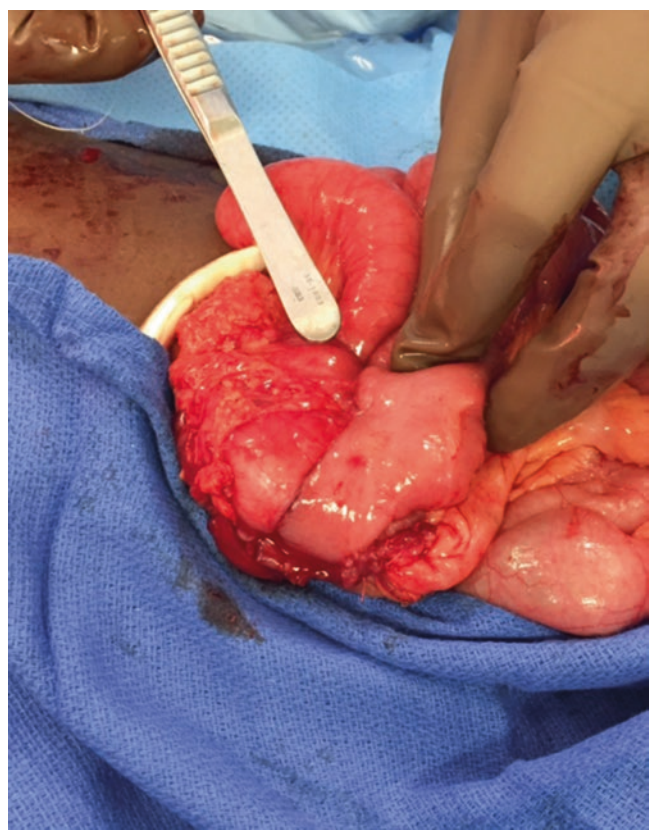

Figure 26-9. Complete side-to-side ileocolic anastomosis. Courtesy of Howard Ross, M.D.

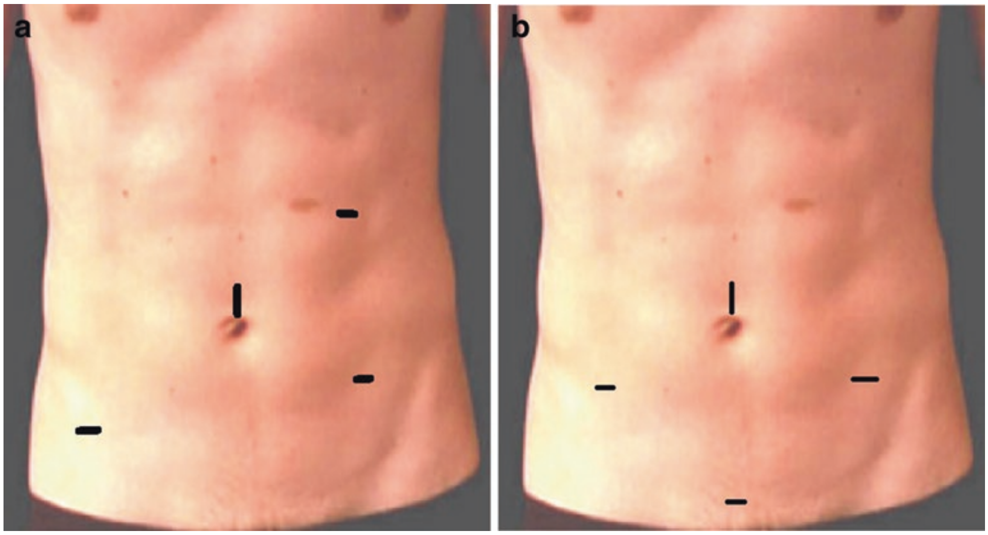

FIGURE 26-10. (**a**) Port placement for a laparoscopic right colectomy, (**b**) port placement for a laparoscopic right colectomy.

camera port is at the apex of the pneumoperitoneum. This is typically in the midline and at the midpoint between the xiphoid process and the pubic symphysis, which can either be above or below the umbilicus. Once pneumoperitoneum is established and the abdomen is adequately explored, the dissection can be carried out in a medial-to-lateral, lateral-to-medial, or posterior approach. For this chapter, the medial-to-lateral and posterior approaches will be presented.

Medial-to-Lateral Approach

Once the peritoneum is accessed, pneumoperitoneum is established and the ports are placed, the abdomen is completely examined, and the tumor is localized. The patient is then placed in steep Trendelenburg and airplaned right-side up. The omentum is placed in the upper abdomen to expose the transverse colon and the hepatic flexure. The small bowel is moved to the left side of the abdomen to fully expose the right colon mesentery. The first step of the dissection is to grab the mesentery at the junction of the terminal ileum and cecum and pull it to the right lower quadrant. This puts the ileocolic pedicle on tension and can be identified as it creates a bowstring in the mesentery. The pedicle is then grasped more proximally, and the peritoneum on the caudad aspect is incised in a direction parallel to the vessels. A wider incision in the peritoneum provides better exposure. Blunt dissection is used to get through the mesentery into the retroperitoneum. Once in the retroperitoneum, the duodenum is readily identified and reflected into the retroperitoneum. This dissection is aided by providing sufficient traction allowing tension, and 15 mmHg of CO_2 pressure aids the development of the avascular planes between the visceral and parietal fascia of the retroperitoneum. The dissection is done bluntly and carried cephalad and lateral as far as possible to safely separate the duodenum from the right colon mesentery, which allows the ileocolic pedicle to be isolated and ligated at its origin from the superior mesenteric vessels. The pedicle can be ligated with clips, staples, or vessel-sealing devices. In order to identify and isolate the right branch of the middle colic vessels, the transverse colon mesentery is elevated under tension. The pedicle is then identified as the vessel that bowstrings just medial to the cut edge of the right colon mesentery. This will help identify the distal site of transection of the colon. The peritoneum from the colon medial to the pedicle is scored down to the base of the pedicle and across it to the mesenteric cut edge. The pedicle is isolated with gentle blunt dissection along this plane. Once through the transverse colon mesentery, the omentum may be adherent to the mesentery in the lesser sac, so it may need to be dissected free to isolate the pedicle. With the pedicle ligated, the window through the mesentery into the retroperitoneum is wider, and the right colon mesentery should be mobilized off the retroperitoneum from the mid-transverse colon, out to the hepatic flexure, and lateral to the ascending colon. Ideally, all that remains at this point is the lateral peritoneal and omental attachments. The cecum is grasped and reflected medially and cephalad, the peritoneum is incised, and the dissected retroperitoneal space is entered. The posterior peritoneal attachments of the small bowel mesentery need to be divided up to the level of duodenum, so the small bowel has enough mobilization for extraction, resection, and anastomosis. Now the lateral attachments of the right colon are divided under tension all the way up the hepatic flexure. If the dissection is proceeding well, the hepatic flexure can be mobilized in this same direction by separating the hepatocolic/lesser omentum from the transverse colon mesentery to enter the lesser sac. If it is difficult to get adequate exposure, the approach can be altered by returning the colon to its anatomic position and identifying the distal site where the colon will be divided. The greater omentum is then divided at this point, and the lesser sac is entered by separating the lesser omentum from the transverse colon and its mesentery. This is an avascular plane, so it can be separated bluntly under tension. Once this plane has been developed, the dissection progresses toward the hepatic flexure by dividing the lesser omentum. As the dissection progresses beyond the pylorus, the retroperitoneal dissection plane should be entered, and the remaining attachments along the liver can be safely divided because the duodenum has been dissected free of this tissue. The colon is now completely mobilized and can be extracted via the surgeon's site of choice. For cancer cases, the use of a wound protector for extraction is highly recommended to minimize the risk of a wound recurrence. Once the colon is extracted, it is resected, and the anastomosis can be created using one of the techniques described earlier.

Posterior Approach

The peritoneal cavity is entered, ports are placed, and the abdomen is thoroughly explored. The patient is placed in steep Trendelenburg, and the omentum is reflected over the transverse colon to expose the hepatic flexure. The small bowel is placed in the right upper quadrant to expose the posterior aspect of the small bowel mesentery. The patient should not be tilted right-side up, so the small bowel will stay in the right upper quadrant. To obtain the exposure, the terminal ileum is identified and reflected toward the right colon. This will expose the fold of where the small bowel mesentery joins the retroperitoneum. Moving the small bowel to the right upper quadrant and following this fold in a cephalad direction will expose the fourth portion of the duodenum (Fig. 26.11). An instrument in the surgeon's right hand elevates the proximal aspect of the small bowel mesentery under tension, and the first assistant via a right lower quadrant port elevates the distal aspect of the small bowel mesentery, which provides exposure of the duodenum and posterior peritoneum of the small bowel mesentery. With the use of an energy source, the peritoneum is incised from the duodenum to the cecum allowing access to the retroperitoneum, and the right colon mesentery can be elevated off the retroperitoneum. The duodenum is reflected posteriorly, and the mesentery is elevated from the mid-transverse colon, out to the hepatic flexure, and down the ascending colon to the cecum (Fig. 26.12). The further this dissection is carried beyond the colon laterally and superiorly, the easier the lateral and hepatic flexure mobilization will be. Now the patient is airplaned right-side up, and the small bowel and omentum are pulled to the left side of the abdomen to expose the lateral aspect of the right colon. The lateral attachments are divided by grabbing the cecum and retracting it medial and cephalad toward the spleen (Fig. 26.13). The attachments are divided toward the hepatic flexure as far as possible. Just like that described in the medial-to-lateral approach, if the lesser sac can be easily developed and entered, the dissection can proceed in this direction. If this approach is too difficult, place the colon back in its anatomic position, and identify the distal site where the colon will be

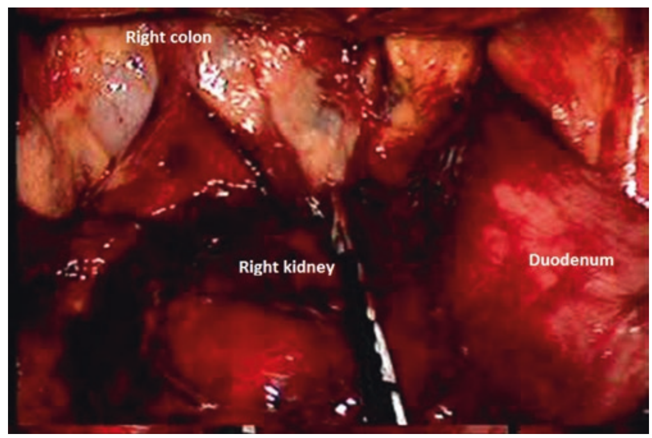

Figure 26-12. Posterior mobilization of the right colon mesentery off the retroperitoneum.

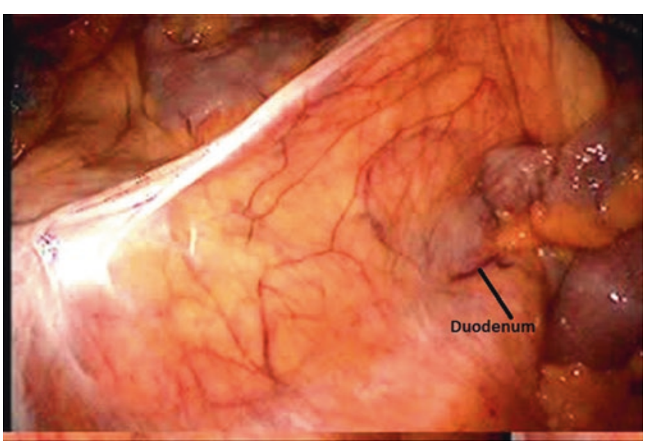

Figure 26-11. Exposure of posterior aspect of the small bowel mesentery for a laparoscopic posterior approach.

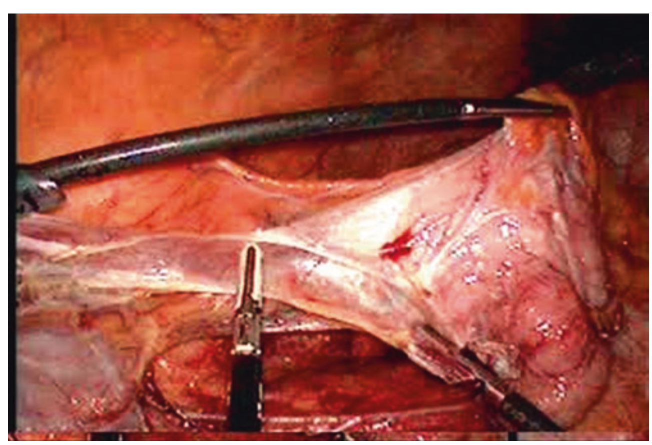

Figure 26-13. Exposure of the lateral attachments after the posterior dissection.

divided. This is accomplished by elevating the transverse colon mesentery and putting the right branch of the middle colic vessels on stretch (Fig. 26.14). The vessel is medial to the bare area of the right colon mesentery. The greater omentum is then divided at this point, and the lesser sac is entered by separating the lesser omentum from the transverse colon and its mesentery (Fig. 26.15). This is an avascular plane, so it can be separated bluntly under tension. Once this plane has been developed, the dissection progresses toward the hepatic flexure by dividing the lesser omentum. As the dissection progresses beyond the pylorus, the retroperitoneal dissection plane can be identified by the purplish tissue planes indicative of the previous posterior dissection. This plane can be safely entered, and the remaining attachments along the liver can be safely divided because the duodenum has been dissected free of the right colon mesentery (Fig. 26.16). At this point, the right colon and hepatic flexure have been completely mobilized. The next step is to isolate and ligate the vasculature. The ileocolic pedicles are identified by grasping the mesentery on the inside of the ileocecal valve and pulling to the right lower quadrant. The pedicle will bowstring, and because it has been mobilized off the retroperitoneum, bare areas can be seen on the caudad and cephalad (bare area over the duodenum) aspects (Fig. 26.17). The peritoneum on the caudad aspect is scored parallel to the pedicle, and blunt dissection through the mesentery will allow entry into the retroperitoneum. The duodenum can be visualized to ensure it is completely free of the pedicle. The peritoneum is then scored over the base of the pedicle toward the cephalad bare area, and the pedicle is safely isolated and ligated. The medial cut edge of the mesentery near the right branch of the middle colic vessels is grasped and reflected to the video right, allowing any remaining attachments to the duodenum, stomach, or omentum which can be seen and gently sweep free. The transverse colon mesentery is then elevated under tension, which allows for the right branch to bowstring, and, ideally, a bare area is seen medial to the vessel (Fig. 26.18). The peritoneum is then scored from the colon down to the base of the vessel and then across it to connect with the cut edge of the mesentery. Blunt dissection of the bare area will allow access into the lesser sac and for safe ligation of the pedicle. Because the omentum has been previously dissected free from entering the lesser sac, the vessel can be safely ligated without the risk of injury to

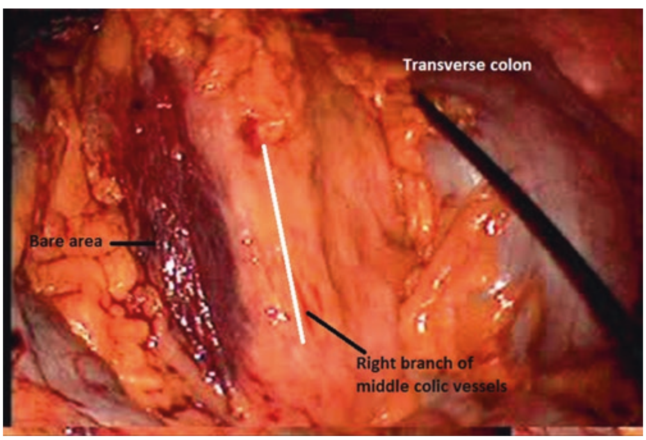

FIGURE 26-14. Exposure of the right branch of the middle colic vessels.

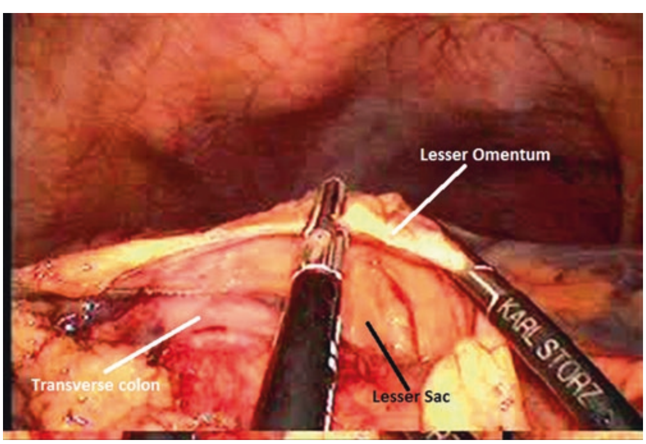

FIGURE 26-15. Entering the lesser sac by separating the lesser omentum from the transverse colon at the distal site of transection.

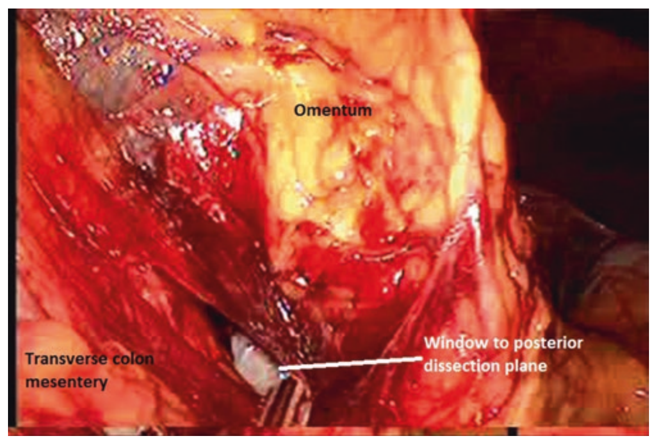

FIGURE 26-16. Exposure of posterior dissection plane from the superior approach.

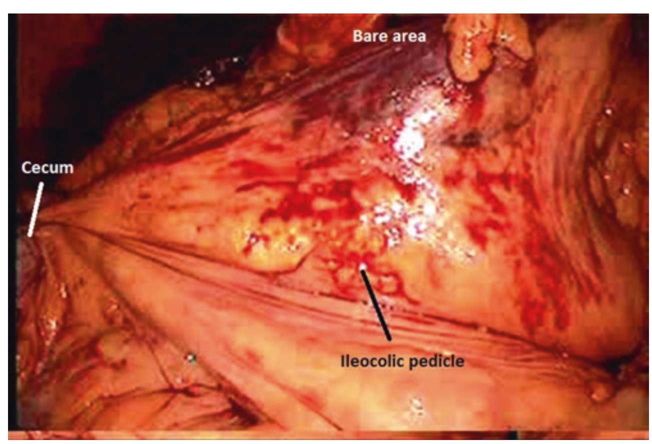

FIGURE 26-17. Identification of the ileocolic pedicle.

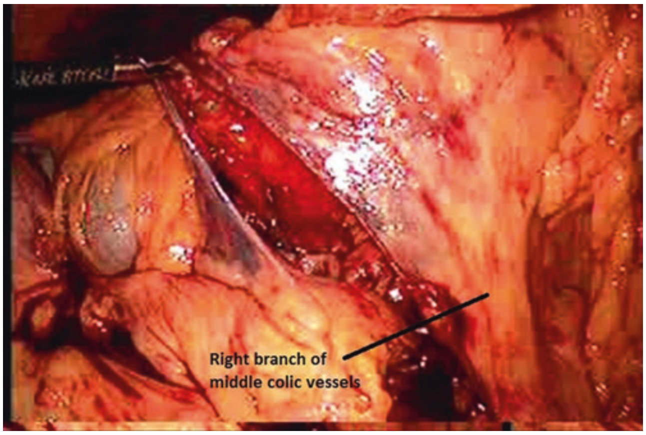

FIGURE 26-18. Identification of the right branch of the middle colic vessels.

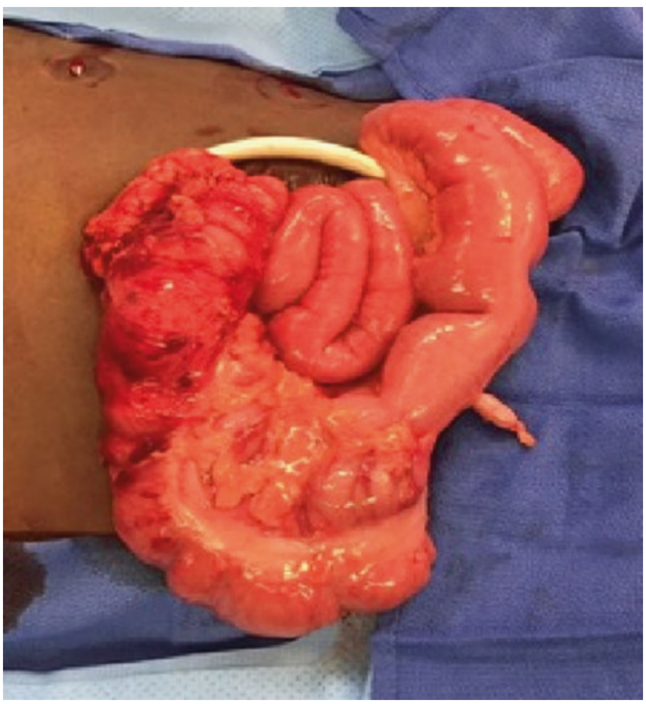

FIGURE 26-19. Extraction of the right colon.

surrounding structures. The colon can now be extracted and resected and the anastomosis created as described in the medial-to-lateral section (Fig. 26.19).

Left Colectomy

Open

The patient is placed in the lithotomy position to have access to the perineum for the anastomosis and anastomotic assessment. One of the patient's arms can be tucked to his/her side, and the Mayo stand for the scrub nurse can be placed over the patient's head, or the scrub nurse can stand off one of the patient's hips. The peritoneum is entered via a midline incision that allows for complete exploration and mobilization of the splenic flexure. With the abdomen open, a wound protector can be inserted, and a self-retaining retractor can be utilized. Initial exposure of the left colon anatomy is accomplished by packing the small bowel in the right upper quadrant, so the base of the left colon mesentery includes exposing the inferior mesenteric artery (IMA) at its origin (Fig. 26.20) and the inferior mesenteric vein (IMV) as it courses near the ligament of Treitz and inferior border of the pancreas (Fig. 26.21). The cecum and terminal ileum are also

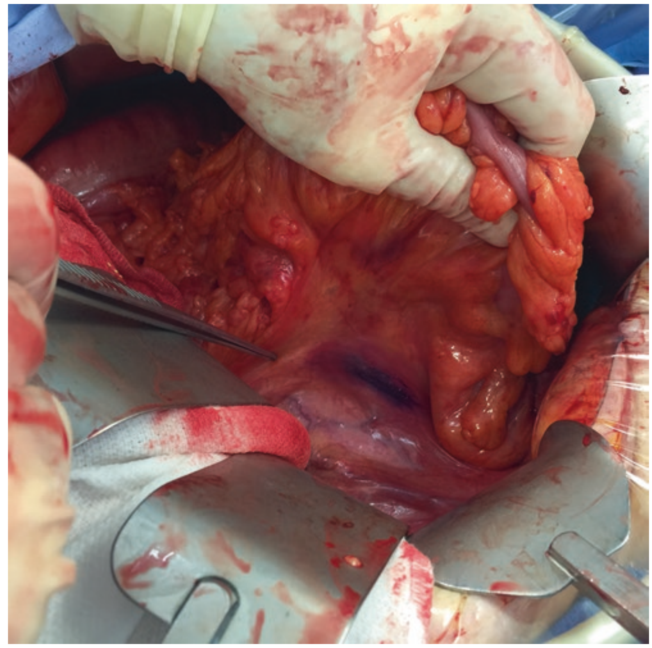

FIGURE 26-20. Medial exposure of the IMA.

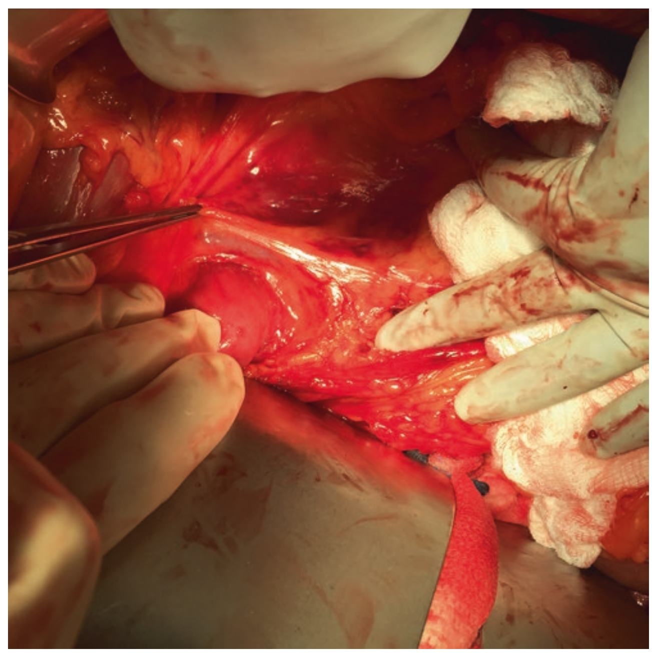

FIGURE 26-21. Medial exposure of the IMV.

packed away to provide complete exposure into the pelvis and the sacral promontory. The dissection begins with division of the lateral attachments of the sigmoid colon to allow for visualization of the white line of Toldt from the upper rectum to the proximal descending colon. The sigmoid colon and descending colon are elevated and retracted medially, and a long incision is made in the peritoneum to enter the retroperitoneal plane. With adequate tension on the colon and its mesentery, the areolar plane of dissection along the retroperitoneal plane is easily identified. The dissection is facilitated by exposing and dividing the retroperitoneal attachments along a plane of dissection as long as possible. The sigmoid colon and its mesentery should be completely medialized to the midline to expose and identify the left ureter. The dissection is then carried toward the splenic flexure. Mobilization of the splenic flexure can be facilitated by dissecting the posterior aspect of the mesentery up to the inferior border of the pancreas. The anatomy of the splenic flexure can be obscured by attachments of the omentum to the descending colon or medial aspect of the transverse colon. Separating these attachments restores normal anatomy, which can make the splenic flexure mobilization much easier. The next goal is to enter the lesser sac, and this is accomplished by separating the omentum from the transverse colon. By incising the peritoneal layer along the length of the transverse colon, the lesser sac is eventually entered, and the posterior attachments of the omentum to the colon mesentery can be exposed and divided. This will allow the lesser sac to be completely exposed from the flexure to beyond midline. This will also expose the remaining lateral attachments of the flexure which can be divided by either retracting the colon medially or placing a hand into the retroperitoneum and rolling the colon medially over the hand. With the lesser sac completely open and the flexure mobilized, the posterior attachments along the inferior border of the pancreas can be divided. With the posterior mesenteric dissection carried all the way up to the inferior border of the pancreas, the surgeon's right hand is passed into the retroperitoneum in the lateral-to-medial direction. The fold of the splenic flexure mesentery can be palpated and separated from the inferior aspect of the pancreas, and the overlying peritoneum is divided to the midline. Care should be taken not to injure the IMV as the dissection is carried medially. With the left colon and splenic flexure completely mobilized, the vascular pedicles can be isolated and ligated. The sigmoid colon is elevated and retracted laterally to expose the base of the mesentery at the level of the sacral promontory. The peritoneum is incised from just below the promontory toward the attachments of the proximal jejunum and ligament of Treitz. This will allow for the superior rectal artery to be elevated off the retroperitoneum and expose the lateral plane of dissection. The surgeon can then pass his/her right hand under the superior rectal artery and divide the cephalad attachments, so the IMA can be isolated at its origin from the aorta (Fig. 26.22). The artery is isolated by creating a window on its cephalad side and medial to the IMV. It can then be ligated once the left ureter is clearly out of harm's way. The IMV is now elevated off the retroperitoneum and isolated at the inferior border of the pancreas, and its ligation will ensure adequate mobilization for a tension-free anastomosis (Fig. 26.23). This allows for complete exposure of the retroperitoneum (Fig. 26.24). The proximal site of transection is dependent upon the location of the tumor and should ensure a minimum of a 5 cm margin. The distal site of transection should be at the proximal rectum to ensure an adequate distal margin and avoid having distal sigmoid colon

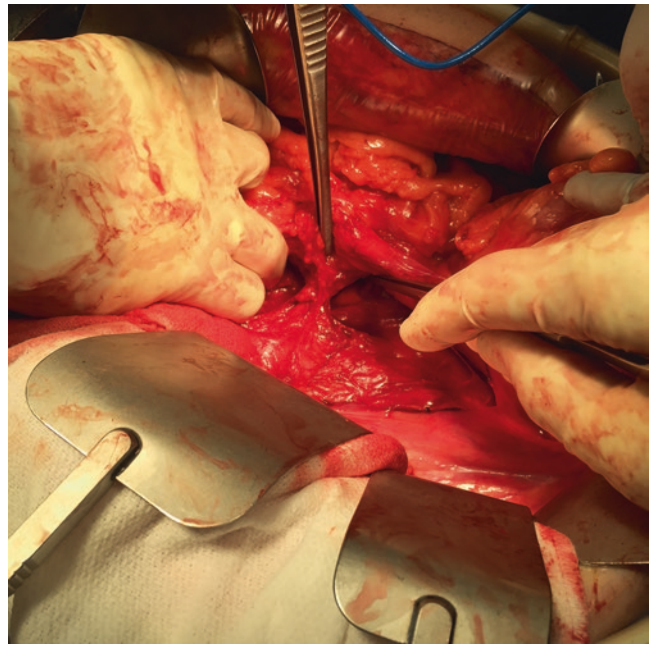

Figure 26-22. Isolation of the IMA.

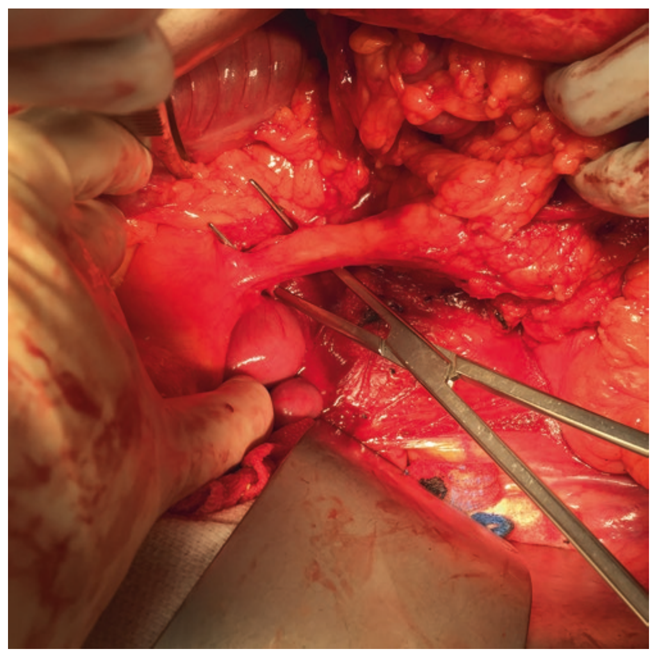

Figure 26-23. Isolation of the IMV.

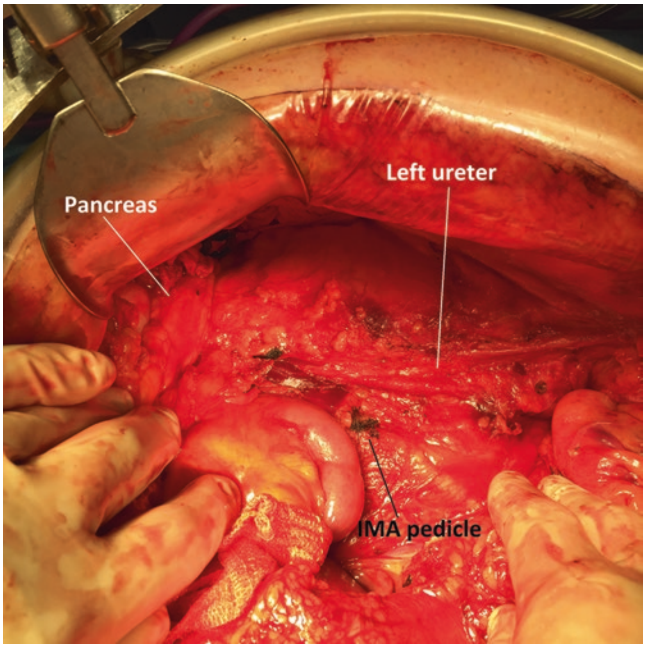

FIGURE 26-24. Left retroperitoneum.

included in the anastomosis. The rectum is stapled and divided with a linear stapler. The anastomosis is most easily accomplished with an end-to-end double-stapled technique (see Chap. 9). The anvil is placed in the proximal colotomy after the creation of a purse string. The purse string is tightened while ensuring that the edges of the colotomy are everted, so all edges of the colotomy are incorporated into the purse string. The stapling cartridge is passed transanally to the top of the rectal stump. The stapler head should be flushed with the transverse staple line. A rectal fold or pelvic adhesion will sometimes prevent the stapler head from sitting flush. If a rectal fold is preventing this, the rectum can be further mobilized and divided a few centimeters lower, and if it is a pelvic adhesion preventing passing of the stapling cartridge, further mobilization of the rectum will often be adequate to get the stapler up to the staple line. The spike of the stapler is deployed just anterior or posterior to the transverse staple line. The anvil is reassembled to make sure there is no twist in the left colon and its mesentery.

Anastomotic Assessment

Anastomotic assessment with either an air leak test alone or combined with endoscopic visualization is critical to ensuring a safe anastomosis. Anastomotic assessment has been shown to be associated with a decreased incidence of anastomotic leak from left-sided anastomosis. Kwon et al. audited the data from the Washington state's Surgical Care and Outcomes Assessment Program regarding the utilization and outcomes associated with routine testing of colorectal anastomosis [27]. For this study, anastomotic testing consisted of insufflation of Betadine, methylene blue, or air under pressure, and an adverse event included a return to the operating room for an ostomy creation, anastomotic revision, or drainage of abscess associated with a documented leak. For hospitals where the surgeons routinely performed anastomotic leak tests (defined as occurring in >90 % of cases), there was a 75 % lower risk of anastomotic leak (adjusted OR, 0.50; 95 % CI, 0.05–0.99) compared to those hospitals that employed selective leak testing (adjusted OR, 2.68; 95 % CI, 1.14–6.26). A retrospective review by Ricciardi et al. demonstrated an overall leak rate of 4.8 % for 998 patients that underwent a left-sided colorectal anastomosis without proximal diversion [28]. Ninety percent of patients underwent air leak testing, and the associated leak rates were 7.7 % with a positive air leak test, 3.8 % with a negative air leak test, and 8.1 % when no air leak test was performed ($p<0.03$). Additionally, they examined the measures taken to address the positive air leak test and the associated outcomes. Suture repair alone resulted in a leak rate of 12.2 % versus 0 % ($p=0.19$) for either anastomotic revision or proximal diversion. The lack of statistical significance is most likely related to the small number of leaks. Despite this, it is clear that anastomotic testing is critical, and an anastomosis with a positive leak test can be safely managed with a low incidence of a clinical leak. An acceptable alternative to the above-described leak testing is an endoscopic assessment. Li et al. compared the outcomes of patients with left-sided colorectal anastomosis who underwent routine intraoperative endoscopy (107 patients) versus those who had selective intraoperative endoscopy (137 patients) [29]. The routine endoscopy group had a 0 % anastomotic leak rate, and 0.9 % of the patients had bleeding from the staple line that required intervention. Twenty-two percent of the patients in the selective group underwent endoscopic assessment with a 5 % incidence of an anastomotic complication. This was not statistically significant, but it does highlight the safety and utility to assess for and address anastomotic complications intraoperatively. A second study examining the utility of intraoperative endoscopy included 415 consecutive patients with 17 patients having an anastomotic abnormality identified [30]. Fifteen patients had an air leak from the staple line, and all were managed safely without an anastomotic leak. The data above clearly supports the routine use of anastomotic assessment for left-sided anastomosis, which can be performed with either an air leak test alone or in conjunction with endoscopic visualization. However, successful anastomotic healing is also dependent upon both ends of the bowel having adequate blood supply and the creation of a tension-free anastomosis using soft, pliable, normal bowel.

Straight Laparoscopic Medial-to-Lateral Approach

The patient is positioned and secured to the operating table in the same manner as described above for the laparoscopic right colectomy. Typically, both arms are tucked to the patient's sides, and the legs are in the lithotomy position. The abdomen is accessed via an open or closed technique in the supraumbilical position. There are various options for port placement, and the choice is dependent upon surgeon preference (Fig. 26.25). Typically, there are three working ports—two for the surgeon and one for the assistant. Once the abdomen has been thoroughly explored and the lesion located, the patient is placed in steep Trendelenburg and airplaned so the left side is up. This allows gravity to retract the small bowel to the right upper quadrant and expose the left colon mesentery. The omentum is reflected cephalad to the transverse colon to expose it and the splenic flexure. The IMV and the superior rectal artery are the vascular landmarks to be identified. At the level of the sacral promontory, the superior rectal artery is grasped and elevated with the surgeon's right hand. This will allow for the course of the artery to be seen and traced to its origin. With the energy source of choice in the left hand, the peritoneum is incised from below the sacral promontory to the IMA origin on the aorta. The wider the incision, the wider the window to the retroperitoneum will be, and this will maximize visualization of the retroperitoneum. Once the incision is made, the facial covering of the artery can be identified. Early in this dissection, the proper retroperitoneal plane is often difficult to see because it is heading up and away from the view as it follows the curve of the pelvic brim anteriorly. With a wide window to the retroperitoneum, the superior rectal artery can be elevated and pulled slightly toward the camera to visualize the proper plane. The retroperitoneum is swept posteriorly until the left ureter is identified. If the left ureter is difficult to identify, an alternative approach should be taken, and it will be described below. Once the left ureter is safely swept into the retroperitoneum, the superior rectal artery is dissected free to the origin of the IMA at the aorta. The peritoneum is then scored across the base of the IMA and medial to the IMV. The vein is then grasped and elevated off the retroperitoneum by scoring the peritoneum up to the ligament of Treitz. This will allow access into the retroperitoneum once again, and the plane is developed in a caudad direction to join with the original retroperitoneal dissection plane. The IMA is safely isolated, and the left ureter can be traced from the pelvic brim up to near the kidney. The IMA can be ligated with any energy source of choice. Next, the IMV can be isolated by separating the mesentery from the retroperitoneum to the inferior border of the pancreas. Once isolated, it can be safely ligated. Now there is a giant window into the retroperitoneum, and the left colon mesentery is mobilized out beyond the colon laterally. This dissection should extend from the sigmoid colon up to the splenic flexure, so all that remains are the lateral attachments. Beginning near the pelvic brim, the lateral peritoneum is incised by retracting the sigmoid colon medially and cephalad. This will allow for entry into the medial plane of dissection, and the lateral dissection continues toward the splenic flexure. As the splenic flexure is neared, there needs to be a transition from dividing the lateral peritoneal attachments to separating the omentum from the colon, and this is dependent upon the adhesions between the two structures. Mobilization of the splenic flexure usually requires a third working instrument. The omentum just above its attachment to the colon is retracted anteriorly, and the colon is retracted posteriorly, which puts the plane to be incised in a vertical position. This superficial peritoneal plane is incised toward the midline, and the lesser sac is eventually entered. Once the lesser sac is entered, the deeper attachments of the omentum and transverse colon can be divided. These deeper attachments are identified by pulling the colon down to the lower abdomen and watching for where the omentum moves or is attached. The omentum and colon are grabbed at this point, and by making the plane vertical, they are divided. The lesser sac is completely opened in this fashion so that all that remains are the peritoneal attachments to the inferior border of the pancreas. These attachments are divided by retracting the splenic flexure medially and caudad while elevating it off the retroperitoneum. This will allow for visualization along the retroperitoneal and lesser sac sides of this attachment. Division of this attachment to the midline will allow for adequate mobilization for extraction, resection, and tension-free anastomosis. The rectum can be divided either intracorporeally or in an open fashion through a suprapubic extraction site. If the rectum is divided intracorporeally, the colon can be extracted through either a left lower quadrant or suprapubic site. With either method of rectal division, the colon is extracted and resected, and the anvil is placed in the same method as described above for an end-to-end anastomosis. The proximal colon is then returned to the abdomen, and the extraction port can be closed temporarily or definitively. Under laparoscopic visualization, the stapler is passed transanally up to the top of the rectal stump, and the anvil is reassembled making sure there is no twist in the left colon and its mesentery. An air leak test or endoscopic assessment is performed under laparoscopic

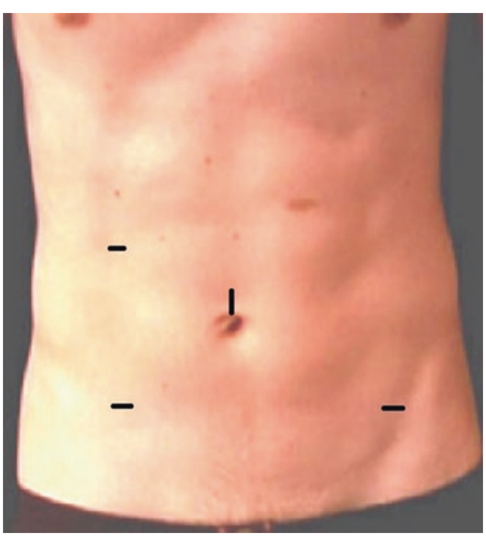

FIGURE 26-25. Port placement for laparoscopic left colectomy.

visualization. Typically, only 10–12 mm port sites need to have the fascial defect closed, and this can be accomplished open via the skin incision or laparoscopically using a transfascial suture passer.

Hand-Assisted Medial-to-Lateral Approach

Patient preparation and position are the same as for the straight laparoscopic approach. The hand port can be placed in the suprapubic, periumbilical, or left lower quadrant based on surgeon preference (Fig. 26.26). A suprapubic hand port has the advantage of having direct access to the pelvis to aid the pelvic dissection, divide the rectum, perform the anastomosis, and manage anastomotic complications. The port can be placed through a vertical midline or Pfannenstiel incision. For a suprapubic hand port, the camera port is placed in the supraumbilical position to avoid interfering with the hand port. A working port is placed on the right side, half the distance between the hand and camera ports and lateral to the rectum muscle. A second working port is placed in the left lower quadrant to help with the lateral and splenic flexure mobilization. This port is placed lateral to the rectus muscle and as low as possible to minimize the time working against the camera. With the patient placed in steep Trendelenburg and left-side up, the small bowel is put in the right upper quadrant, and the omentum is reflected to the upper abdomen. This exposes the left colon mesentery and splenic flexure as previously described. The surgeon stands on the patient's right side and places his/her right hand in the abdomen. The superior rectal artery at the level of the sacral promontory is grasped and elevated (Fig. 26.27), and the peritoneum is incised as described above (Fig. 26.28). The hand acting as a retractor elevates the vessel to expose the retroperitoneum. The identification of the left ureter and its reflection into the retroperitoneum is the same as described above (Fig. 26.29). Once the left ureter is identified and separated from the mesentery, the index finger is used to elevate

Figure 26-26. Port placement for HALS left colectomy.

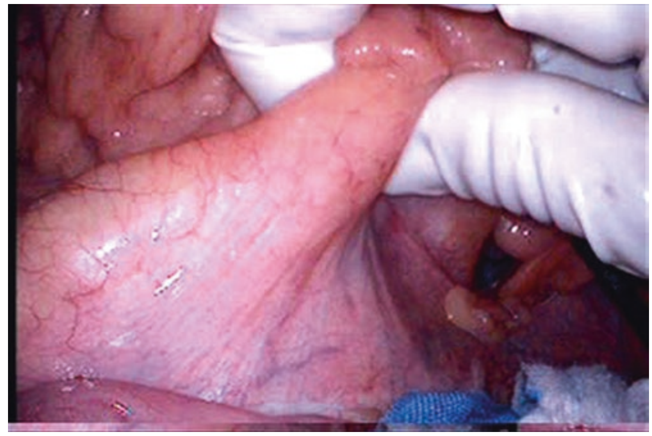

Figure 26-27. Isolation of the superior rectal artery at the level of the sacral promontory.

Figure 26-28. Accessing the retroperitoneum at the level of the sacral promontory.

Figure 26–29. Identification of the left ureter from a medial-to-lateral approach.

the superior rectal artery under tension. The middle finger can then bluntly sweep down the retroperitoneum working toward the origin of the IMA (Fig. 26.30). Care should be used to sweep the retroperitoneal tissue and associated sympathetic nerves posteriorly to avoid their injury during the ligation of the vessel. This dissection is carried cephalad to the vessel to expose and elevate the window medial to the IMV. The peritoneum is incised across the IMA origin, and the retroperitoneum can be entered medial to the IMV. The hand now elevates the IMV, and the peritoneum is incised up to the ligament of Treitz (Fig. 26.31). The retroperitoneum is swept down, and the thumb elevates the IMV and mesentery to keep it on tension. Once the retroperitoneal plane is adequately developed, the index finger elevates the IMV, and the middle finger sweeps the retroperitoneum down as the IVM is elevated to isolate it at the inferior border of the pancreas (Fig. 26.32). Now that both vascular structures are safely isolated and the left ureter is safely in the retroperitoneum, both vessels can be ligated (Fig. 26.33). For ligating both the artery and vein, the index and middle fingers are placed in the retroperitoneum behind the vessel to create space, the fourth and fifth fingers lay in front of the vessel to protect the small bowel, and the thumb can help elevate any mesentery or fat obscuring the view (Fig. 26.34). With both pedicles ligated, the hand is placed palm down under the mesentery. It elevates the mesentery under tension, so the retroperitoneal dissection can be carried out laterally beyond the colon (Fig. 26.35). The extent of the dissection should be from the

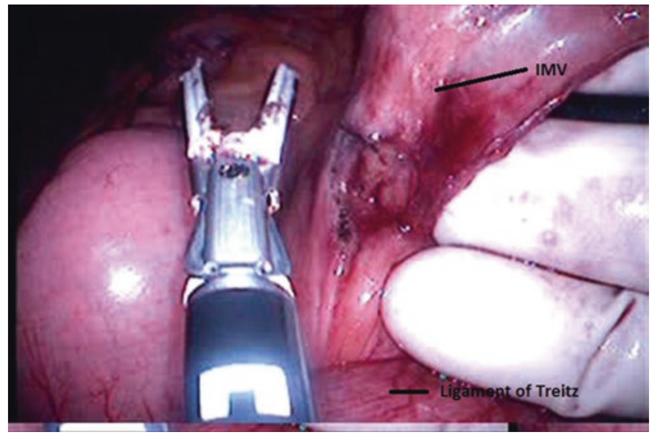

FIGURE 26-32. Isolating the IMV near the ligament of Treitz and the inferior border of the pancreas.

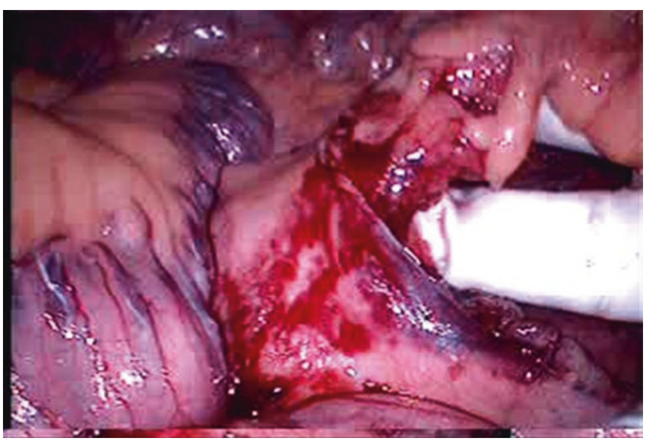

FIGURE 26-30. Isolating the IMA at its origin.

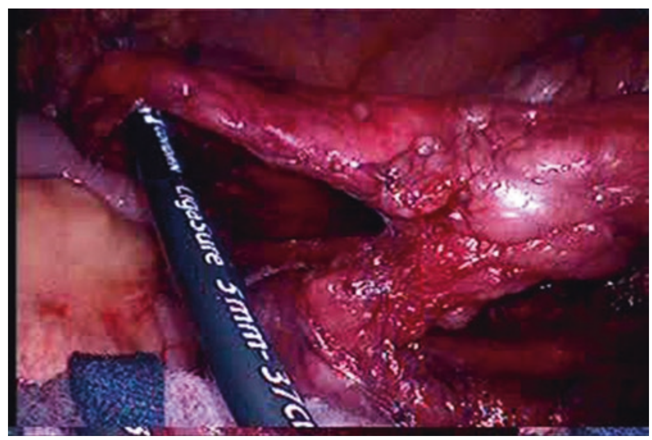

FIGURE 26-33. Safe isolation of the IMA.

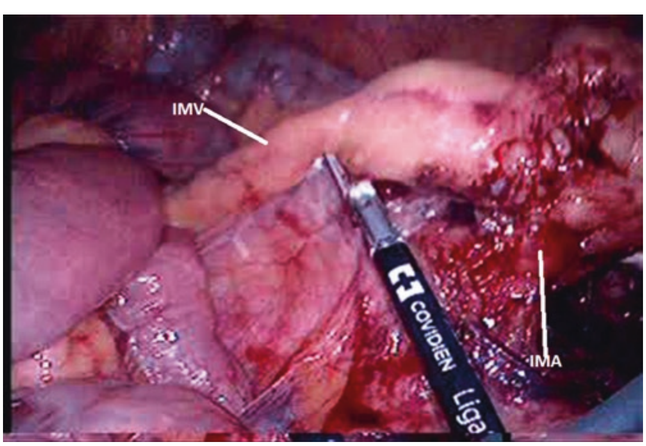

FIGURE 26-31. Accessing the retroperitoneum medial to the IMV.

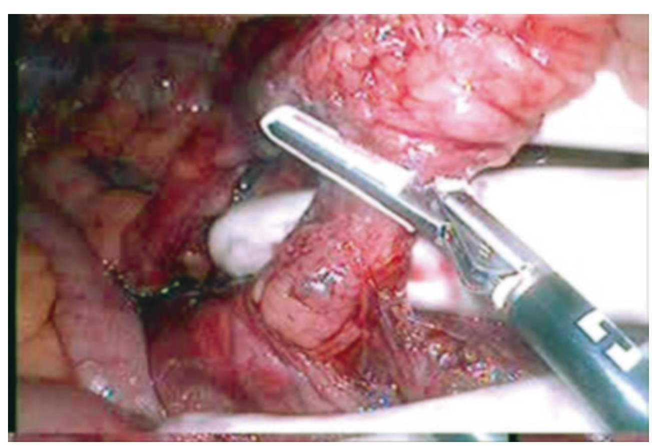

FIGURE 26-34. Hand position for ligating the IMA and IMV.

sigmoid colon caudad up to the splenic flexure cephalad and along the inferior border of the pancreas medially. The lateral dissection begins by mobilizing the sigmoid colon. Often, the hand gets in the way for this dissection, so solutions include depressing the sigmoid colon with the fingers and passing the energy device between the fingers to get the proper angle or removing the hand and placing an instrument through the hand port to begin the dissection straight laparoscopically. Once the retroperitoneal dissection plane is entered (Fig. 26.36), the hand can be passed into the retroperitoneum, and the lateral attachments can be exposed on the hand just like an open case (Fig. 26.37). The assistant stands between the legs and uses the left lower quadrant port to divide the tissue. The dissection continues toward the splenic flexure until the need to transition to the omentum. At the omental attachments, the omentum is elevated and pulled to the video right with the grasper, and the colon is retracted down with the hand (Fig. 26.38). Pulling with the grasper to the right helps to keep it out of the way of the energy device during this dissection. The peritoneum is incised along the transverse colon, and the lesser sac is eventually entered. With the hand and instrument, the colon is pulled to the lower abdomen, and the next level of omental attachments is identified. At this point, the omentum is elevated, and the colon is depressed allowing for the attachments to be divided. This is continued until the lesser sac is wide open from the splenic flexure to the midline (Fig. 26.39). The only remain-

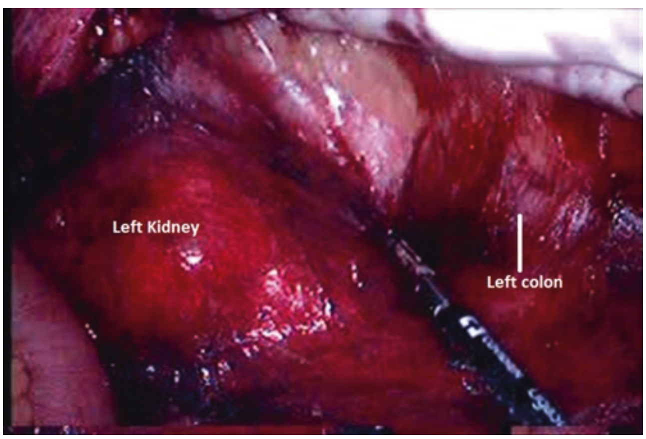

FIGURE 26-35. Medial-to-lateral mobilization of the left colon mesentery off the retroperitoneum.

FIGURE 26-36. Incision of the lateral attachments and entry into the retroperitoneal plane.

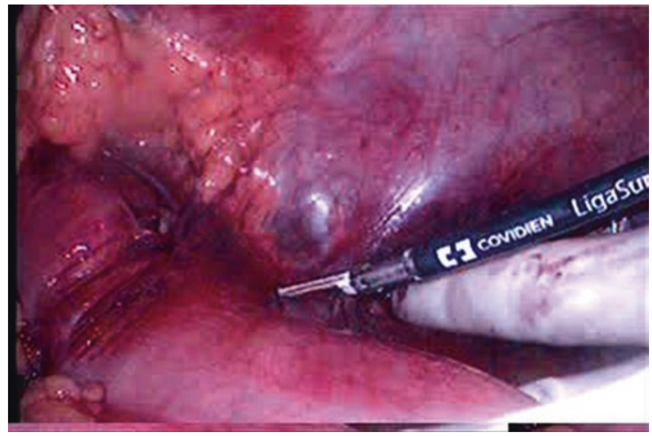

FIGURE 26-37. Lateral mobilization of the left colon.

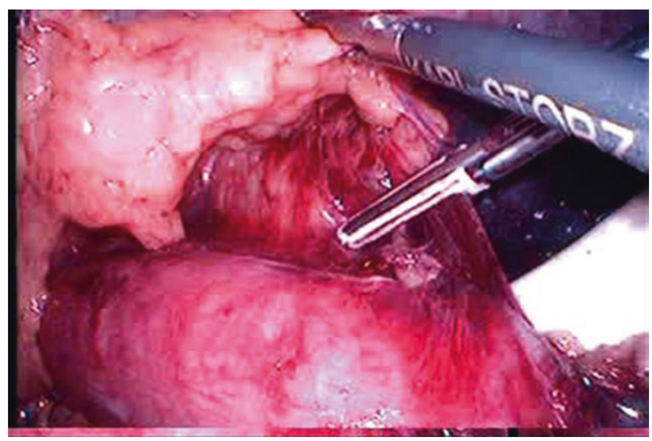

FIGURE 26-38. Entering the lesser sac by separating the omentum from the transverse colon.

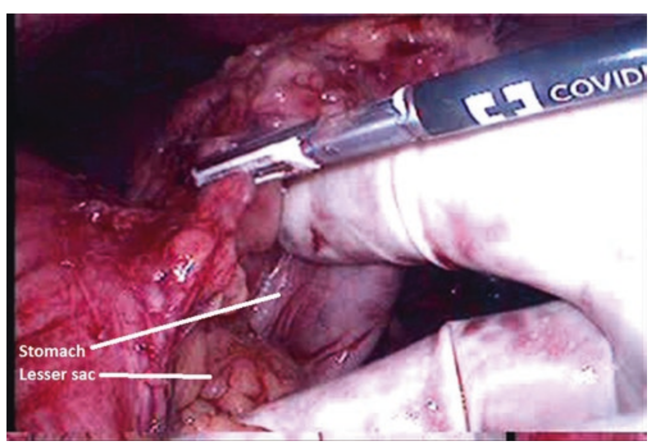

FIGURE 26-39. Completing the opening of the lesser sac.

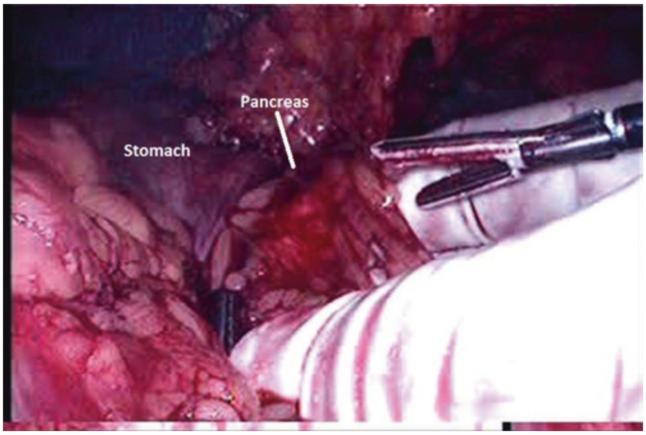

Figure 26-40. Division of the peritoneal attachments between the transverse colon mesentery and the inferior border of the pancreas.

ing attachments are along the inferior border of the pancreas. With the colon pulled to the lower abdomen, the lateral cut edge of the mobilization is seen. The hand is passed into the retroperitoneum along the inferior border of the pancreas. Much like the open approach, the fold of the mesentery can be palpated and separated from the pancreas allowing for safe division to the midline (Fig. 26.40). The colon is completely mobilized at this point and can be extracted for resection and anastomosis. Typically, the proximal colon is divided, the stapling anvil is placed, and the rectum is divided. This procedure has been previously described. However, this can be difficult in patients with a fat or bulky mesentery. This can be managed by dividing the rectum and the mesorectum first allowing for easier extraction of the proximal colon. The anastomosis and anastomotic assessment can be performed under direct vision via the hand port or laparoscopically.

Laparoscopic Identification of the Left Ureter

The IMA or IMV should not be ligated until the left ureter is clearly identified and safely dissected free of the left colon mesentery. There is a simple three-step algorithm that can help facilitate safe identification of the left ureter. The first approach is at the level of the superior rectal artery as the retroperitoneum is accessed at the level of the sacral promontory as described above. If the ureter is not easily identified, the approach should change to the IMV. The IMV is grasped and elevated, and the medial aspect of the peritoneum is incised. The retroperitoneum is accessed and the plane developed. This part of the retroperitoneum is flat, so identification of the proper plane is much easier. Once in the proper plane, the dissection can be directed in a caudad direction to see if the original plane started at the level of the sacral promontory can be entered to identify the ureter. If the left ureter can still not be identified, the colon can be mobilized in a lateral-to-medial direction. If unable to identify the ureter at this point, consider conversion to an open procedure, or, if using a hand port, remove the top of the port and identify it in an open fashion through the hand port. A ureteral stent should be employed at the discretion of the surgeon.

Subtotal Colectomy

Tumors of the transverse colon often increase the complexity of the required resection because of the need to divide most or all of the branches of the middle colic vessels. An extended right colectomy can adequately treat a tumor from the hepatic flexure to the mid-transverse colon. With complete mobilization of the small bowel mesentery and widely opening the lesser sac toward the splenic flexure, there should be adequate mobilization to create an ileocolic anastomosis with proper bowel orientation and without tension from either an open or laparoscopic approach. However, distal transverse colon tumors tend be more difficult to manage. Some surgeons advocate a transverse colectomy, but challenges associated with this type of resection include obtaining an adequate mesenteric resection and mobilization of the right and left colon to create a safe, tension-free anastomosis. For patients with a redundant and mobile transverse colon, it may be feasible to perform an extended left colectomy. If the transverse colon cannot be mobilized enough to reach the top of the rectum, it may be more appropriate to perform a subtotal colectomy. This entails resection of the right and transverse colon and creation of an ileo-descending colon anastomosis.

Open Approach

The right colon mobilization begins as described above, and as the hepatic flexure is mobilized, the lesser sac is entered by separating the omentum from the transverse colon mesentery. The plane to the right of the midline tends to be fused, but it is an avascular plane so it can be developed bluntly. With careful dissection under tension, the plane can be developed, and the proper lesser sac is entered. The lesser omentum is divided toward the splenic flexure as far as possible. With the right colon and hepatic flexure mobilized and the lesser sac completely open, the mesentery can be ligated. This begins with isolation and ligation of the ileocolic pedicle and division of the terminal ileum and its mesentery as described in the open right colectomy section. The middle colic vessels are isolated by pulling the transverse colon caudad and having the surgeon, who is standing on the patient's left side, pass his/her left hand through the ileocolic mesenteric defect from the retroperitoneal to peritoneal side. The index finger is elevated against the junction of the SMA and the origins of the middle colic vessels, which allows for a safe high ligation of these vessels. Now the left colon needs to be mobilized, and the surgeon switches to the patient's right side packing the small bowel into the right upper quadrant. The sigmoid colon, left colon, and splenic flexure are mobilized as described in the open left colectomy section. The IMV is isolated by grasping and elevating it, so the peritoneum medial to it can be incised. This allows access into the retroperitoneal dissection plane, and the IMV can be isolated and ligated at the inferior border of the pancreas. The IMA is not isolated or ligated to preserve the blood supply to the distal colon. The distal bowel and mesentery are divided to provide an adequate distal margin. For the creation of a side-to-side ileocolic anastomosis, the orientation of the small bowel is very important. If the stapled end of the terminal ileum is brought over the top of the small bowel to perform a side-to-side anastomosis on the left side, this will create the potential for the small bowel to volvulize through the mesenteric defect. To avoid this complication, the small bowel needs to be rotated 180° counterclockwise, so the cut edge of the mesentery is brought underneath the remaining small bowel. This allows for the cut edge of the small bowel mesentery to pass under the small bowel and face the patient's left side in a straight line. Also, the entire small bowel from the ligament of Treitz to the anastomosis is on top of the mesenteric defect, so there is no risk of a small bowel volvulus. This will allow for a side-to-side stapled anastomosis to be performed.

Laparoscopic Approach

This extended resection can occur either straight laparoscopically or hand assisted. For the straight laparoscopic approach, the right colon is mobilized in the same fashion as described for right colectomy. Once the lesser sac is entered, the lesser omentum is divided as far as possible toward the splenic flexure. This exposes the lesser sac as much as possible and facilitates ligation of the middle colic vessels by clearing any posterior mesenteric attachments. With the ileocolic vessel ligated, the middle colic vessels are exposed. This is accomplished with the first assistant via one or two right-sided ports elevating the transverse colon in an ole-type fashion. The peritoneum from near the ligament of Treitz is scored across the base of the vessels to the cut edge of the mesentery on the right. This allows the individual branches of the middle colic vessels to be isolated and safely ligated. With the right colon and transverse colon mobilized and the mesentery ligated, attention is turned to the left colon. The patient is positioned as described for a laparoscopic left colon. The IMV is identified and elevated so the peritoneum can be incised allowing access to the retroperitoneum. The IMV is mobilized, isolated, and ligated at the inferior border of the pancreas. The mesenteric side of the IMV and the cut edge of the transverse colon mesentery are elevated, and the intervening mesentery is divided. Ideally, there should not be any remaining vessels in this remaining bit of mesentery. With the mesentery of the colon to be resected completely divided, the left colon mesentery is mobilized out laterally beyond the colon. To ensure adequate mobilization for extraction and the anastomosis, the sigmoid colon should be mobilized. The lateral attachments starting at the sigmoid colon are incised and divided toward the splenic flexure. The splenic flexure is mobilized as described in the left colectomy section. Once the colon is completely mobilized and before it can be extracted, the IMV needs to be divided again along the line of the distal resection margin. If it is not divided before extraction, the specimen will be tethered by this vessel preventing adequate exposure. Some surgeons will divide the entire specimen intracorporeally. Prior to performing the anastomosis, the small bowel and its mesentery must be oriented as described above. The specimen can then be extracted via a midline incision.

For a hand-assisted approach, the port placement is the same as described for the left colectomy. The dissection begins with mobilization of the right colon. The posterior approach will be described here. The small bowel is placed in the right upper quadrant exposing the posterior attachments of the small bowel mesentery to the retroperitoneum. The mesentery is grasped and elevated with the middle finger and thumb of the left hand. The index finger pointing toward the head swings over the pedicle to further expose the duodenum (Fig. 26.41). The peritoneum is incised from the duodenum to the cecum. With the hand palm down, the fingers elevate this peritoneal incision, and the retroperitoneum is entered. The hand continues to elevate the right colon mesentery, and the duodenum is exposed and reflected posteriorly (Fig. 26.42). This dissection is continued superiorly and laterally beyond the transverse colon, hepatic flexure, and ascending colon. The patient is then tilted right-side up to move the small bowel to the left side of the abdomen and expose the lateral planes. The lateral dissection begins at the level of the cecum by placing the hand in the retroperitoneal plane and lateral to the cecum and right colon to expose the lateral attachments (Fig. 26.43). They are divided heading toward the hepatic flexure, which is mobilized by entering

FIGURE 26-41. HALS exposure of the posterior aspect of the small bowel mesentery for the right colon dissection.

the lesser sac. The lesser sac is entered by separating the lesser omentum from the transverse colon mesentery (Fig. 26.44). Once the plane is developed, the cut edge of the lesser omentum is grasped with a grasper and elevated, so the hand can control the colon and develop the plane into the lesser sac. The lesser omentum is divided out toward the splenic flexure as far as possible. Now the right colon and transverse colon mesentery can be ligated. The ileocolic pedicle is isolated by pulling to the right lower quadrant. The peritoneum on the caudad aspect is incised, and the mesentery is dissected to expose the retroperitoneum. The index and middle fingers are passed through the mesenteric defect to expose the vessels and the bare area on their cephalad aspect (Fig. 26.45). The bare area is incised along the lines of resection to isolate and ligate the ileocolic pedicles. To isolate the middle colic vessels, the left hand is passed through the mesenteric defect into the retroperitoneum and lesser sac. The transverse colon mesentery is exposed by elevating the hand, and the first assistant via right lower quadrant port elevated the distal transverse colon (Fig. 26.46). The peritoneum is incised from the ligament of Treitz to the cut edge of the right colon mesentery. The hand is able to palpate each middle colic vessel to facilitate its isolation and ligation. With the right and transverse colon mesentery

FIGURE 26-44. Mobilization of the hepatic flexure by entering the lesser sac.

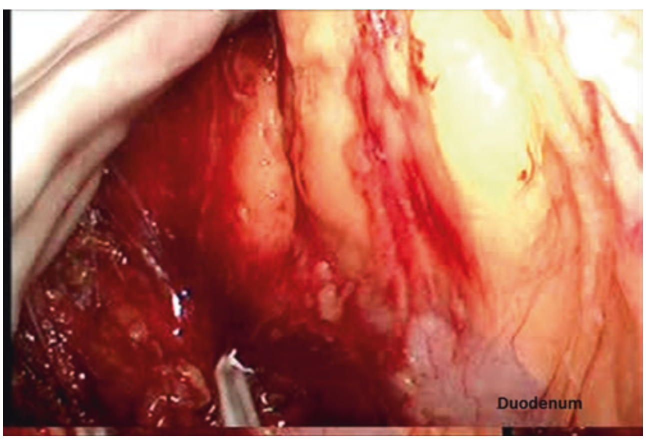

FIGURE 26-42. Accessing the retroperitoneal plane: elevating the right colon mesentery and dissecting the duodenum posteriorly.

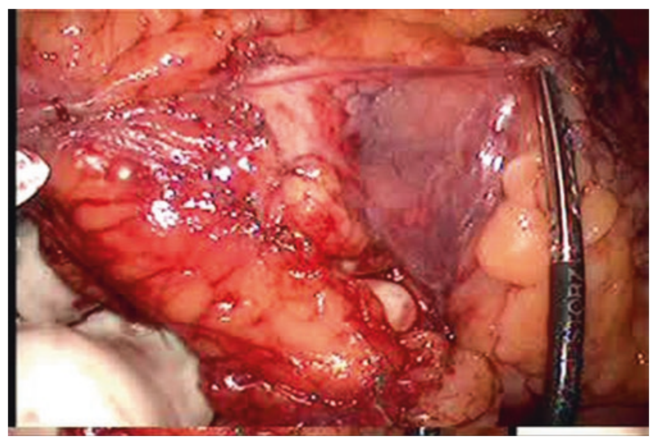

FIGURE 26-45. Isolation of the ileocolic pedicle by passing the hand through the mesenteric defect on the ileal side of the pedicle.

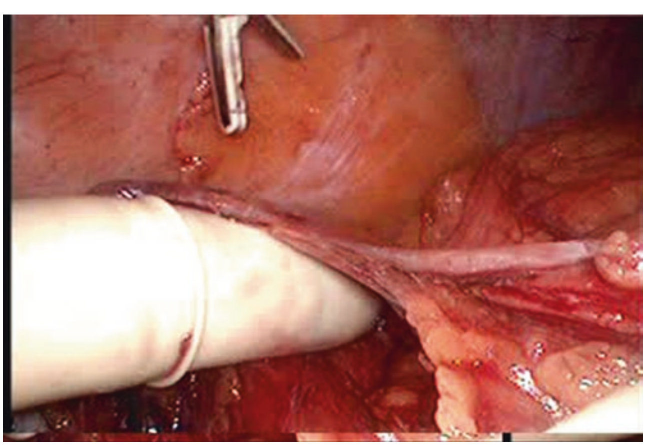

FIGURE 26-43. Division of the lateral attachments of the right colon.

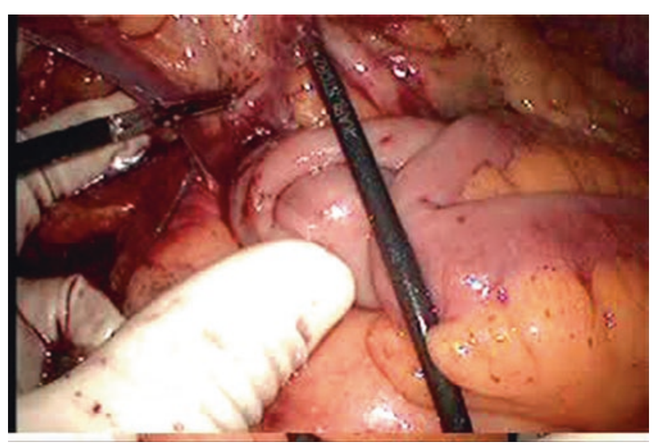

FIGURE 26-46. Exposure of the middle colic vessels.

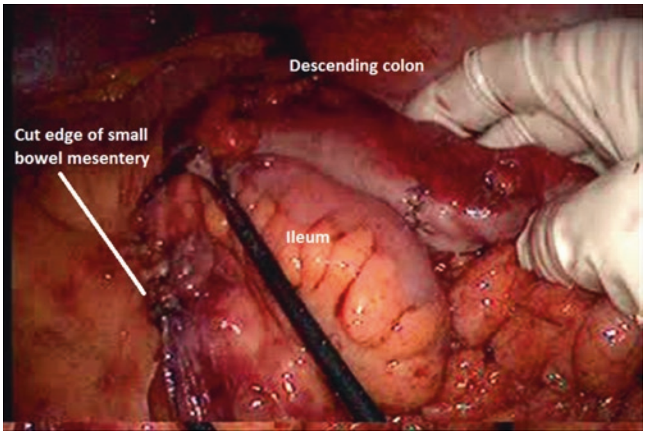

FIGURE 26-47. Orientation of the small bowel mesentery for an ileo-descending colon anastomosis.

divided, attention is turned to the left colon, and the left colon is mobilized as described in the paragraph above but using the hand-assisted technique for the left colon. The IMA is preserved to maintain blood supply to the sigmoid and descending colon. The IMV is then again divided at the distal resection margin, and the colon is then extracted through the hand port for resection. Just as described for the open approach, the small bowel and its mesentery are rotated 180° counterclockwise to allow the cut edge of the mesentery to face the patient's left side (Fig. 26.47). After the small bowel is properly oriented, a side-to-side anastomosis can be performed via the hand port.

Total Abdominal Colectomy with Ileorectal Anastomosis

Total abdominal colectomy may be indicated for patients with synchronous tumors or hereditary cancer syndromes such as hereditary nonpolyposis colorectal cancer or familial adenomatous polyposis. The entire abdominal colon is resected, and an ileorectal anastomosis can be performed in either an end-to-end, end-to-side, or isoperistaltic side-to-side fashion. Postoperative cancer surveillance can often be performed in the office, without sedation using either a rigid or flexible endoscopy.

Open Approach

The procedure begins with accessing the abdomen via a midline incision and performing a thorough exploration. The right colon and transverse colon are mobilized, and the associated mesentery is divided as described above in the open right colectomy and subtotal colectomy sections. The terminal ileal mesentery is divided up to the level of the bowel. For an end-to-end anastomosis, the bowel is divided sharply, the purse string is placed, and a 28 or 29 mm stapler anvil is placed inside the lumen. The purse string is cinched down making sure that all of the edges of the enterotomy are everted. It is rare that 28 or 29 mm anvil will not fit into the small bowel, so the need to use a smaller circular stapler is rare. The small bowel is then packed to the right upper quadrant and the left colon, and the splenic flexure is mobilized as described in the open left colectomy section. After the IMA is ligated at its origin and the IMV divided near the inferior border of the pancreas, the entire mesentery of the colon has been divided. The top of the rectum is identified, and the upper rectum is mobilized. At the site of distal transection, the peritoneum of the mesorectum is scored, and a window is created between the posterior rectal wall and the mesorectum. The rectum is then stapled and divided. The remaining mesorectum is then ligated. With the specimen removed, the anastomosis is completed by passing the stapling cartridge that is passed transanally to the top of the rectal stump. The spike is deployed, and the anvil is reassembled making sure the small bowel mesentery is not twisted. The small bowel should be oriented, so it is on the left side of the abdomen and the cut edge of the mesentery is facing to the patient's right side. The anastomosis must be tested with either an air leak test or endoscopically.

Laparoscopic Approach

The procedure can be performed by a straight laparoscopic approach or a hand-assisted approach based on the surgeon's preference. Port placement is typically symmetrical around the camera port. In other words, the surgeon's working ports are placed in same place for a right and left colectomy, so they are mirror images of each other. For a hand-assisted approach, the hand port is typically placed in the suprapubic position. Once again, the procedure begins with mobilization of the right and transverse colon with ligation of its mesentery as described in the laparoscopic right colectomy and subtotal colectomy sections. The left colon and its mesentery are resected as described in the laparoscopic left colectomy section. For the straight laparoscopic approach, the rectum and mesorectum are divided intracorporeally, and the specimen is extracted. The extraction site for a straight laparoscopic approach can be in the midline around the umbilicus or suprapubic or a muscle-splitting incision in the right or left lower quadrant. The terminal ileal mesentery is divided, and the terminal ileum is prepared for anastomosis. For the hand-assisted approach, the colon is extracted via the hand port. During the extraction, the small bowel must be passed underneath the colon, so when exteriorized, the small bowel mesentery will be properly oriented. The terminal ileum is resected and prepared for anastomosis, and the rectum and mesorectum are divided through the hand port. For the straight laparoscopic approach, the terminal ileum is returned to the abdomen, the extraction site is closed, and the anastomosis is created and tested laparoscopically. For the hand-assisted approach, this can be performed open through the hand port.

Special Circumstances

Laparoscopy

In 2004, the laparoscopic approach began its adoption into the surgeon's armamentarium for treating colon cancer with the publishing of the results of the US multicenter prospective randomized COST trial. The results of UK's CLASICC and European COLOR trials soon followed. Collectively, these studies demonstrated that the laparoscopic approach is not inferior to the open approach for the surgical management of colon cancer. Each study had unique findings that are worth discussing.

The COST Trial

The COST trial was designed as a non-inferiority study, which means it was designed to test the hypothesis that the laparoscopic approach was as effective as and not worse than the open approach for the treatment of colon cancer [31]. It included right and left colon cancers but excluded transverse colon cancers. Forty-eight centers and 66 credentialed surgeons participated and enrolled and randomized 435 patients to the laparoscopic group and 428 patients to the open group. The initial results were published with 4.4 years of follow-up and demonstrated that short-term outcomes favored the laparoscopic group with a shorter length of stay [5.6 days vs. 6.4 days ($p<0.001$)] and fewer days of intravenous and oral analgesics [3.2 days vs. 4.0 days ($p<0.001$) and 1.9 days vs. 2.2 days ($p=0.03$), respectively] [31, 32]. However, this did not translate into any significant difference in pain or quality of life scores, except that laparoscopy had a better global quality of life at 2 weeks after surgery only. There was a 21 % conversion rate and no difference in intraoperative complications, 30-day morbidity, or hospital readmission rates. Finally, there was no difference in the 3-year recurrence or overall survival rates [16 % vs. 18 % ($p=0.32$) and 86 % vs. 85 % ($p=0.51$) in the laparoscopic versus open groups, respectively], and these outcomes were similar stage for stage [32]. The initial results of this trial demonstrated that the laparoscopic approach was not inferior to the open surgical approach for the resection of colon cancer. The 5-year results confirmed the initial results as there was no difference in the primary endpoint of time to recurrence and secondary endpoints of disease-free (laparoscopic 69.2 % vs. open 68.4 %, $p=0.94$) and overall survival (laparoscopic 76.4 % vs. open 74.6 %, $p=0.93$) [33]. The site of first recurrence was also equivalent for each group [liver (5.8 % vs. 5.5 %)>lung (4.6 % vs. 4.6 %)>wound (0.5 % vs. 0.9 %), respectively]. Patients that underwent conversion had a worse 5-year overall survival compared to those completed laparoscopically and open. However, there was no difference in 5-year disease-free survival or recurrence associated with conversion. Long-term follow-up of quality of life data demonstrated that the laparoscopic group had a small but significant improvement in total quality of life index at 18 months after surgery, and those patients with poor preoperative quality of life were at higher risk of a "difficult" postoperative course [34].

The MRC CLASICC Trial

The CLASICC trial took place in the UK and included 27 medical centers. The surgeons were credentialed similarly to the COST trial. The study design was to assess short-term endpoints such as pathologic findings, hospital course, and quality of life and long-term endpoints of survival and recurrence at 3 and 5 years [35]. Patients were randomized 2:1 to the laparoscopic and open arms. Additionally, the study included both colon and rectal cancer patients. Two hundred seventy-three patients were randomized to the laparoscopic group and 140 patients to the open arm for colon cancer. Short-term outcomes showed no statistical difference in length of stay, return of bowel function, rate of curative resection, complications, and quality of life measures. There was a 29 % conversion rate, which steadily decreased over the course of enrollment into the study. Patients who underwent conversion were more likely to have a complication and less likely to have a curative resection, which highlights the importance of patient selection. Analysis of the cost of care and resource utilization for colectomy revealed that there was no difference in overall cost as well as cost of the operating room, equipment, recovery room, intensive care, and hospitalization [36]. An interesting sidenote was that the cost of laparoscopic surgery for rectal cancer was found to be higher than for open surgery. In 2007, the 3-year survival and recurrence data was published [37]. The 3-year overall survival ($p=0.51$) and 3-year disease-free survival ($p=0.75$) rates were similar for the laparoscopic and open arms of the colon cancer group. Additionally, these outcomes were equivalent for all stages. The results held up for the 5-year outcomes as well [38, 39]. They reported a median overall survival of 105.7 months in the open arm versus 81.9 months in the laparoscopic arm (log rank=0.87, $p=0.352$). There was no difference between overall survival and disease-free survival. However, conversion from laparoscopy to open for patients with colon cancer was associated with a worse overall survival (HR, 2.28; 95 % CI, 1.47–3.53; $p<0.001$) and disease-free survival (HR, 2.20; 95 % CI, 1.31–3.67; $p<0.007$). Therefore, based on the long-term data of the CLASICC trial, the utilization of the laparoscopic approach for colon cancer is equivalent to the open approach, but patient selection is critical to ensure an optimal outcome.

The COLOR Trial

The COLOR trial was a European-based prospective, randomized trial of laparoscopic versus open resection of colon cancer designed as non-inferiority study to identify a 7 % difference in outcome between each arm [40]. A total of 29 hospitals throughout Europe participated. The trial's primary endpoint was a 3-year cancer-free survival. There were 534 patients in the laparoscopic arm and 542 patients in the open arm in the final analysis. The laparoscopic approach was found to have the short-term benefits of faster return of bowel function and shorter length of stay and was associated with a conversion rate of 19 % [41]. There was no difference in lymph node harvest or overall morbidity. Analysis of short-term outcomes with regard to hospital volume (high, medium, and low volume) demonstrated that operative times, conversions, and complications were lowest in the high-volume centers and were highest in the low-volume centers [42]. There was no difference in the 3-year disease-free survival at 74.2 % in the laparoscopic group and 76.2 % in the open group ($p=0.70$), which equated to a 2 % difference between the two treatment arms [43]. The final analysis was unable to rule out a difference in 3-year disease-free survival that favored the open approach because the upper limit of the 95 % confidence interval exceeds the predetermined non-inferiority boundary of 7 %. However, the authors felt the difference was small and clinically acceptable to justify that the laparoscopic approach for colon cancer is safe.

Other Trials

The Japan Clinical Oncology Group Study JCOG 0404 was a prospective randomized trial of laparoscopic versus open resection of T3 or T4 (without involvement of other organs) colon cancers [44]. It was a non-inferiority study design with 524 patients in the laparoscopic arm and 533 patients in the open arm. Short-term outcomes demonstrated shorter length of stay, faster return of bowel function, less narcotic use, and fewer complications in the laparoscopic arm. The 3-year oncologic results are pending at this point in time.

A prospective, randomized trial of laparoscopic versus open resection of colon cancer in Australia and New Zealand included a total of 587 patients [45]. The primary endpoints were 5-year overall survival, recurrence-free survival, and freedom from recurrence, and the long-term results demonstrated no difference in these outcomes between the two treatment groups.

These five prospective, randomized clinical trials all demonstrated short-term benefits for the laparoscopic approach with no associated differences in long-term overall survival, disease-free survival, and recurrence rates. Therefore, it is safe and effective to employ the laparoscopic approach for the surgical management of colon cancer.

Obstructing Colon Cancers

The management of obstructing colon cancers presents unique challenges in that the treatment of the acute or subacute obstructive process is dictating the oncologic management of the cancer. As a result, the overall outcome in terms of survival and recurrence is worse for patients whose initial presentation is with obstruction or obstructive symptoms. This is because by the time a tumor grows to the point of luminal obstruction, it is frequently a T3 or T4 lesion, and these tumors have a higher incidence of lymph node, peritoneal, or distant metastasis. Cortet et al. presented recurrence and survival data on 3375 colon cancers of which 8.5 % ($N=287$) presented with obstruction [46]. The 5-year risk of local recurrence [HR, 1.53; 95 % CI, 1.01–2.34 ($p=0.047$)] and distant recurrence [HR, 1.25; 95 % CI, 0.99–1.59 ($p=0.057$)] were higher for obstructing versus nonobstructing colon cancers.

The management options for obstructing colon cancers are many, and there are no well-established guidelines. For example, proximal diversion alleviates the obstruction but does not address the cancer, and resection of the primary tumor addresses both issues but carries significant morbidity and a high stoma rate. The introduction of self-expanding stents as a means for a bridge to therapy (surgery vs. chemotherapy) or as palliation in the setting of unresectable tumors is an additional option. The morbidity associated with urgent resection with ostomy creation or primary anastomosis can be as high as 60 % with wound complications, deep organ-space infections, respiratory complications, and intensive care unit admissions being some of the most common [47]. Therefore, the concept of endoscopically alleviating the obstruction, which would allow for complete colonic evaluation and elective, one-step resection, has significant appeal.

Initial single-institution reports demonstrated significant benefit of endoscopic stenting as a bridge to surgery compared to emergent surgery. These studies have reported a high incidence of technical and clinical success of greater than 90 % of cases and are associated with a stoma-free rate of 60–90 % [47–51]. The major complications associated with endoscopic stents are perforation, migration, and bleeding, which have been reported as being relatively low. It must be kept in mind that retrospective, single-institution studies suffer from many potential sources of bias such as patient selection, small numbers, and missing data. A multicenter, prospective, randomized trial of colonic stenting versus emergent surgery for acute left-sided malignant colon obstruction was undertaken in the Netherlands [49]. The study was scheduled to enroll 60 patients in each arm with the primary outcome being the mean global quality of life, and secondary outcomes were morbidity and mortality. The study was stopped after the enrollment of 47 patients in the stenting arm and 51 in the surgery arm due to six procedure-related perforations in the stent arm. The technical success rate of 70 % was felt to be too low compared to the previous published literature, and the study was stopped. Interestingly, there was no statistical difference between the two arms with regard to global quality of life, morbidity/mortality profiles, and stoma rates. There have been two subsequent meta-analysis that have examined the safety and efficacy of endoscopic stenting as a bridge to surgery. The review by Cirocchi et al. analyzed three clinical trials with a total of 97 patients in the stent arm and 100 patients in the surgery arm [52]. The clinical success rate (which was defined differently in each study) was significantly higher in the surgery group (99 % vs. 52 %, $p<0.00001$), respectively. The stent group had a higher primary anastomosis rate (64.9 % vs. 55 %, $p=0.003$), and the overall stoma rate (45.3 % vs. 62 %, $p=0.02$) was lower. However, there was no difference in the overall or 30-day postoperative complication rates. A more recent meta-analysis, which included seven studies, confirmed the findings that endoscopic stenting is associated with increased rate of primary anastomosis, decreased stoma rate, and a trend toward improved complication rates [48]. Endoscopic stenting clearly has a role in the management of obstructing colon cancers, but proper patient selection is of paramount importance to its success [53]. Completely obstructing cancers, particularly when confirmed by contrast enema, have a low rate of technical success and increased likelihood of a stent-related complication. Stenting should also be avoided in patients with peritonitis, hemodynamic instability, or concern for impending perforation. Patients with obstructive symptoms but who are not completely obstructed have a normal white blood cell count and no peritonitis, and normal or correctable laboratory values are candidates for endoscopic stenting as a bridge to surgical resection 72 or more days later. Concern has been raised that endoscopic stenting can have a negative impact on the oncologic outcomes of these patients. There is limited data examining this issue, and what is available are small single-institution retrospective reviews. However, these studies have not demonstrated a deleterious effect of stenting on cancer-related outcomes [54].

Surgical intervention remains the mainstay of managing obstructed colon cancers as it provides alleviation of the obstruction and resection of the tumor in one setting. The extent of the operative procedure is highly dependent upon the condition of the patient and the extent of the obstruction. Proximal diversion alone should be performed only in selected situations such as complete obstruction with dilated small bowel that makes resection too difficult or in a setting where neoadjuvant therapy would be beneficial. The extent of resection and restoration of intestinal continuity remain to be debated and are dependent upon the physiology of the patient and the intraoperative findings. If there is evidence of impending perforation or ischemia of the proximal colon, resection of the entire colon proximal to the obstruction is recommended, and performing a primary anastomosis should be avoided. However, if the proximal colon is dilated, a healthy segmental versus extended colectomy can be performed based on the clinical situation. A recent literature review found no difference in morbidity or mortality between segmental resection and total abdominal colectomy for obstructing colon cancers. However, patients who underwent total abdominal colectomy have a significantly higher rate of bowel dysfunction. The creation of an end stoma is the technically easier procedure and eliminates the risk of anastomotic leak, but 40–60 % of the stomas created will remain permanent [55, 56]. The decision to perform a primary anastomosis is dependent upon the condition of the patient and quality of the proximal bowel. There is limited data comparing a Hartmann's resection with end colostomy or resection and primary anastomosis, but a recent review of the literature reported the anastomotic leak rate for primary anastomosis to range from 2 to 12 % [55, 56]. This appears to be comparable to the literature for elective left-sided resection and anastomosis, which ranges from 2 to 8 %. There does appear to be benefit of decreased anastomotic leaks and infectious complications when either manual disimpaction or on-table lavage of the proximal colon is performed prior to a primary anastomosis.

Perforated Colon Cancers

Perforated colon cancers present the challenge of adequately addressing the sepsis associated with a perforated colon while attempting to maintain the oncologic principles of resection for the malignant disease. The acute septic injury has the greatest impact on short-term outcomes, which in turn impacts the long-term outcome of the cancer. These patients typically present with a contained perforation much like diverticulitis or with a free perforation requiring an emergent operation. Either scenario results in a poorer outcome compared to non-perforated cancers. Cheynel et al. presented a comparison of the short- and long-term outcomes for 89 perforated colon cancers and 5462 uncomplicated colon cancers [57]. They reported that perforated cancers had higher operative mortality [20.2 % vs. 6.6 % ($p=<0.001$)] and 5-year local recurrence and peritoneal carcinomatosis rates [15.7 % vs. 7.8 % ($p=0.021$) and 13.8 % vs. 7.8 % ($p=0.036$), respectively] than uncomplicated colon cancers. Zielinski et al. compared 41 patients with free perforation and 45 patients with contained perforation to 85 non-perforated patients that were matched for age, stage, and resection status [58]. They found that patients with free perforation were more likely to get a stoma [79 % vs. 39 % vs. 29 % ($p=0.008$)] and had a higher rate of metastatic disease at the time of presentation. Interestingly, in the small study size, they found no difference in the rates of R0, R1, and R2 resections between the three groups. Sixty-seven percent of patients with free perforations were able to have all gross disease resected (R0 62 % and R1 5 %). The 5-year overall survival was significantly poorer in the free perforation versus the contained perforation group (24 % vs. 62 % ($p=0.003$)). Additionally, patients with a free perforation had a significantly higher operative morality, and their 5-year disease-free survival was significantly poorer. Interestingly, on the multivariate analysis, perforation (free or contained) was not a risk factor for adjusted survival, but residual gross disease after resection was a risk factor (HR, 1.94; 95 % CI, 1.09–3.46; $p=0.02$). Therefore, patients that present with perforated tumors should undergo an oncologically based resection if their physiologic state will allow as this will provide them with the best cancer-related outcome.

Management of Primary Colon Cancer in the Setting of Distant Metastasis

Advances in chemotherapy have greatly impacted our management strategies of patients who present with metastatic colon cancer. Current recommendations are for patients with symptomatic (bleeding or obstructing) primary tumors to undergo resection of their primary tumor before initiating systemic therapy for their metastatic disease. However, if the tumor is asymptomatic and the patient has a good performance status, the first-line treatment should be systemic chemotherapy, the rationale being that most patients will succumb to their metastatic disease before the primary tumor causes complications. This concept has gained traction with the significant improvement in tumor response to FOLFOX-based chemotherapies and a low rate of complications associated with leaving the primary tumor in situ. In 2007, Muratore et al. reported that patients with stage IV colon cancer with asymptomatic primary tumors who received FOLFOX chemotherapy had a 43 % rate of downstaging of metastatic disease to resectability, and none of the 35 patients developed symptoms related to their primary tumor while receiving chemotherapy [59]. A subsequent review of the literature examined seven studies comparing chemotherapy as initial therapy ($N=314$ patients) versus resection of the primary followed by chemotherapy ($N=536$ patients) [60]. For the patients who received chemotherapy first, the rate of symptoms associated with the primary tumor was obstruction 13 %, bleeding 3 %, and perforation/fistula 6 %. Ultimately, greater than 40 % of patients went on to have their liver lesions resected with curative intent. For the patients that had resection of their primary tumor as first-line therapy, the pooled major complication rate was 12 %, and the pooled minor complication rate was 21 %. The survival rate for the chemotherapy-first group ranged from 8.2 to 22 months, and the surgery first group was 14–23 months. Multivariate analysis identified the extent of hepatic disease and presence of peritoneal disease, performance statuses were independent predictors of the outcome, and resection status of the primary tumor did not impact survival. The benefit of FOLFOX-based chemotherapy has on the ability to downstage a patient to the point of resectability was reported in a recent literature review by Lam et al. [61]. They examined ten studies with 1886 patients who received neoadjuvant chemotherapy for liver metastasis. Sixty-four percent of patients had regression of their tumor with 22 % of these patients undergoing resection of the liver metastasis with curative intent. This translated to a 45-month overall median survival with 15 % of the patients remaining disease-free at that time point. Therefore, the literature supports a chemotherapy-first approach to stage IV colon cancer with an asymptomatic primary as a chemotherapy that has the ability to downstage metastatic disease, minimize the progression of symptoms associated with the primary tumor, and improve overall survival.

Outcomes for Colon Cancer

Short Term

Short-term outcomes for colectomy for cancer include morbidity, mortality, length of hospital stay, and intraoperative parameters such as conversion from laparoscopy. The most recent clinical trials that have examined operative techniques and the perioperative outcomes are the major multicenter, prospective, randomized trials comparing laparoscopic versus open colectomy for cancer, and they provide some of the best data for short-term outcomes. The COST trial reported an overall complication rate of 21 % for laparoscopy and 20 % for the open approach ($p=0.64$), with only 4 and 2 % ($p=0.11$) occurring intraoperatively, respectively [32]. The 30-day morbidity was similar between the groups, but the rate of specific complications was not reported. Overall mortality was 2 and 4 % ($p=0.40$). The conversion rate was 21 % and was associated with an increased length of stay and 30-day complication rate. The CLASICC trial reported an overall complication rate of 26 % in the laparoscopic group, 27 % in the open group, and 45 % in the converted group [35]. The mortality rate of laparoscopy was 2 and 4 % for open patients. They did include specific complications for the laparoscopic, open, and converted groups, which included wound complications of 5 %, 5 %, and 8 %; pneumonia rate of 7 %, 4 %, and 10 %; anastomotic leak rate of 3 %, 3 %, and 3 %; and deep venous thrombosis rate of 2 %, 0 %, and 0 %, respectively. The COLOR trial reported a similar morbidity and mortality profile [41]. The overall complication rate was 21 % for laparoscopy and 20 % for the open approach, with a 4 % and 3 % wound infection rate, 2 % and 2 % pulmonary complication rate, 1 % and 2 % cardiac complication rate, 2 % and 2 % rate of significant bleeding, 2 % and 2 % rate of urinary tract infection, 3 % and 2 % anastomotic leak rate, and 1 % and 2 % associated mortality, respectively. The complication profiles are very similar between the three clinical trials, so it would appear that this data sets a reasonable benchmark. It must be kept in mind that there were ASA and BMI exclusions for these studies, and those factors are associated with increased rates of morbidity and mortality. As mentioned in the beginning of the chapter, the ACS-NSQIP risk calculator can provide a reasonable assessment of operative and perioperative complication risk. Results regarding length of stay, return of bowel function, narcotic use, and quality of life were discussed previously.

Long-Term Outcomes

The 5-year survival and recurrence rates for colon cancer are dependent upon the stage of disease at the time of surgery. Based on data published from 2012 by the Surveillance, Epidemiology, and End Results Program (SEERS), the

5-year overall relative survival for stage I is 90 %, stage IIA is 87 %, stage IIB is 63 %, stage IIIA is 89 %, stage IIIB is 69 %, stage IIIC is 53 %, and stage IV is 13 % [62]. The survival has improved every 5 years since 1975, which reflects improvements in detection, surgical technique, and adjuvant therapy. The aspects of these statistics that need to be noted are that patients with stage IIB (T4, N0, M0) colon cancer behave similarly to patients with stage IIIB (T3–T4a, N1, M0; T2–T3, N2a, M0; or T1–T2, N2b, M0). Therefore, it is imperative for the surgeon to understand and recognize patients with stage IIB cancers, so they can be appropriately referred for adjuvant therapy in a timely fashion. Surgeons play a critical role in the referral of cancer patients to medical oncologist, so a comprehensive knowledge of the indications for adjuvant chemotherapy is essential. The other notable observation is that patients with stage IIIA (T1–T2, N1, M0 or T1, N2a, M0) do as well as those with stage IIA (T3, N0, M0). This highlights the importance of surgical technique and the importance of resecting all potentially metastatic lymph nodes. Additionally, the addition of adjuvant chemotherapy to node-positive colon cancer with FOLFOX-based therapies improved 5-year disease-free survival from 65 to 78 % [63, 64]. This improvement is significant, but it also demonstrates that surgical quality is the most important component of care because surgical clearance of potentially metastatic lymph nodes offers the greatest chance for cure.

References

1. Teeuwen PH, Bremers AJ, Groenewoud JM, van Laarhoven CJ, Bleichrodt RP. Predictive value of POSSUM and ACPGBI scoring in mortality and morbidity of colorectal resection: a case-control study. J Gastrointest Surg. 2011;15(2):294–303.
2. Tekkis PP, Prytherch DR, Kocher HM, Senapati A, Poloniecki JD, Stamatakis JD, Windsor AC. Development of a dedicated risk-adjustment scoring system for colorectal surgery (colorectal POSSUM). Br J Surg. 2004;91(9):1174–82.
3. Oomen JL, Cuesta MA, Engel AF. Comparison of outcome of POSSUM, p-POSSUM, and cr-POSSUM scoring after elective resection of the sigmoid colon for carcinoma or complicated diverticular disease. Scand J Gastroenterol. 2007;42(7):841–7.
4. Leung E, Ferjani AM, Stellard N, Wong LS. Predicting post-operative mortality in patients undergoing colorectal surgery using P-POSSUM and CR-POSSUM scores: a prospective study. Int J Colorectal Dis. 2009;24(12):1459–64.
5. Ren L, Upadhyay AM, Wang L, Li L, Lu J, Fu W. Mortality rate prediction by Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM), Portsmouth POSSUM and Colorectal POSSUM and the development of new scoring systems in Chinese colorectal cancer patients. Am J Surg. 2009;198(1):31–8.
6. Hariharan S, Chen D, Ramkissoon A, Taklalsingh N, Bodkyn C, Cupidore R, Ramdin A, Ramsaroop A, Sinanan V, Teelucksingh S, Verma S. Perioperative outcome of colorectal cancer and validation of CR-POSSUM in a Caribbean country. Int J Surg. 2009;7(6):534–8.
7. Gomes A, Rocha R, Marinho R, Sousa M, Pignatelli N, Carneiro C, Nunes V. Colorectal surgical mortality and morbidity in elderly patients: comparison of POSSUM, P-POSSUM, CR-POSSUM, and CR-BHOM. Int J Colorectal Dis. 2015;30(2):173–9.
8. Cologne KG, Keller DS, Liwanag L, Devaraj B, Senagore AJ. Use of the American College of Surgeons NSQIP surgical risk calculator for laparoscopic colectomy: how good is it and how can we improve it? J Am Coll Surg. 2015;220(3):281–6.
9. Kohut AY, Liu JJ, Stein DE, Sensenig R, Poggio JL. Patient-specific risk factors are predictive for postoperative adverse events in colorectal surgery: an American College of Surgeons National Surgical Quality Improvement Program-based analysis. Am J Surg. 2015;209(2):219–29.
10. Cohen ME, Bilimoria KY, Ko CY, Hall BL. Development of an American College of Surgeons National Surgery Quality Improvement Program: morbidity and mortality risk calculator for colorectal surgery. J Am Coll Surg. 2009;208(6):1009–16.
11. Vignati P, Welch JP, Cohen JL. Endoscopic localization of colon cancers. Surg Endosc. 1994;8(9):1085–7.
12. Cho YB, Lee WY, Yun HR, Lee WS, Yun SH, Chun HK. Tumor localization for laparoscopic colorectal surgery. World J Surg. 2007;31(7):1491–5.
13. Park SH, Lee JH, Lee SS, Kim JC, Yu CS, Kim HC, Ye BD, Kim MJ, Kim AY, Ha HK. CT colonography for detection and characterization of synchronous proximal colonic lesions in patients with stenosing colorectal cancer. Gut. 2012;61(12):1716–22.
14. Morrin MM, Farrell RJ, Raptopoulos V, McGee JB, Bleday R, Kruskal JB. Role of virtual computed tomographic colonography in patients with colorectal cancers and obstructing colorectal lesions. Dis Colon Rectum. 2000;43(3):303–11.
15. Kim JH, Kim WH, Kim TI, Kim NK, Lee KY, Kim MJ, Kim KW. Incomplete colonoscopy in patients with occlusive colorectal cancer: usefulness of CT colonography according to tumor location. Yonsei Med J. 2007;48(6):934–41.
16. McArthur DR, Mehrzad H, Patel R, Dadds J, Pallan A, Karandikar SS, Roy-Choudhury S. CT colonography for synchronous colorectal lesions in patients with colorectal cancer: initial experience. Eur Radiol. 2010;20(3):621–9.
17. Maras-Simunic M, Druzijanic N, Simunic M, Roglic J, Tomic S, Perko Z. Use of modified multidetector CT colonography for the evaluation of acute and subacute colon obstruction caused by colorectal cancer: a feasibility study. Dis Colon Rectum. 2009;52(3):489–95.
18. http://www.nccn.org/professionals/physician_gls/f_guidlines.asp#site
19. Rørvig S, Schlesinger N, Mårtensson NL, Engel S, Engel U, Holck S. Is the longitudinal margin of carcinoma-bearing colon resections a neglected parameter? Clin Colorectal Cancer. 2014;13(1):68–72.
20. Read TE, Mutch MG, Chang BW, McNevin MS, Fleshman JW, Birnbaum EH, Fry RD, Caushaj PF, Kodner IJ. Locoregional recurrence and survival after curative resection of adenocarcinoma of the colon. J Am Coll Surg. 2002;195(1):33–40.
21. Matsuda K, Hotta T, Takifuji K, Yokoyama S, Oku Y, Watanabe T, Mitani Y, Ieda J, Mizumoto Y, Yamaue H. Randomized clinical trial of defaecatory function after anterior resection for rectal cancer with high versus low ligation of the inferior mesenteric artery. Br J Surg. 2015;102(5):501–8.
22. Kanemitsu Y, Hirai T, Komori K, Kato T. Survival benefit of high ligation of the inferior mesenteric artery in sigmoid colon or rectal cancer surgery. Br J Surg. 2006;93(5):609–15.

23. Chin CC, Yeh CY, Tang R, Changchien CR, Huang WS, Wang JY. The oncologic benefit of high ligation of the inferior mesenteric artery in the surgical treatment of rectal or sigmoid colon cancer. Int J Colorectal Dis. 2008;23(8):783–8.
24. Hohenberger W, Weber K, Matzel K, Papadopoulos T, Merkel S. Standardized surgery for colonic cancer: complete mesocolic excision and central ligation–technical notes and outcome. Colorectal Dis. 2009;11(4):354–64.
25. Galizia G, Lieto E, De Vita F, Ferraraccio F, Zamboli A, Mabilia A, Auricchio A, Castellano P, Napolitano V, Orditura M. Is complete mesocolic excision with central vascular ligation safe and effective in the surgical treatment of right-sided colon cancers? A prospective study. Int J Colorectal Dis. 2014;29(1):89–97.
26. West NP, Kobayashi H, Takahashi K, Perrakis A, Weber K, Hohenberger W, Sugihara K, Quirke P. Understanding optimal colonic cancer surgery: comparison of Japanese D3 resection and European complete mesocolic excision with central vascular ligation. J Clin Oncol. 2012;30(15):1763–9.
27. Kwon S, Morris A, Billingham R, Frankhouse J, Horvath K, Johnson M, McNevin S, Simons A, Symons R, Steele S, Thirlby R, Whiteford M, Flum DR, Surgical Care and Outcomes Assessment Program (SCOAP) collaborative. Routine leak testing in colorectal surgery in the Surgical Care and Outcomes Assessment Program. Arch Surg. 2012;147(4):345–51.
28. Ricciardi R, Roberts PL, Marcello PW, Hall JF, Read TE, Schoetz DJ. Anastomotic leak testing after colorectal resection: what are the data? Arch Surg. 2009;144(5):407–11.
29. Li VK, Wexner SD, Pulido N, Wang H, Jin HY, Weiss EG, Nogeuras JJ, Sands DR. Use of routine intraoperative endoscopy in elective laparoscopic colorectal surgery: can it further avoid anastomotic failure? Surg Endosc. 2009;23(11):2459–65.
30. Kamal T, Pai A, Velchuru V, Zawadzki M, Park J, Marecik S, Abcarian H, Prasad L. Should anastomotic assessment with flexible sigmoidoscopy be routine following laparoscopic restorative left colorectal resection? Colorectal Dis. 2015;17(2):160–4.
31. Weeks JC, Nelson H, Gelber S, Sargent D, Schroeder G, Clinical Outcomes of Surgical Therapy (COST) Study Group. Short-term quality-of-life outcomes following laparoscopic-assisted colectomy vs. open colectomy for colon cancer: a randomized trial. JAMA. 2002;287(3):321–8.
32. Clinical Outcomes of Surgical Therapy Study Group. A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med. 2004;350(20):2050–9.
33. Fleshman J, Sargent DJ, Green E, Anvari M, Stryker SJ, Beart Jr RW, Hellinger M, Flanagan Jr R, Peters W, Nelson H, Clinical Outcomes of Surgical Therapy Study Group. Laparoscopic colectomy for cancer is not inferior to open surgery based on 5-year data from the COST Study Group trial. Ann Surg. 2007;246(4):655–62.
34. Stucky CC, Pockaj BA, Novotny PJ, Sloan JA, Sargent DJ, O'Connell MJ, Beart RW, Skibber JM, Nelson H, Weeks JC. Long-term follow-up and individual item analysis of quality of life assessments related to laparoscopic-assisted colectomy in the COST trial 93-46-53 (INT 0146). Ann Surg Oncol. 2011;18(9):2422–31.
35. Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM, MRC CLASICC trial group. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet. 2005; 365(9472):1718–26.
36. Franks PJ, Bosanquet N, Thorpe H, Brown JM, Copeland J, Smith AM, Quirke P, Guillou PJ, CLASICC trial participants. Short-term costs of conventional vs. laparoscopic assisted surgery in patients with colorectal cancer (MRC CLASICC trial). Br J Cancer. 2006;95(1):6–12.
37. Jayne DG, Guillou PJ, Thorpe H, Quirke P, Copeland J, Smith AM, Heath RM, Brown JM, UK MRC CLASICC Trial Group. Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC CLASICC Trial Group. J Clin Oncol. 2007;25(21):3061–8.
38. Green BL, Marshall HC, Collinson F, Quirke P, Guillou P, Jayne DG, Brown JM. Long-term follow-up of the Medical Research Council CLASICC trial of conventional versus laparoscopically assisted resection in colorectal cancer. Br J Surg. 2013;100(1):75–82.
39. Jayne DG, Thorpe HC, Copeland J, Quirke P, Brown JM, Guillou PJ. Five-year follow-up of the Medical Research Council CLASICC trial of laparoscopically assisted versus open surgery for colorectal cancer. Br J Surg. 2010;97(11): 1638–45.
40. Hazebroek EJ, Color Study Group. COLOR: a randomized clinical trial comparing laparoscopic and open resection for colon cancer. Surg Endosc. 2002;16(6):949–53.
41. Veldkamp R, Kuhry E, Hop WC, Jeekel J, Kazemier G, Bonjer HJ, Haglind E, Påhlman L, Cuesta MA, Msika S, Morino M, Lacy AM, Colon cancer Laparoscopic or Open Resection Study Group (COLOR). Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. Lancet Oncol. 2005;6(7):477–84.
42. Kuhry E, Bonjer HJ, Haglind E, Hop WC, Veldkamp R, Cuesta MA, Jeekel J, Påhlman L, Morino M, Lacy A, Delgado S, COLOR Study Group. Impact of hospital case volume on short-term outcome after laparoscopic operation for colonic cancer. Surg Endosc. 2005;19(5):687–92.
43. Colon Cancer Laparoscopic or Open Resection Study Group, Buunen M, Veldkamp R, Hop WC, Kuhry E, Jeekel J, Haglind E, Påhlman L, Cuesta MA, Msika S, Morino M, Lacy A, Bonjer HJ. Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. Lancet Oncol. 2009;10(1):44–52.
44. Yamamoto S, Inomata M, Katayama H, Mizusawa J, Etoh T, Konishi F, Sugihara K, Watanabe M, Moriya Y, Kitano S, Japan Clinical Oncology Group Colorectal Cancer Study Group. Short-term surgical outcomes from a randomized controlled trial to evaluate laparoscopic and open D3 dissection for stage II/III colon cancer: Japan Clinical Oncology Group Study JCOG 0404. Ann Surg. 2014;260(1):23–30.
45. Bagshaw PF, Allardyce RA, Frampton CM, Frizelle FA, Hewett PJ, McMurrick PJ, Rieger NA, Smith JS, Solomon MJ, Stevenson AR, Australasian Laparoscopic Colon Cancer Study Group. Long-term outcomes of the australasian randomized clinical trial comparing laparoscopic and conventional open surgical treatments for colon cancer: the Australasian Laparoscopic Colon Cancer Study trial. Ann Surg. 2012;256(6): 915–9.
46. Cortet M, Grimault A, Cheynel N, Lepage C, Bouvier AM, Faivre J. Patterns of recurrence of obstructing colon cancers after surgery for cure: a population-based study. Colorectal Dis. 2013;15(9):1100–6.
47. Gianotti L, Tamini N, Nespoli L, Rota M, Bolzonaro E, Frego R, Redaelli A, Antolini L, Ardito A, Nespoli A, Dinelli M. A

prospective evaluation of short-term and long-term results from colonic stenting for palliation or as a bridge to elective operation versus immediate surgery for large-bowel obstruction. Surg Endosc. 2013;27(3):832–42.
48. Huang X, Lv B, Zhang S, Meng L. Preoperative colonic stents versus emergency surgery for acute left-sided malignant colonic obstruction: a meta-analysis. J Gastrointest Surg. 2014;18(3):584–91.
49. van Hooft JE, Bemelman WA, Oldenburg B, Marinelli AW, Lutke Holzik MF, Grubben MJ, Sprangers MA, Dijkgraaf MG, Fockens P, Collaborative Dutch Stent-In study group. Colonic stenting versus emergency surgery for acute left-sided malignant colonic obstruction: a multicentre randomised trial. Lancet Oncol. 2011;12(4):344–52.
50. Dastur JK, Forshaw MJ, Modarai B, Solkar MM, Raymond T, Parker MC. Comparison of short-and long-term outcomes following either insertion of self-expanding metallic stents or emergency surgery in malignant large bowel obstruction. Tech Coloproctol. 2008;12(1):51–5.
51. Kim JS, Hur H, Min BS, Sohn SK, Cho CH, Kim NK. Oncologic outcomes of self-expanding metallic stent insertion as a bridge to surgery in the management of left-sided colon cancer obstruction: comparison with nonobstructing elective surgery. World J Surg. 2009;33(6):1281–6.
52. Cirocchi R, Farinella E, Trastulli S, Desiderio J, Listorti C, Boselli C, Parisi A, Noya G, Sagar J. Safety and efficacy of endoscopic colonic stenting as a bridge to surgery in the management of intestinal obstruction due to left colon and rectal cancer: a systematic review and meta-analysis. Surg Oncol. 2013;22(1):14–21.
53. Sagar J. Colorectal stents for the management of malignant colonic obstructions. Cochrane Database Syst Rev. 2011;11, CD007378.
54. Knight AL, Trompetas V, Saunders MP, Anderson HJ. Does stenting of left-sided colorectal cancer as a “bridge to surgery” adversely affect oncological outcomes? A comparison with non-obstructing elective left-sided colonic resections. Int J Colorectal Dis. 2012;27(11):1509–14.
55. Trompetas V. Emergency management of malignant acute left-sided colonic obstruction. Ann R Coll Surg Engl. 2008;90(3):181–6.
56. Ansaloni L, Andersson RE, Bazzoli F, Catena F, Cennamo V, Di Saverio S, Fuccio L, Jeekel H, Leppäniemi A, Moore E, Pinna AD, Pisano M, Repici A, Sugarbaker PH, Tuech JJ. Guidelines in the management of obstructing cancer of the left colon: consensus conference of the world society of emergency surgery (WSES) and peritoneum and surgery (PnS) society. World J Emerg Surg. 2010;5:29.
57. Cheynel N, Cortet M, Lepage C, Ortega-Debalon P, Faivre J, Bouvier AM. Incidence, patterns of failure, and prognosis of perforated colorectal cancers in a well-defined population. Dis Colon Rectum. 2009;52(3):406–11.
58. Zielinski MD, Merchea A, Heller SF, You YN. Emergency management of perforated colon cancers: how aggressive should we be? J Gastrointest Surg. 2011;15(12):2232–8.
59. Muratore A, Zorzi D, Bouzari H, Amisano M, Massucco P, Sperti E, Capussotti L. Asymptomatic colorectal cancer with un-resectable liver metastases: immediate colorectal resection or up-front systemic chemotherapy? Ann Surg Oncol. 2007;14(2):766–70.
60. Scheer MG, Sloots CE, van der Wilt GJ, Ruers TJ. Management of patients with asymptomatic colorectal cancer and synchronous irresectable metastases. Ann Oncol. 2008;19(11):1829–35.
61. Lam VW, Spiro C, Laurence JM, Johnston E, Hollands MJ, Pleass HC, Richardson AJ. A systematic review of clinical response and survival outcomes of downsizing systemic chemotherapy and rescue liver surgery in patients with initially unresectable colorectal liver metastases. Ann Surg Oncol. 2012;19(4):1292–301.
62. http://seer.cancer.gov/statfacts/html/colorect.html
63. Kuebler JP, Wieand HS, O’Connell MJ, Smith RE, Colangelo LH, Yothers G, Petrelli NJ, Findlay MP, Seay TE, Atkins JN, Zapas JL, Goodwin JW, Fehrenbacher L, Ramanathan RK, Conley BA, Flynn PJ, Soori G, Colman LK, Levine EA, Lanier KS, Wolmark N. Oxaliplatin combined with weekly bolus fluorouracil and leucovorin as surgical adjuvant chemotherapy for stage II and III colon cancer: results from NSABP C-07. J Clin Oncol. 2007;25(16):2198–204.
64. André T, Boni C, Mounedji-Boudiaf L, Navarro M, Tabernero J, Hickish T, Topham C, Zaninelli M, Clingan P, Bridgewater J, Tabah-Fisch I, de Gramont A, Multicenter International Study of Oxaliplatin/5-Fluorouracil/Leucovorin in the Adjuvant Treatment of Colon Cancer (MOSAIC) Investigators. Oxaliplatin, fluorouracil, and leucovorin as adjuvant treatment for colon cancer. N Engl J Med. 2004;350(23):2343–51.