Ovunc Bardakcioglu
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Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery

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All text boxes (Tips and Caveats) are written by Dr. Ovunc Bardakcioglu

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ISBN 978-1-4899-7530-0 ISBN 978-1-4899-7531-7 (eBook)
DOI 10.1007/978-1-4899-7531-7
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2014956901

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

To my father, my first mentor and most talented surgeon I know.

O.B.

Foreword

Numerous colorectal textbooks have been authored, which generally include both open and minimally invasive approaches. This textbook, Advanced Techniques in Minimal Invasive and Robotic Colon and Rectal Surgery, is unique in that Dr. Ovunc Bardakcioglu has deftly amalgamated an impressive array of accomplished authors to meticulously review the gamut of minimally invasive approaches to colorectal disease. I am unaware of any other publication which so thoroughly and comprehensively addresses this exciting new arena. Furthermore, Dr. Bardakcioglu has managed to include a compendium of contents allowing the reader to share the data and information from a myriad of acknowledged content experts. Dr. Bardakcioglu has included an adequate number of chapters to deliberately offer the requisite amount of overlap for emphasis but avoid creating subject redundancy in the volume. The chapters are written in a very user-friendly, easy-to-review, and clinically relevant approach; the illustrated and descriptive operative steps and videos facilitate comprehension of the content. I highly commend Advanced Techniques in Minimally Invasive and Robotic Colon and Rectal Surgery to any surgeon who practices these techniques as well as to surgical residents and medical students who are in the process of acquiring these skills. I am also optimistic that after reading these chapters, this book will provide a resource with which to periodically refresh one's knowledge. I wish to congratulate Dr. Bardakcioglu for his tremendous artistry in creating the concept and expertly executing the work. Artistry because he has woven the fabric of this textbook into a beautifully blended product, a feat that is not necessarily easy when the individual contributory elements are authored by a myriad of people using a plethora of writing and illustrative styles. The end result of his labors is that this book is indeed very impressive and as such highly recommended.

Weston, FL — Steven D. Wexner, MD, PhD, FACS, FRCS, FRCS

Preface

Over the last decade, the field of colon and rectal surgery has evolved a plethora of new surgical minimal invasive techniques to address both benign and malignant diseases.

HD laparoscopy, 3-D laparoscopy, robotic surgery, single-port laparoscopy (SPL), transanal endoscopic surgery (TES), and natural orifice transluminal endoscopic surgery (NOTES) all fall under the ever-growing umbrella of technological advances in colon and rectal surgery. These new developments may have started out in other fields but are a very active aspect of the field of colon and rectal surgery.

Is the new primary surgical goal to achieve the ever more minimally invasive surgery until one day “scarless” surgery is achieved for all patients? The goal might be to provide the surgeon with a multitude of options, an array of tools, to use at his or her disposal as dictated by the complexities of a given patient’s surgical disease and anatomy.

Many textbooks on surgical procedures exist; however, one of the shortcomings of these textbooks is that a procedure is typically not described in all its existing variations and details that many different surgeons utilize. A chapter on a specific surgical procedure is usually only described based on the author’s personal experience and technique and is often biased.

Beginning early in my career, I have created my own scripts and summaries of procedures by learning from different surgeons during my training, learning from discussions with colleagues, reviewing procedural videos, which are available in textbooks, the Internet and conference presentations, and developing my own techniques. This led to the idea of this textbook to include many such described and utilized techniques for a specific colorectal surgical procedure. The authors of all chapters were therefore encouraged to think beyond their typical approach to a surgical procedure, and all chapters were revised and standardized to support this overall goal.

The chapters include a breakdown of the procedures into standard operative steps, which are graded by technical difficulty. This grading can guide novice surgeons, residents, fellows, and their teachers to a stepwise approach to get familiar and master minimal invasive techniques in colon and rectal surgery. I have also included many technical tips, tricks, and caveats throughout the text to help with difficulties the surgeon might encounter.

I wish this textbook will encourage surgeons not familiar with minimal invasive surgery to increasingly offer these approaches to their patients, and I hope the master surgeon will enjoy discovering new facets of the ever-evolving change to surgical procedures in colon and rectal surgery.

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Part I

Introduction

Development of Minimally Invasive Colorectal Surgery: History, Evidence, Learning Curve, and Current Adaptation

1

Kyle G. Cologne and Anthony J. Senagore

Introduction

Minimally invasive surgery has revolutionized the way surgeons practice colorectal surgery. It has resulted in decreased lengths of stay and a marked decrease in wound infections and has shown some evidence of an overall lower complication rate versus open surgery [1]. This chapter will outline the history of minimally invasive colorectal surgery, examine evidence detailing its safety compared with open surgery, discuss the learning curve required to achieve proficiency, and outline the extent of its current use.

History

Laparoscopy is not a new invention. Its first use was described long before we think of contemporary surgery. In fact, Aulus Cornelius Celsus (25 B.C.–50 A.D.) was the first to describe the use of percutaneous devices (now called trocars) to "drain evil humors" [2]. The term "trocar" was coined in 1706 and was thought to be derived from the term "*trochartortroisequarts*," a three-faced instrument consisting of a perforator enclosed in a metal cannula. The first use of a device used to peer inside the abdominal cavity was in 1901 by George Kelling, a German surgeon, who used a cystoscope to examine the abdominal viscera of a dog after insufflating the peritoneal cavity with air. In 1910, Jacobeus performed the first laparoscopic drainage of ascites in humans in Sweden [3]. In 1911, Bertram Bernheim published his series from Johns Hopkins entitled "Organoscopy: Cystoscopy of the Abdominal Cavity" [4]. As technology improved, so did the capability of laparoscopic procedures. In 1929, Heinz Kalk, a German gastroenterologist, developed a 135-degree lens system and a dual-trocar approach. Ten years later, he published his experience of 2,000 liver biopsies performed using local anesthesia without a single mortality [5].

Early laparoscopy was not without its problems. The combination of a high rate of trocar injury to bowel, lack of an alternative to unipolar cautery (which caused a number of additional bowel and other organ injuries), and lack of a regulator to prevent high insufflation pressures meant that many surgeons deemed laparoscopy as too high risk. In addition, visualization was extremely poor because there was no good method to illuminate the abdominal cavity, and the eyepiece limited the field of vision to a narrow area. It was not until 1952 when Fourestier, Gladu, and Valmiere developed a new lighting system that revolutionized endoscopy. They utilized a quartz rod to transmit an intense light beam distally along a telescope and permitted the light intensity to be concentrated enough to photograph images [6]. In 1960, German gynecologist Kurt Semm invented an automatic insufflator that solved the insufflation pressure problem [7]. Finally, in the early 1980s, the first solid-state camera was introduced that allowed video laparoscopy. Prior to this, an eyepiece was required that only allowed a single observer to visualize the abdominal cavity.

Despite these advances, it took a long time for more complex laparoscopic surgeries to be considered. Mühe performed the first laparoscopic cholecystectomy in the mid-1980s, several years after the development of video laparoscopy [8, 9]. The single most important invention that allowed laparoscopic colorectal surgeries to be performed was the laparoscopic stapler. This allowed the first colorectal procedures to be performed.

The first laparoscopic colonic resection was a right hemicolectomy performed by Moises Jacobs in Miami, Florida, in June of 1990. Dennis Fowler performed the first laparoscopic sigmoid resection in October of 1990. Joseph Uddo performed a laparoscopic colostomy closure on November 14, 1990 (anastomosis was constructed with a circular stapling

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_1,

device). Patrick Leahy resected a proximal rectal cancer with low anterior anastomosis. And on July 26, 1991, Joseph Uddo performed an entirely laparoscopic right hemicolectomy when the ileocolic anastomosis was constructed intracorporeally. From this point on, many surgeons throughout the world started to perform laparoscopic surgery [10, 11].

Evidence of Safety

As is the case with any new technology or procedure, there were skeptics. An important question was whether the laparoscopic approach was equivalent oncologically to the traditional open method. Some early reports of trocar site recurrences following laparoscopic resections raised concern among many [12]. In addition, early results of studies that included laparoscopic treatment of rectal cancer showed a trend towards higher rates of positive circumferential margins and a high conversion rate of 34 % [13]. However, long-term follow-up has demonstrated this not to be true.

Several randomized trials have now shown no difference in survival and local recurrence rates when comparing laparoscopic to open approaches. In fact, laparoscopic approaches even have some advantages over open surgery. The COST trial [14], COLOR trial [15], and CLASICC trial [13, 16] have shown the procedure to be safe with similar outcomes to open surgery. Potential benefits were discovered in a Cochrane Review, where the laparoscopic approach resulted in decreased blood loss, a quicker return to diet, less pain (measured by narcotic use), and lower rate of wound complications as compared to open surgery. These differences were obtained while showing no difference in margins or lymph nodes and similar mortality/leak rates [17]. These results were further confirmed by a study that examined national trends among 402 hospitals. Laparoscopic approach to colectomy resulted in longer operative time (195 vs. 80 min) but a shorter mean hospital stay (7.0 vs. 8.1 days), fewer transfusions (odds ratio 0.68), fewer in-hospital complications, and less readmissions within 30 days (odds ratio 0.89) [1]. The use of enhanced recovery protocols has further decreased the length of stay and the rate of complications, though how much is due to a laparoscopic approach and how much is due to the enhanced recovery are difficult to separate [18].

Learning Curve

Laparoscopic colon surgery is in every sense of the word complex. It requires surgery in multiple quadrants, large vessel ligation, bowel division, and re-anastomosis. Performing these tasks requires a significant amount of skill in a laparoscopic arena, where tactile sensation and multiple specialized retractors are not available. In addition, laparoscopic colon resection requires correct identification of planes that are not typically used in an open approach (for medial to lateral dissection). For these reasons, and the fact that the procedures often take longer than open surgery, laparoscopic colorectal surgery is not for the faint hearted. After performing a laparoscopic total proctocolectomy, which combines the difficulties of colon resection in all quadrants, Theodore Saclarides once said: “The patient looks better than the surgeon the next day.” Anyone who has performed laparoscopy in an obese patient can understand this statement.

As part of some of the aforementioned randomized trials looking at outcomes for laparoscopic surgery, participants had to demonstrate successful performance of 20 procedures, as this was initially considered to be the learning curve [14]. It was later determined that this was an underestimate. A subsequent study using cumulative sum analysis adjusted for case mix demonstrated that 55 procedures were necessary for right colectomy and 62 procedures for left colectomy to overcome the learning curve [19]. This presents a problem in that the average general surgeon performs ten colon resections per year. At this rate, it would take 5–6 years to overcome the learning curve. Specialized training programs in colorectal surgery allow faster achievement of this goal and have led some to recommend that a specialist only undertakes laparoscopic colon surgery.

Advances in technology have also aided progress. High-definition video laparoscopes improve visualization over the first-generation scopes. Energy devices such as the Harmonic® ACE (Ethicon Endo-Surgery, USA), LigaSure™ (Covidien, USA), and ENSEAL® (Ethicon) give the surgeon greater flexibility to transect vessels varying from 5 to 7 mm in size [20]. Finally, reticulating staplers allow transection of bowel deeper within the pelvis.

Single-port laparoscopy is adding another level of technical difficulty. Even for surgeons who are well experienced with the conventional laparoscopic techniques, an additional learning curve of 10–20 cases seems to exist [21].

The use of the robot has provided an interesting dilemma for colorectal surgeons. Published learning curves for use of the robot average about 20 cases [22]. It should be noted that this is often in surgeons who have mastered the laparoscopic learning curve. In almost every study to date, the robotic procedure takes longer than its laparoscopic counterpart, though the difference has decreased with more experience. Much of the difference now comes from docking and maneuvering the robot. The outcome of robotic versus laparoscopic surgery shows overall equivocal outcome [23, 24]. The proponents of robotic surgery point out that this technology may help to increase the utilization of minimal invasive surgery for pelvic procedures. Further studies will help to define the benefits of robotic colorectal surgery.

Similar to the robotic platform, newer 3-dimensional laparoscopes are now available, and early evidence demonstrates that this may shorten the laparoscopic learning curve for novice surgeons trying to master a 3-dimensional environment with only two-dimensional visualization. This difference is not seen in expert laparoscopists [25]. Perhaps because of improved visualization, novice surgeons were able to perform complex tasks such as suturing more efficiently and with fewer errors while using 3D versus 2D. This effect was not seen in expert laparoscopists, who had learned to adapt to the flat image. Additional studies currently underway may further define the role of 3D laparoscopy.

Current Trends

Nationally, only a fraction of colorectal resections are performed laparoscopically since 1990. In 2005, only 26 % was performed using a minimally invasive approach [26]. By 2011, there was a marked increase to 42.2 % of procedures performed laparoscopically at academic centers. Conversion to an open procedure was required in 15.8 % of cases based on a survey of data from national academic centers [27]. There seems to be an overall trend of increasing uptake of the laparoscopic approach in the United States since 2008 [28]. Risk factors for conversion have been well documented and include: surgeon experience, obesity, male gender, and higher ASA score [29]. As laparoscopic tools continue to grow, the learning curve may be shortened, thus allowing more surgeons to perform minimally invasive procedures. Additionally, enhanced recovery protocols further decrease length of stay and complications following colectomy [30, 31]. In 2010, only 30 % of institutions had an enhanced recovery protocol in place [32]. As experience with laparoscopic colectomy and enhanced recovery continues to grow, length of stay will likely decrease [32].

Summary

We have come a long way since the advent of the first minimally invasive procedures. Many studies have shown that laparoscopy is oncologically at least as good as open surgery and offers other significant advantages, such as decreased pain, shorter hospital stay, and less complications such as wound infections.

Current technology continues to grow. It remains to be seen what the newest innovation will bring. The use of NOTES (natural orifice transluminal endoscopic surgery) technology promises to bring further technical advancement to the field of laparoscopy. In all likelihood, the way we practice minimally invasive surgery in 20 years will be vastly different from what it is today, and all surgeons will need to adopt the ability to gain new skills in technologies that pass the scrutiny test. The field will continue to need people to test and validate new technology.

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Preoperative Planning and Postoperative Care in Minimal Invasive Colorectal Surgery

2

David J. Maron and Lisa M. Haubert

Preoperative Planning

Preoperative Work-Up

Many of the general principles that have been learned from open colon and rectal surgery can be applied to laparoscopic and robotic surgery. Patients undergoing minimally invasive colorectal surgery need a full history and physical exam, with particular attention paid to the number and types of previous abdominal surgeries, as well as any history of any significant abdominal infection. This should be accompanied by appropriate blood work, electrocardiogram, chest x-ray, and other investigations as dictated by the patient's age and comorbidities. For patients with colon and rectal cancer, routine preoperative evaluation includes preoperative staging and assessment of resectability, as well as a full colonoscopy to rule out synchronous lesions.

In minimally invasive colon and rectal surgery, tumor localization is a key component of the preoperative work-up. Unlike in open or hand-assisted cases, the tumor cannot be palpated for localization during the case, and tumors may not be visible during laparoscopy. If accurate localization is not obtained prior to the operation, the wrong segment of the colon may be removed [1]. In fact, a survey of members of the American Society of Colon and Rectal Surgeons showed that 6.5 % of respondents had removed the wrong section of the colon [2].

Options available for preoperative localization include barium enema, computed tomographic (CT) colonography, colonoscopy with India ink injection or placement of metallic clips, and intraoperative endoscopy. Barium enema has been found to have a low sensitivity (0.35–0.41) and high specificity (0.82–0.86) for detection of colon and rectal tumors with decreased reliability as the size of the lesion decreases [3, 4]. CT colonography has been shown to be superior to barium enema with a higher sensitivity (0.49–0.73) and a higher specificity (0.84–0.89). As with barium enema, the detection of lesions decreases with decreasing size [3, 4]. Although preoperative imaging may adequately demonstrate the location of the tumor, translation to accurate intraoperative localization and resection may not be reliable.

Colonoscopy has become the gold standard in detecting lesions as it has the highest sensitivity (0.97–0.987) and specificity (0.996–0.999) [3, 4]. Even though colonoscopy continues to be the best tool for detection, there are still errors in localization. The literature has shown an error rate in predicting the accurate location of a lesion within the colon ranging from 3 to 21 % [5–8]. Intraoperative colonoscopy can be used when lesions are not able to be located; however, this can insufflate the bowel and make the rest of the operation cumbersome [9, 10]. The use of CO_2 insufflation may help to significantly reduce this problem [11]. Serosal clips or sutures may be used with the help of intraoperative colonoscopy to mark the lesion; however, clips may fall off or be too small to see after placement [9, 12].

Another option is preoperative marking of the lesion by endoscopically placing a metal clip. The clip is applied to the mucosa and then fluoroscopy or ultrasound is used intraoperatively to locate the clip (Box 2.1). This technique can have disadvantages including migration or dislodgement of the clips, increased operative times, and radiation exposure to the patient [9, 10, 12].

Box 2.1 Tip

A preoperative abdominal x-ray reveals the approximate location of the clip in relationship to the colon, which might guide the selection of the right segmental resection and subsequent initial trocar placement.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_2, © Springer Science+Business Media New York 2015

Submucosal injection of India ink to tattoo the area distal to the lesion is increasingly being used and is the most reliable method for endoscopic localization of colon lesions (Box 2.2) [13]. The injection is performed in three to four areas circumferentially to improve localization of the tattoo, as injecting only one area may lead to inadequate identification if the tattoo is on the side of the colon attached to the retroperitoneum or the greater omentum [9, 10]. Overall, tattooing with India ink allows for accurate localization (97.9 %) with a low complication rate (0.22 %) [14, 15].

Box 2.2 Tip
Care should be taken to identify the possibility of multiple injections by other providers which might confuse the selection of correct resection margins.

Bowel Preparation

Controversy exists regarding the use of a preoperative bowel preparation for colon and rectal surgery (Box 2.3). Although several randomized trials and meta-analyses have demonstrated that there is no clear evidence of benefit from a mechanical bowel prep, the practice is still widely used [16–21]. These findings, however, cannot be generalized to minimally invasive surgery. Evidence-based guidelines concerning this specific issue are lacking. Some authors support the use of a bowel preparation for laparoscopic surgery, as an empty colon can ease handling of the bowel and allow for better exposure [22, 23]. Others have argued that no bowel preparation allows for better visualization secondary to no increase in diameter of the small bowel due to large volume preparations and solid matter in the bowel may allow for gravity to increase exposure [17, 22, 24]. To alleviate the increased diameter of the small bowel, some surgeons are using a 2–3-day preparation or a smaller volume of preparation [25].

Box 2.3 Tip
Bowel preparation might be necessary if intraoperative localization or confirmation of the pathology is planned using colonoscopy.

Specific Operative Issues

One of the main concerns with minimally invasive surgery is the associated learning curve [26–28]. Studies have shown that the required case numbers range from 11 to 152 [26, 28, 29] and there is an increased incidence of adverse events early in training [27, 28]. This is significant as several studies show that patients who undergo conversion from a minimally invasive approach have been shown to have a higher rate of complications [29–32]. If conversion is done early in the case, these patients have similar outcomes to patients undergoing conventional surgery [33]. Factors influencing conversion have been shown to include increased age, body mass index, body surface area, American Society of Anesthesiologists Classification, presence of abscess at time of operation, pelvic dissection, previous abdominal surgeries, and diagnosis of inflammatory bowel disease and cancer [27, 34–36]. Even though there is no consensus that careful patient selection decreases complications during the early portions of the learning curve, some evidence exists to support this concept [26, 28].

During the early institution of minimally invasive surgery for cancer, port site implants were a significant concern [37]. The results of multiple trials have demonstrated that similar oncologic resections can be obtained with laparoscopic colon resections when compared to the standard open operations [38–41]. Laparoscopic resection of rectal cancer has been proven by multiple single-institution studies to be safe and results in similar recurrence and disease-free survival [42–45]. Robotic colorectal surgery has shown similar recurrence and disease-free survival in short-term follow-up, but long-term studies are needed [46–48].

Contraindications for Laparoscopic or Robotic Surgery

Very few absolute contraindications to minimally invasive surgery still remain [49, 50]. It was previously believed that advanced age, obesity, cancer, fistulas, previous abdominal surgeries, severe pulmonary disease, or congestive heart failure were contraindications to laparoscopic colon and rectal surgery. [49]. Recently, studies have called into question whether these remain as contraindications.[49–55]. Invasive monitoring is recommended in patients who have an American Society of Anesthesiologists Grade of III–IV [55]. Authors have reported using laparoscopic techniques even in emergency cases such as sigmoid volvulus and bowel obstruction [56, 57]. Most still perform standard open operations for fecal peritonitis, toxic megacolon, and in unstable patients [49].

Postoperative Care

Fast-Track Recovery

Traditionally after colorectal surgery patients were kept nothing by mouth (NPO) until they demonstrated return of bowel function [58, 59]. Decompression with nasogastric tubes was often used along with this protocol [58, 60]. Research supports the elimination of nasogastric tubes after colorectal surgery in favor of selective use [58, 60–62], and no obvious benefit has been found for keeping patients NPO [59]. Fast-track or enhanced recovery after surgery (ERAS) often includes the institution of oral fluids on postoperative day zero [63]. No universal protocol exists, but the main points include preoperative patient education, avoidance of preoperative bowel preparation, early institution of nutrition and advancement as tolerated, omitting the use of nasogastric tubes, early ambulation, and multimodal analgesia. ERAS has been shown to accelerate return of bowel function and reduce postoperative morbidity, mortality, and average length of hospitalization [63–66].

Scatizzi et al. showed that ERAS can be safely instituted for laparoscopic colorectal surgery and was found to reduce length of hospital stay [67]. Implementation of ERAS specifically for laparoscopic rectal surgery only showed a success rate of 52.5 % [68]. Patients with low rectal lesions are at a greater risk of ERAS failure secondary to surgery-related complications [68].

Postoperative Nausea and Vomiting

Postoperative nausea and vomiting (PONV) are common complications after surgery. Approximately 20–30 % of patients will suffer from PONV after surgery [69–71], and in high-risk patients PONV can be as high as 70–80 % [69]. Risk factors include type of surgery, female gender, nonsmokers, history of PONV or motion sickness, and younger age. Laparoscopic surgery was found to be the second most common type of surgery causing PONV [70]. Research demonstrates that prolonged duration of anesthesia, postoperative opioid use, and the use of volatile anesthetics and nitrous oxide are also risk factors for PONV [69, 70]. Use of propofol for induction, perioperative oxygen supplementation, increased hydration, avoidance of volatile anesthetics and nitrous oxide, and decreasing the intra- and postoperative use of opioids decreases the incidence of PONV [72]. Consensus guidelines regarding the administration of prophylactic antiemetic medications based on risk score stratification recommend that only patients who are moderate to high risk for PONV should receive prophylaxis [72]. After instituting these guidelines, one study showed a significant decrease from 8.36 to 3.01 % of PONV [69].

Many pharmacologic options are available for prophylaxis against postoperative nausea and vomiting. 5-HT_3 receptor antagonists have been found to be most effective when given at the end of surgery [72]. Dexamethasone effectively prevents PONV when given prior to induction of anesthesia. Droperidol is as effective as 5-HT_3 in the prevention of PONV when given at the end of surgery; however, its use has been limited by the FDA due to safety concerns. Other medications that can be used include dimenhydrinate, scopolamine, promethazine, prochlorperazine, and ephedrine [72]. Less conventional options for treatment of PONV include acupuncture, transcutaneous electrical nerve stimulation, acupoint stimulation, acupressure, and hypnosis [72–75].

Ileus

Postoperative ileus (POI) is defined as the temporary decrease in motility of the gastrointestinal tract after surgery. It can present with nausea, vomiting, abdominal pain, abdominal distention, and absence of flatus and bowel movements [76]. The frequency of POI ranges from 3 to 32 % of patients and can cause considerable distress to those affected. It can also increase length of stay, which may increase hospital-acquired infections and healthcare costs [77].

The cause of POI is multifactorial [76]. Use of opioids significantly correlates with POI, whereas epidural analgesia has not been shown to have this negative effect [76, 78]. Since opioids are known to decrease gastrointestinal motility, recent research has focused on pharmacologic agents such as alvimopan, a peripherally acting μ-opioid receptor antagonist [78, 79]. The use of alvimopan may decrease time to return of bowel function [79], but the use of this medication has not been studied following laparoscopic colorectal surgery. Currently there is no standard pharmacologic treatment or consensus of management of POI [80].

Gum chewing, a form of sham feeding, promotes the cephalic phase of digestion. This may be the reason that gum chewing was reported to reduce the time to first flatus and bowel movement [81]. Zaghiyan et al. though, showed no benefit to chewing gum when compared to no gum chewing in colorectal surgery patients [82]. Other factors shown to decrease POI include early feeding, elimination of nasogastric tubes, and early ambulation [78, 81].

Minimally invasive techniques have been shown to be associated with earlier recovery of gastrointestinal function and decreased POI [83, 84]. Laparoscopy has been reported to have a POI of 10 % [77]. van Bree et al. reported laparoscopic surgery was a significant independent predictive factor of improved colonic transit [85]. Delaney et al. also showed mean bowel recovery and length of stay after laparoscopic colectomy was accelerated when compared with open colectomy [86].

Analgesic Options

Adequate control of postoperative pain is of great importance in colorectal surgery, as it allows for early ambulation and can increase patient satisfaction [87]. Following minimally invasive colorectal surgery, there is no evidence that any specific postoperative analgesic option is optimal [88]. The use of narcotics results in adequate pain control; however, their use is known to decrease gastrointestinal activity via stimulation of μ-opioid receptors [80] thereby potentially prolonging postoperative ileus. When compared to intravenous narcotics, epidural analgesia has reduced pain scores without a significant change in return of bowel function or length of stay [89, 90]. Epidurals containing only local anesthetic (bupivacaine) have been shown to reduce the duration of ileus when compared with epidurals containing only opioids or a combination of opioids and bupivacaine [91, 92].

Other alternatives to narcotics are available for postoperative pain management. Nonsteroidal antiinflammatory drugs and acetaminophen are widely used to augment pain management postoperatively [88]. Nonsteroidal antiinflammatory drugs, however, may be associated with an increased risk of anastomotic leakage [93]. Studies have demonstrated that the addition of ketorolac can decrease postoperative pain, use of narcotics, and time to return of bowel function, but has no effect on length of stay [94, 95]. The use of tramadol and gabapentin has not been thoroughly studied in colorectal surgery patients [88]. Intravenous acetaminophen has been found to be safe and well tolerated in adult inpatients with statistically significant analgesic efficacy when compared with placebo after abdominal laparoscopic surgery [96, 97]. Liposomal bupivacaine injected into the surgical site prior to wound closure has been shown to decrease postoperative opioid use by half and shorten length of stay [98].

Pulmonary Impairment

Pulmonary complications are a well-known problem after colorectal surgery [87]. All patients have some form of pulmonary impairment after abdominal surgery [99]. When compared to open surgery, studies have shown an earlier return of forced expiratory volumes and decreased incidence of postoperative pulmonary complications in laparoscopic cases [100–103]. Incentive spirometry is designed to compel patients to take long, slow, deep breaths resulting in decreased pleural pressure, increased lung expansion, and better gas exchange [104]. Incentive spirometry has been widely adopted in most hospitals, but studies show inconclusive results for its support [99, 104–106]. Delayed ambulation and uncontrolled pain have been found to correlate with worsened pulmonary function [107, 108].

Early Ambulation

The concept of early ambulation following surgery was proposed as early as 1817 [109]. Leithauser published several articles, which popularized early ambulation as a means to decrease pulmonary, circulatory, and gastrointestinal complications [110, 111]. Early ambulation has been shown to correlate with reduced morbidity, recovery time, and length of stay after colorectal surgery without an increase in complications [63, 112]. Benefits from early ambulation on gastrointestinal function remain inconclusive at this time, as studies have shown a reduced length in stay, but no change in time to flatus or bowel movement [113, 114].

Venous Thromboembolism Prophylaxis

Hospitalization confers a high risk of venous thromboembolism (VTE) in the form of deep vein thrombosis (DVT) and pulmonary embolism (PE). Without thrombophylaxis, the incidence of hospital-acquired DVT ranges from 10 to 40 % [115]. Risk factors include type of surgery, inflammatory bowel disease, malignancy, immobilization, increasing age, and venous compression [115–119]. Laparoscopic surgery was shown to reduce the risk of VTE when compared to open techniques [120].

VTE prophylaxis should be a standard component of the postoperative care of colorectal patients. The American Society of Colon and Rectal Surgeons published their practice guidelines for the prevention of VTE. Patients are stratified preoperatively into low, moderate, high, and highest risk, and postoperative prophylaxis is based on this stratification. Low-risk patients do not require any specific measures other than early ambulation. Either mechanical sequential compression devices or low-dose unfractionated heparin (LDUH) every 8–12 h may be used for moderate-risk patients. High-risk and highest-risk patients should be given either LDUH or low-molecular-weight heparin (LMWH) [121]. Some controversy exists, though, regarding the use of LMWH. One study showed that prophylactic therapy with LMWH was not completely effective in the prevention of postoperative VTE in patients with inflammatory bowel disease [122].

Postoperative Complications

Wound infections are one of the most common postoperative complications in surgical patients. Surgical site infections (SSIs) are the second leading cause of all nosocomial infections [123]. Up to 13.5 % of patients undergoing bowel surgery will develop an SSI [124]. The Surgical Care Improvement Project (SCIP) uses evidence-based medicine to establish surgical practice guidelines. SCIP measures to reduce SSIs include prophylactic antibiotics received within 60 min prior to incision, appropriate antibiotic selection, discontinuation of antibiotics postoperatively within 24 h, maintaining normothermia perioperatively, and the use of clippers for hair removal [125]. There is some evidence that compliance with SCIP guidelines has decreased SSIs, but this has not been substantiated by large-scale national studies [126]. Laparoscopy has been shown to significantly decrease SSI when compared to open operations [127]. When wound complications occur following laparoscopic surgery, they are often much less severe than open laparotomy SSIs [127].

An anastomotic leak is one of the most dreaded complications following colorectal surgery. The prevalence has been reported to range from 0.5 to 21 % [128–131], and both morbidity and mortality significantly increase after an anastomotic leak. Mortality following anastomotic leak has been reported to range from 12 to 27 % [132–136]. Anastomotic leaks are also associated with longer hospital stays and increased hospital costs [137]. Anastomotic complications can be secondary to technical factors including ischemia, tension, stapler malfunction, malnutrition, immunosuppression, morbid obesity, radiation exposure, and an anastomosis less than 10 cm from the anal verge [138, 139]. Although most studies show equivalent leak rates when compared with open surgery, laparoscopy was shown to decrease anastomotic leaks in a recent study [137]. Ricciardi et al. demonstrated that if an anastomosis was found to have an air leak at the time of surgery, suture repair alone was associated with the highest rate of postoperative clinical leak (12.2 %) compared with diversion (0 %) or reconstruction of the anastomosis (0 %) [140].

Anastomotic bleeding has been reported to occur in 5.4 % of stapled and 3.1 % of hand-sewn colorectal anastomoses [141]. Most cases resolve with conservative management. One study reported an intervention rate requiring therapy in addition to a blood transfusion of 0.8 % [142]. For those who require intervention, options include endoscopic control with injection or clip application and reoperation with refashioning of the anastomosis. Angiographic embolization or injection of vasopressin should be avoided as this may result in ischemia of the anastomotic segment with subsequent leak or stricture formation [142, 143].

Intra-abdominal abscesses can form from an anastomotic leak, spillage of stool at the time of surgery, missed enterotomies, or postoperative hematomas. Patients that demonstrate signs of infection such as localized peritonitis, fever, or increased white blood cell count should be evaluated with a CT scan of the abdomen and pelvis with oral and intravenous contrast [139, 144]. The extravasation of rectal contrast, when used, is the most reliable marker of an anastomotic leak. Some authors therefore believe that it should be used in all cases to evaluate left-sided anastomoses [145]. CT-guided abscess drainage is an effective intervention with a 65 % rate of resolution after the first and 85 % resolution after the second drainage [146]. CT-guided drainage may be appropriate for patients with abscesses over 3 cm, but operative intervention should be undertaken for patients with generalized peritonitis, if drainage is not feasible or if the patient shows no improvement or continues to deteriorate. For abscesses smaller than 3 cm in diameter, CT-guided aspiration may also be an option [144]. Broad-spectrum intravenous antibiotics should also be started, as small abscesses may respond to antibiotics alone [147].

Adhesive small bowel obstructions (SBO) are common after abdominal surgeries and remain a leading cause of hospital admissions [148]. The rate of SBO has been reported to be as high as 10 % after colectomies [149]. Some authors have shown that there is a significant reduction in the readmission rate after laparoscopic colorectal surgery when compared with open surgery [150], while others have found no difference in the rates of SBO [151].

Summary

Preoperative planning is an important aspect of minimally invasive colorectal surgery. Colonoscopy remains the gold standard for localization. Most surgeons continue to use mechanical bowel preparations, though evidence-based guidelines are lacking. ERAS can be successfully implemented in minimally invasive surgery. Laparoscopy has been shown to decrease POI, pulmonary complications, and length of stay.

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Operating Room Setup and General Techniques in Minimal Invasive Colorectal Surgery

3

Saif A. Ghole and Steven Mills

Introduction

The use of minimally invasive techniques (laparoscopic and robotic) is expanding rapidly in the field of colorectal surgery [1]. An increasing percentage of colorectal surgeons is incorporating minimally invasive techniques into their practices. Additionally, training in laparoscopy has become a required component of colon and rectal surgery fellowships throughout the nation.

Minimally invasive techniques have demonstrated tangible benefits to patients in terms of diminished postoperative pain, reduction in postoperative ileus, earlier tolerance of a diet, diminished hospital stay, earlier return to normal activities, and improved cosmesis [2–6]. These benefits, however, are offset partially by the presence of an established learning curve (>20 cases) ascribed to obtaining proficiency in minimally invasive colon and rectal surgery [2, 5]. Additionally, laparoscopic and robotic operations are associated with increased operating room times and requisite operating room costs. These disadvantages are most evident early in a surgeon's minimally invasive practice, namely, until one has attained efficiency and an adequate case volume in laparoscopic and robotic surgery to employ minimally invasive techniques proficiently. Despite these drawbacks, minimally invasive colon and rectal operations have been shown to be cost-effective and clearly offer numerous patient-centered benefits when compared to open operations [7–10].

Central to attaining proficiency in minimally invasive colon and rectum surgery is obtaining an understanding of the proper operating room setup, necessary specialized equipment and instrumentation, as well as a basic understanding of patient positioning for these operations. As such, these topics form the basis of this chapter.

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Equipment

Specific surgical equipment is required for performance of laparoscopic and robotic operations. Though hospitals regularly perform common laparoscopic cases such as appendectomy and cholecystectomy, and most up-to-date operating rooms are equipped with laparoscopic instruments, some specialized instruments will facilitate laparoscopic colon and rectal surgery. Instrumentation will be reviewed in detail below.

Laparoscopes, Cameras, Light Source, and Monitor

The ability to obtain adequate visualization and lighting within the peritoneal cavity is of paramount importance in performing minimally invasive surgery. A wide array of laparoscopes of different diameters and viewing angles are available specifically for this purpose. In practice, 5 and 10 mm, oblique-viewing (30°) laparoscopes are used most often. Flexible-tip laparoscopes, which provide the operator with the ability to view intraperitoneal contents at different angles without having to rotate or move the shaft of the laparoscope, are also available and can facilitate laparoscopic operations (Fig. 3.1). Traditionally, a rod-lense style laparoscope is attached at its base to a video camera head. The video camera head (either analog or high definition) is connected to a camera control terminal, which then projects the video image to monitors present within the operating room. In many operating rooms, the available monitors are flat screen, LCD monitors. Increasingly, high-definition cameras and monitors are becoming commonplace, in turn, significantly improving picture quality for the surgeon. As these HD cameras and monitors provide a superior view, they should be used whenever available.

A xenon (300 W) light source is connected via the rod-lens to project adequate lighting onto the operative field (Fig. 3.2). Alternatively, some laparoscopes have integrated

O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_3, © Springer Science+Business Media New York 2015

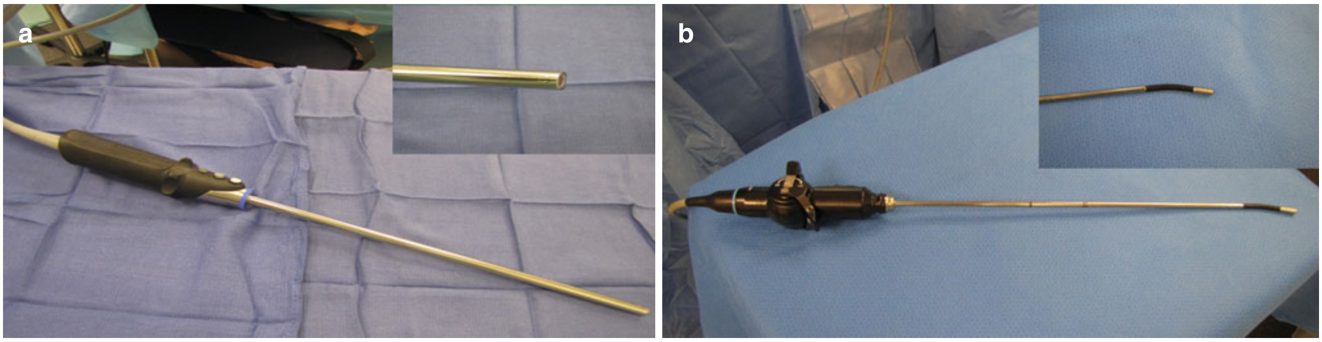

Fig. 3.1 Laparoscopes of different sizes and viewing angles facilitate visualization. (**a**) A 10-mm 30° angled tip laparoscope. (**b**) A 5-mm flexible-tip laparoscope

Fig. 3.2 Standard light sources are shown

light sources. The light is carried to the rod-lens via fiber-optic cables. When passing the fiber-optic light source cable on and off the operative field, care must be taken to avoid damaging the relatively fragile fiber-optic cables, as damage to these will result in diminished light output and therefore an inferior image. It is recommended that the camera control equipment be connected to digital recording and storage devices to permit documentation, to promote teaching, and for use of the video in research endeavors.

Insufflator

An electronically controlled carbon dioxide insufflator is used to establish and maintain pneumoperitoneum (Fig. 3.3). This system consists of the following: an intra-abdominal pressure display, an adjustable pressure selector, and digital

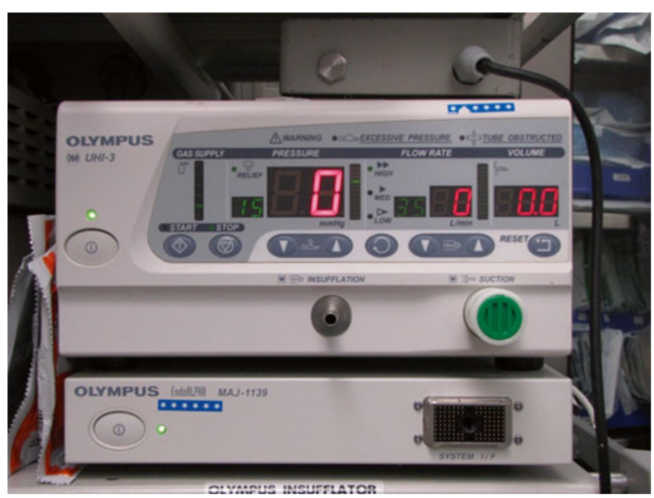

Fig. 3.3 A standard insufflator permitting pneumoperitoneum for laparoscopic and robotic operations is shown

flow and volume displays. Once pneumoperitoneum is initially established, high flow settings (20–40 L/min) are generally used to maintain the pneumoperitoneum. The system self-regulates to maintain the desired pneumoperitoneum.

Instruments

A number of instruments have been designed specifically for use during laparoscopy. Many come in both reusable and disposable forms. The basic instruments that we advise having available for minimally invasive operations are the following:

Suction-irrigation device – this device allows for rapid intraoperative aspiration of blood, fluid, spilled bowel contents, etc., and/or irrigation of the same should the need arise.

Laparoscopic warmers – this allows one to keep the rod-lens device warmed to 37–40 centigrade in a saline bath to prevent fogging upon insertion into the warm, humid confines of the peritoneum. Having an antifog solution (Dr. Fog, Aspen Surgical MI, USA; Fred, Cardinal Health, OH, USA) available on the operative field can also facilitate rapid lens de-fogging. Newer laparoscopes, which have antifog features built into the rod-lens system, are available which eliminate the need for these baths.

Trocars – a variety of 5-, 10-, and 12- mm trocars are available. While the number and type depend on surgeon's preference as well as the particular case being performed, we generally recommend having several 5- and 12-mm trocars readily available. Blunt tip trocars should be used to decrease the risk of injury to either the intestines or the abdominal wall musculature. The older, bladed trocars should be avoided [11].

Graspers (bowel and heavy graspers) – graspers are available in various sizes (5 mm and 10 mm), lengths (31 cm is standard), and shapes. Generally atraumatic (bowel), toothed, Maryland, Babcock, and right-angle graspers are the most useful for performing laparoscopic colorectal surgery.

Scissors – scissors permit both blunt and sharp dissection. Additionally, most can be connected to monopolar cautery, permitting improved hemostasis during dissection.

Clip applier and Endoloop – having a laparoscopic clip applier and Endoloop readily available in order to gain control of blood vessels prior to transection or in the emergent setting when rapid control of bleeding is desired is recommended.

Staplers – a variety of disposable laparoscopic staplers have been designed and are available in order to facilitate bowel and vessel transection as well as bowel anastomoses. Depending on the case, linear anastomotic staplers or circular end-to-end anastomosis staplers may be needed.

Energy sources – monopolar and bipolar sources of energy, as well as thermal dissecting devices, are available and are an important complement to the armamentarium of a laparoscopic colorectal surgery. Electrosurgery as well as LigaSure (Covidien, CO, USA), Enseal (Ethicon Endosurgery, OH, USA), and Harmonic scalpel (Ethicon Endosurgery, OH, USA) style devices greatly facilitate bowel surgery, specifically division of blood vessels within the mesentery and omentum.

Hand-Assist Techniques

Another technique for minimal access surgery is via a hand-assist technique. As with straight laparoscopy, laparoscopic instruments are used as well as a laparoscopic camera. A hand-assist port (GelPort Laparoscopic System, Applied Medical, USA) is inserted through a 6–7 cm abdominal wall incision through which the surgeon can pass one hand. The surgeon's hand is then used to retract, dissect, etc. as needed.

Single-Port Techniques

A single-incision technique is also available wherein a 2–3 cm incision is made through the abdominal wall and a single-port device is inserted (GelPoint, Applied Medical, USA; TriPort and QuadPort, Olympus, Japan; SILS Port, Covidien, USA; Single Site Laparoscopic Access System, Ethicon Endosurgery, USA). All ports/instruments as well as the camera are inserted through this port and the procedure is completed without further incisions.

Robotic Techniques

Most robotic operations are hybrid techniques that involve the concurrent use of laparoscopic and robotic instruments. As such, availability of the laparoscopic instruments described in the prior section is essential to robotic cases. In addition to this, however, there are several robot-specific technologies which merit review.

The da Vinci robotic surgical system (Intuitive Surgical, Sunnyvale, USA) is the only robotic system currently available for surgical use. The system consists of a three- or four-armed surgical robot that docks into position at a desired location adjacent to the patient. The initial setup requires obtaining intraperitoneal access as would be done for laparoscopic surgery. Thereafter, a 12-mm endoscopic port is inserted, which permits initial laparoscope and later robotic laparoscope placement. Three reusable robotic instrument ports (8 mm) are then placed intraperitoneally. Each of the ports is configured so that it can be docked to the robotic arms.

The robotic camera contains two separate video chips to allow for a binocular image. It is introduced through the 12-mm trocar and captures three-dimensional video of the intraperitoneal contents. These images are then projected to a control console placed some distance away from the patient. The surgeon sits at the console and is able to remotely control the camera and the robotic instruments connected to the arms of the da Vinci robot. An assistant (who is scrubbed in) is required at the patient's bedside to exchange robotic instruments when necessary and to assist with retraction and suction if needed. The robotic instrument attachments most commonly used are a grasper, shears attached to monopolar cautery, and a bipolar grasper. The main advantages of robotic surgery over laparoscopic surgery are felt to be (1) the superior three-dimensional images that can be obtained of the intraperitoneal contents using the robotic endoscope and (2) the freedom of movement and motion that the robotic instruments allow for. The later is particularly useful when performing complex tasks (i.e., dissecting or suturing) within anatomically confined space. An ongoing randomized trial comparing laparoscopic and robotic surgery for rectal cancer will shed more light on the comparison of the two techniques [12].

General OR Setup for Minimal Invasive Colorectal Surgery

Figure 3.4 demonstrates a typical operating room setup for laparoscopic colorectal surgery. When available, ceiling-mounted booms help keep the various cords organized. We recommend that all cords and tubing enter and exit the sterile field from the same position whenever feasible. For example, for a laparoscopic low anterior resection, all tubes and cords could exit from the left side of the patient above the operative field. Figure 3.5 demonstrates a typical operating room setup for robotic colorectal surgery.

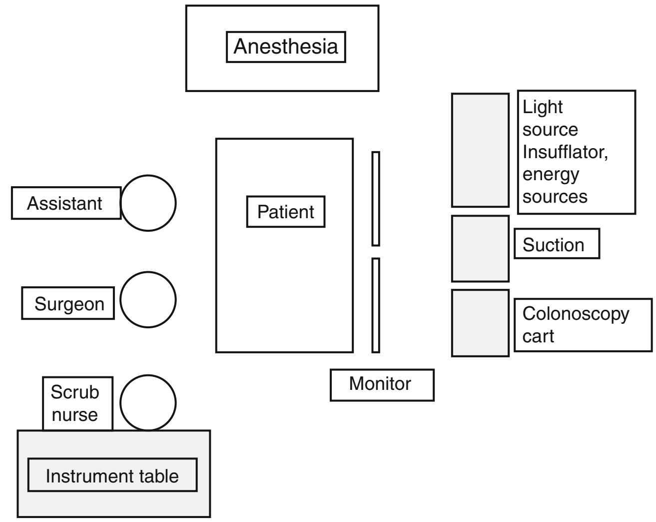

Fig. 3.4 Operating room setup for laparoscopic colorectal surgery

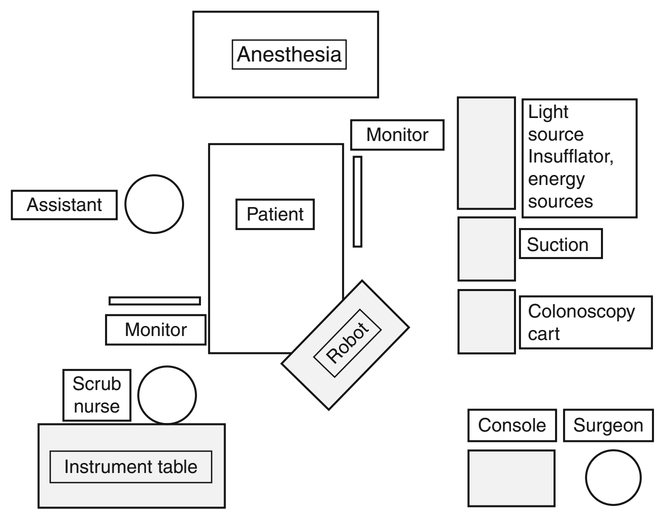

Fig. 3.5 Operating room setup for robotic colorectal surgery

Patient Positioning

In the following section we will discuss general patient positioning for the most common laparoscopic and robotic operations. We will defer discussion of port placement to subsequent chapters of this textbook, which will elaborate upon this topic in detail.

Regardless of the type of operation that is to be performed, a few principles should be kept in mind. First, the patient must be positioned is a manner that precludes pressure or nerve-related injury. All pressure points must be adequately padded and cushioned. Second, the patients should be secured to the operating table and prevented from sliding off the table. This is particularly important in laparoscopic and robotic surgery, where the surgeon may need to incline, turn and recline the patient at extreme angles to facilitate the operation. At our institution we use the Pink Pad – Pigazzi Patient Positioning System (Xodus Medical, PA, USA) – which consists of a single use pink foam pad placed directly on top of the operating table, disposable liftsheet, and body strap – to achieve this objective (Fig. 3.6). Alternatively, the patient can be positioned on a beanbag secured to the operating room table or a gel pad without liftsheets and shoulder pads. Third, all patients must have appropriate IV lines, cardiac monitoring leads, and catheters (including a urinary catheter permitting monitoring of intraoperative urine output) positioned in such a manner that they do not obstruct the surgeon's operative field. Finally, appropriate prophylaxis (IV antibiotics, sequential compression devices, and/or

Fig. 3.6 Pink pad – Pigazzi patient positioning system

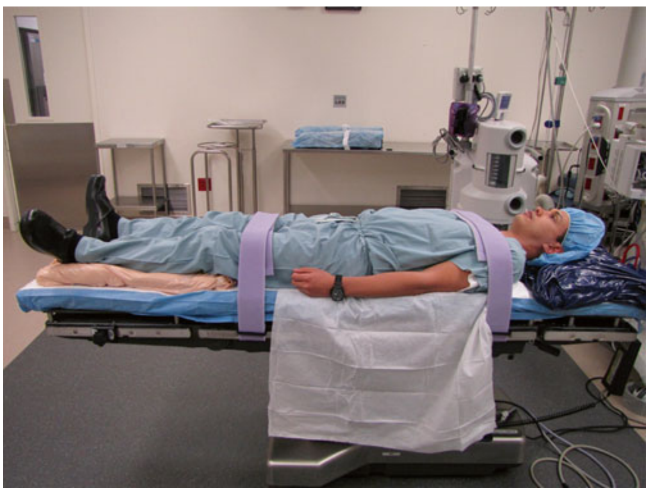

Fig. 3.7 Patient positioning for a laparoscopic or robotic right colectomy

chemical deep venous prophylaxis) must be instituted prior to initiation of the operation and continued/repeated as needed during the operation.

Laparoscopic Right Hemicolectomy

For laparoscopic right colectomies, the patient should be positioned in a supine position with at least the left arm tucked (as both the surgeon and assistant will be standing to the patient's left side) (Fig. 3.7). A chest strap placed superior to the xiphoid process and leg strap placed across the femurs should be applied to secure the patient to the bed for the ensuing operation. The urinary catheter may be passed off over the patient's left leg. The patient's abdomen and pelvis should be prepped from the xiphoid process to the pubic symphysis and from the right posterior axillary line to the left posterior axillary line. An alternative positioning can be supine with the legs in low lithotomy using padded stirrups such as Yellofin Stirrups (Allen Medical Systems, MA, USA). This will allow the surgeon or assistant to stand between the legs if desired and will allow performing an intraoperative colonoscopy if necessary.

Laparoscopic Total Abdominal Colectomy, Left Hemicolectomy, Sigmoidectomy, Low Anterior Resection, and Abdominoperineal Resection

For laparoscopic total abdominal colectomies, sigmoidectomies, low anterior resections, or abdominoperineal resections, the patient should be positioned in a modified lithotomy position with both arms tucked (Fig. 3.8). This provides the surgeon and assistant with rapid access to either side of the patient's body, as well as access to the perineum should colonoscopy, flexible sigmoidoscopy, or proctoscopy be required. Additionally, in the case of sigmoid colectomy and low anterior resections, access to the perineum permits passage of a circular stapler through the anus or for a hand-sewn anastomosis if needed. A chest strap or heavy tape placed superior to the xiphoid process should be applied to secure the patient to the bed for the ensuing operation. The urinary catheter may be passed off under the patient's left leg. The patient's abdomen and pelvis should be prepped from the xiphoid process to the pubic symphysis and from the right posterior axillary line to the left posterior axillary line.

Robotic Right Hemicolectomy

Though not a commonly performed procedure, for a robotic right hemicolectomies, the patient should be positioned in a supine position with both arms tucked (Fig. 3.7). A chest strap placed superior to the xiphoid process and leg strap placed across the femurs should be applied to secure the patient to the bed for the ensuing operation (Box 3.1). The urinary catheter may be passed off over the patient's left leg. The patient's abdomen and pelvis should be prepped from the xiphoid process to the pubic symphysis and from the right posterior axillary line to the left posterior axillary line. The robot will be docked to the right of the patient at an oblique angle.

Box 3.1 Tip
A slight hyperextension of the legs will prevent occasional impairment of robotic arm mobility.

Fig. 3.8 Patient positioning for laparoscopic or robotic total abdominal colectomy, sigmoid colectomy, low anterior resection, and abdominoperineal resection

Robotic Low Anterior Resection, Proctectomy

For robotic low anterior resections and proctectomy, the patient should be positioned in a modified lithotomy position with both arms tucked (Fig. 3.8; Box 3.2). A chest strap placed superior to the xiphoid process should be applied to secure the patient to the bed for the ensuing operation. The urinary catheter may be passed off under the patient's left leg. The patient's abdomen and pelvis should be prepped from the xiphoid process to the pubic symphysis and from the right posterior axillary line to the left posterior axillary line. The robot can be docked from the left side of the patient at an oblique angle (over the hip) or from between the legs.

> **Box 3.2 Tip**
> Lower the left leg enough to avoid collision of the knee while docking the robotic arm from an oblique angle while the patient is in a Trendelenburg position with the left side up.

Obtaining Intraperitoneal Access

There are three principle ways in which intraperitoneal access can be obtained.

Veress Needle

This technique involves the placement of a Veress needle through a small abdominal skin incision, directly through the underlying subcutaneous fat, fascia, and peritoneum into the abdominal cavity. The Veress needle safety mechanism consists of a blunt-tipped spring-loaded inner stylet, which retracts when it meets resistance, revealing a beveled needle (Fig. 3.9). Once the needle is passed through the abdominal wall into the peritoneal cavity, the blunt inner stylet redeploys. The Veress needle is most often inserted periumbilically or in the patient's left upper quadrant (i.e., at Palmer's point). Needle placement can be confirmed by a variety of means. An aspiration syringe with saline is attached to the end of the Veress needle permitting aspiration and ideally revealing only air. Next the saline within the syringe can be injected through the Veress needle to demonstrate free/unobstructed flow through the needle. Finally, the needle is attached to insufflation tubing to check the intraperitoneal pressure and pressure during insufflation. Normal intra-abdominal pressures tend to be very low (<5 mmHg). High pressures can indicate inappropriate needle position. Because the needle insertion is done blindly, there remains a finite chance of injury to adjacent viscera or blood vessels. For this reason, we advocate Veress needle insertion at Palmer's point (just below the left costal margin) where the tenth rib tents the abdominal wall off of the underlying viscera, and, as such, injury to larger blood vessels (i.e., the inferior vena cava, aorta, and iliac vessels) and intestines can be avoided.

Hasson (Open) Access

The open (Hasson) technique for gaining intraperitoneal access has gained favor among those who desire direct visualization of the intraperitoneal contents prior to insertion of a trocar (Fig. 3.10). The open technique consists of incising the abdominal wall, visualizing the underlying fascia, grasping it up, and directly incising the fascia and underlying peritoneum

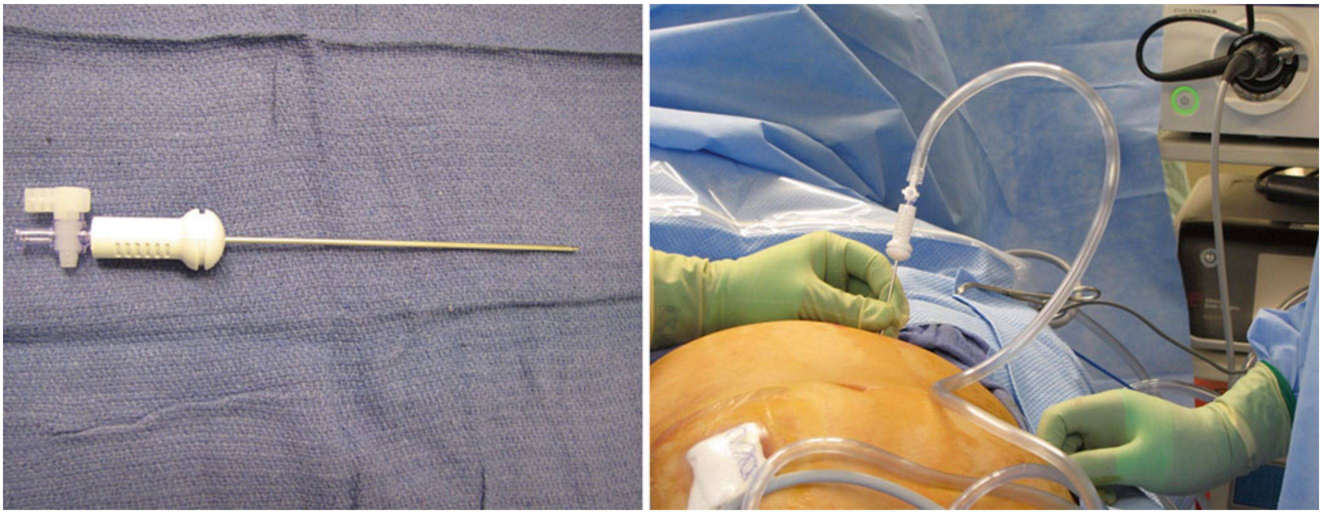

Fig. 3.9 A standard Veress needle is shown

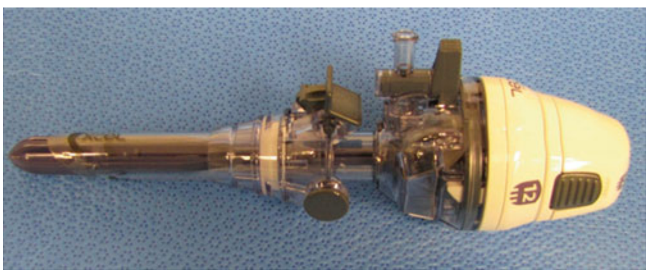

Fig. 3.10 A standard Hasson trocar is shown

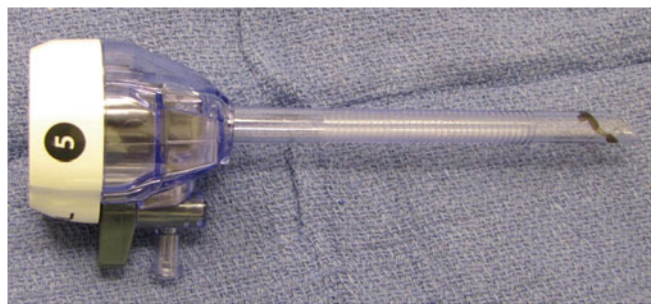

Fig. 3.11 A standard optical access trocar is shown

to gain intraperitoneal access. Once the peritoneum is accessed, stay sutures are applied on the fascial layers on either side of the incision, and a 12-mm Hasson trocar is inserted into the peritoneum. Insufflation is performed through the Hasson trocar. While the open approach avoids vessel injury, there remains a risk of injury to any viscera that may be directly under the abdominal wall when the abdominal wall is incised. This is especially true during reoperations or operations in the setting of intraperitoneal adhesions. In theory, Hasson access can be obtained anywhere on the abdomen but is generally achieved in a periumbilical location.

Optical Access Trocars

An alternative technique for abdominal entry involves the use of optical access trocars (i.e., Optiview, Visiport), which are blunt see-through trocars (Fig. 3.11). After a small skin incision is made on the abdominal wall at a desired location, the optical access trocar and zero-degree laparoscope, inserted through the top of the trocar, are advanced together through the abdominal wall. The layers of the abdominal wall are seen to deform around the trocar as it is placed into the abdominal cavity. The endoscope provides direct visualization of the entry, theoretically minimizing unintended injury to intraperitoneal contents. Optical port access to the peritoneum can be achieved anywhere on the abdominal wall.

A recent Cochrane database review suggested that open (Hasson) access resulted in significantly reduced rates of failed intra-abdominal entry, extraperitoneal insufflation, and omental injury when compared to Veress needle entry. Interestingly, vascular and visceral injuries were not significantly affected by method of entry [13].

Single Port and Hand Assist

Gaining access with either a single-assist or hand-assist device is relatively straightforward. The appropriate sized incision (dependent upon specific device used) is made in the skin and carried down through the layers of the abdominal wall with the same sized incision in the abdominal wall fascia. The peritoneum is opened and the device is inserted. The

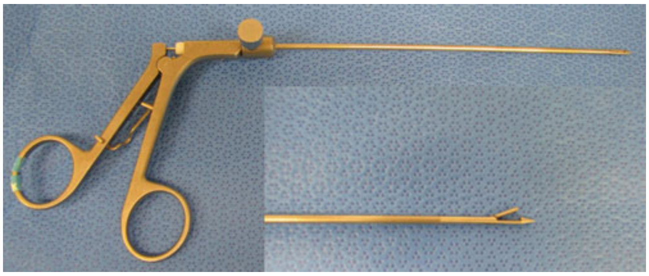

Fig. 3.12 A Carter-Thomason fascial closure device is shown

specific location of the device will depend upon the surgeon's preference and the procedure being performed.

Techniques for Port Closure

Two techniques are generally used for fascial closure of laparoscopic port sites.

Suture Closure of Fascia

The fascia can be closed primarily by approximating and closing the fascial defect through the skin incision itself. In order to do this, toothed forceps are used to grasp the fascial edges and a primary fascial closure is performed with sutures placed in a simple or figure-of-eight fashion.

Fascial Closure Devices

Disposable and nondisposable fascial closure devices (e.g., the Carter-Thomason wound closure system) are available which allow for the primary closure of the fascial edges under direct laparoscopic visualization (Fig. 3.12). A transfascial suture is passed through a stab wound on either side of the fascial defect wound. This suture is then tied extracorporeally down through the skin incision to achieve fascial closure.

Summary

Immediate availability of specialty equipment and instrumentation, standardized operating room setup and patient positioning, and individualized access and closure techniques are the foundation of a successful minimal invasive colorectal procedure.

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4 Operating Room Setup and General Techniques for Robotic Surgery

Seung Yeop Oh, Cristina R. Harnsberger, and Sonia L. Ramamoorthy

Introduction

In this chapter, we will review equipment, setup, and general techniques in robotic surgery. Robotic techniques are increasingly being applied to colorectal surgery. To date, the most common indication for the use of robotics in colorectal surgery is in the pelvis for rectal dissection. More recently, however, robotic colectomy is gaining momentum. Before incorporating robotic technology into practice, a fundamental knowledge of the system and proper use of the equipment and basic procedure setup are critical to patient safety and optimal outcomes.

Preparation for Robotic Surgery

Proper training in robotic surgery is critical for initial success and to optimize patient outcomes [1]. Training can be obtained from industry, society, or local institutions. Following training, case observations and proctoring are highly recommended prior to initiation of procedures. Utilization of robotic-trained bedside assistants, scrub technicians, scrubs nurses, and circulators are highly recommended for robotic-assisted cases. At the end of the chapter, a robotic checklist is offered to enhance patient safety and smooth operations during robotic cases.

Equipment

A typical robotic surgical system consists of the following four components. The *surgeon's console* is the place where the surgeon sits and controls the instrument at the operative field using master manipulator while looking through the viewer (Figs. 4.1, 4.2, and 4.3). The console plays a role in adjusting the whole system and provides the capability to communicate with the other persons in the operating room. More recent robotic systems are equipped with secondary (assistant) consoles, it allows for training, assistance, remote surgery, and surgeon collaboration (Fig. 4.4).

The patient side cart equipped with remote manipulator arms is controlled from the console by a surgeon. The remote

Fig. 4.1 Robotic surgeons console and hand console. For Fig. 4.1: provided here exclusively for promotion and/or media coverage of Intuitive Surgical and its products. This notification serves as an authorization for publications to make duplicate copies of the available high-resolution scans for editorial use only (© 2014 Intuitive Surgical, Inc. All people depicted unless otherwise noted are models)

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_4. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_4, © Springer Science+Business Media New York 2015

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Fig. 4.3 Robotic surgeons console and hand console. For Fig. 4.3: provided here exclusively for promotion and/or media coverage of Intuitive Surgical and its products. This notification serves as an authorization for publications to make duplicate copies of the available high-resolution scans for editorial use only (© 2014 Intuitive Surgical, Inc. All people depicted unless otherwise noted are models)

manipulator arm is designed to move at the same time just like the surgeon is manipulating hand switches. Surgeons can perform a wide range of procedure, such as cutting, suturing, and electrocoagulation through the manipulator (Figs. 4.5 and 4.6).

The visualization system provides a panoramic view of the surgical field with high-resolution 3D images. The input to the surgeon's monitor is generated by a stereo-endoscopic vision system that includes the camera, electronics, and a separate monitor for the operating team and assistants (Figs. 4.7a, b and 4.8).

Instruments are operated through small incisions in the body through which a robotic trocar is placed. There are various types of instruments designed to provide surgeons with natural dexterity and full range of motion for precise operation. The full range of motion and rapid responsiveness facilitate procedures such as suturing, knotting, dissection, and tissue manipulation. Many of the instruments used for robotic surgery mimic those that are available for laparoscopy (Figs. 4.8 and 4.9).

General OR Setup for Robotic Surgery

Setup of the robot is perhaps one of the most challenging aspects of robotic surgery. Early data has cited length of time to setup as a drawback of robotic surgery; however, once the team is efficient at this part of the procedure, the literature suggests that the operating times for laparoscopic and robotic colorectal procedures are similar [2]. Setup proceeds through various processes, according to the procedure and surgeon preference. First, after turning on the robot, calibration is essential for successful operation without delay or conversion. Often this setup is done prior to the surgeon or patient entering the room. It is necessary to calibrate the camera, patient side manipulators, and the master manipulators. If preparation for operation is finished, trocar locations need to be placed properly without "fighting" each other during operation, which results in collisions. The trocars should not be placed too close to each other. It is recommended by the manufacturer that each trocar site should be 8–10 cm apart to avoid collision and maximize arm excursion (Fig. 4.10) (Box 4.1) [3]. In addition, approximately 10–20 cm is the ideal distance between the trocar and target anatomy. Robotic trocars need to be inserted up until the thick black line can be visualized at the level internal surface of the cavity, which is the axis of rotation called the remote sensor (Fig. 4.11a, b).

Box 4.1 Tip

Laparoscopic assistant ports can be placed 5 cm away from the robotic trocars. Occasionally, a patient's smaller torso will prevent placing the third robotic trocar and arm at the minimum distance necessary and should then not be utilized.

Fig. 4.4 Dual robotic surgeon's console. Provided here exclusively for promotion and/or media coverage of Intuitive Surgical and its products. This notification serves as an authorization for publications to make duplicate copies of the available high-resolution scans for editorial use only (© 2014 Intuitive Surgical, Inc. All people depicted unless otherwise noted are models)

Fig. 4.5 Patient side cart. For Fig. 4.5: provided here exclusively for promotion and/or media coverage of Intuitive Surgical and its products. This notification serves as an authorization for publications to make duplicate copies of the available high-resolution scans for editorial use only (© 2014 Intuitive Surgical, Inc. All people depicted unless otherwise noted are models)

Fig. 4.6 Patient side cart. For Fig. 4.6: provided here exclusively for promotion and/or media coverage of Intuitive Surgical and its products. This notification serves as an authorization for publications to make duplicate copies of the available high-resolution scans for editorial use only (© 2014 Intuitive Surgical, Inc. All people depicted unless otherwise noted are models)

Patient Positioning

Obtaining the proper patient position and position in relation to the robot is very important because it is not possible to reposition the patient during the procedure without undocking. Positioning of the patient's side cart according to the procedure follows patient positioning (Fig. 4.12). Docking of the robotic arms should be performed to minimize the arm collisions during operation. To avoid bruising on the skin, each port should be adjusted to slightly evert the skin as opposed to depressing the skin.

Docking

The robot is placed close to the patient such that the arms can be ranged within and reached to the operative field. Robotic arms should be docked to the ports definitely. Collisions can be reduced by robotic arm positioning at the beginning of the procedure. Care must be taken not to contaminate the arms as the robot is brought closer to the sterile surgical field and the

Fig. 4.7 Robotic camera and camera arm. (**a**) Robotic camera, (**b**) robotic arm

same is true for de-docking. The robot must be brought in with careful attention to its proximity to the patient's anatomy such as the face, legs if in stirrups, and arms if not tucked (Box 4.2). If there is a chance that the robot arm may injure the patient during the case, the robot position must be reevaluated and or the patients "at risk" anatomy must be proactively protected. For proper positioning of the camera arm in relation to the patient, the blue indicator tab on the robot identifies the "*sweet spot*" as a guide (Figs. 4.13 and 4.14).

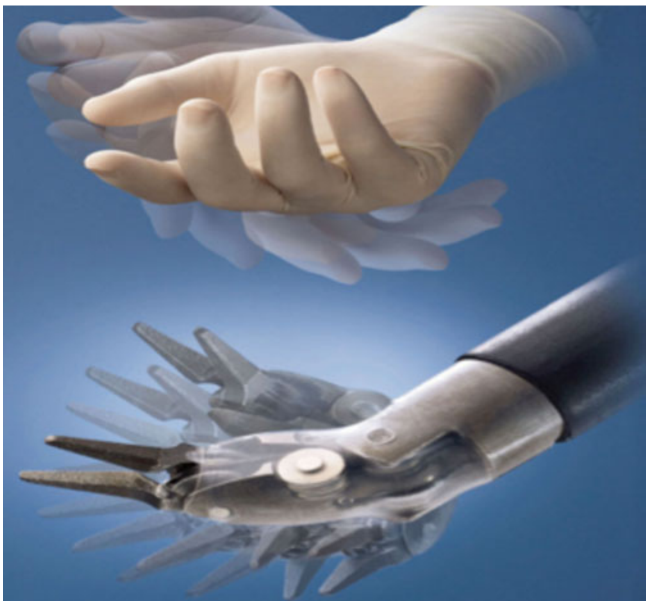

Fig. 4.8 Wristed motion of robotic instruments. Provided here exclusively for promotion and/or media coverage of Intuitive Surgical and its products. This notification serves as an authorization for publications to make duplicate copies of the available high-resolution scans for editorial use only (© 2014 Intuitive Surgical, Inc. All people depicted unless otherwise noted are models)

Box 4.2 Tip
The base of the robotic cart should be lined up parallel to a virtual line between the outer instrument trocars (usually robotic arm 1 and 3).

Instrument Insertion

Instruments should be inserted carefully under direct vision and the memory clutch pressed to prevent injury to the tissues. Instruments should be inserted with end effectors straightened to avoid puncture of trocar seals and under direct vision to prevent tissue injuries. It is advisable to back the camera to widen the view field when instruments are exchanged. If the insertion is the first one of the case, the clutch button will need to be depressed to slide the instrument in and position the arm. If the insertion is a tool change, the clutch button does not need to be depressed to insert the new tool to the existing position. The surgeon goes to the console after final review of the setting up and checks the visual field and operative field.

Undocking

The final step in a robotic procedure is to undock. This too must be carried out carefully. First the instruments must be removed from the patient's abdomen; this should be done under direct visualization. The robot arms then can be undocked from the trocars and carefully retracted away from the patient. The robot can then be withdrawn from the patient OR bed. As the robot is withdrawn, care must be taken to avoid injuring the patient and/or damaging the robot arms. Care must be taken not to break the robot down from sterility until the surgeon is clear there will be no need to re-dock.

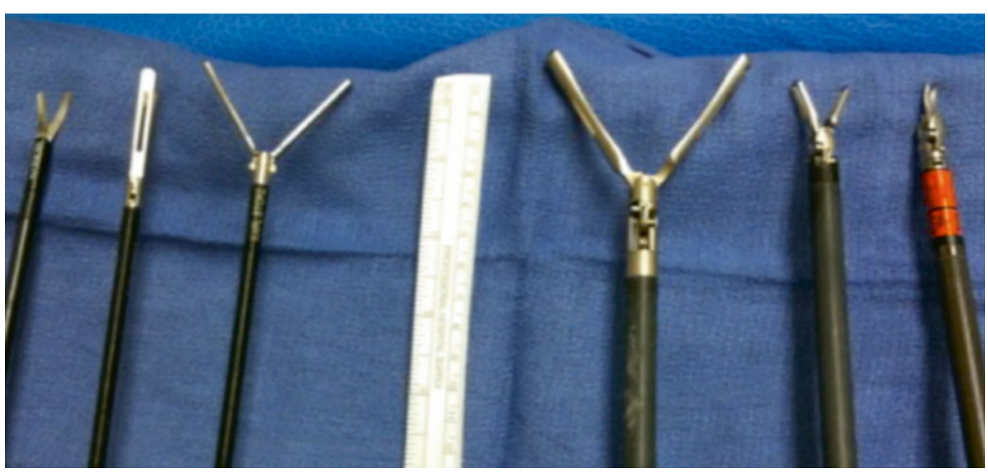

Fig. 4.9 Laparoscopic instruments (*left*) and robotic instruments (*right*) used for bowel surgery

General Techniques

Navigating the Camera and the Surgical Instruments

The surgeon must press the foot pedal while moving both hands in order to properly move and position the camera. Due to the motion scaling capacity of the robotic system and changes in the field of view, operator hand controls may need to be periodically repositioned to the optimal operating position. Clutching is used when the master controllers reach their limits of movement or the surgeon's operating position becomes uncomfortable. The surgeon can move the tip of the instrument up to 90° perpendicular to the shaft of the instrument, which is helpful in complex motions such as reaching behind a structure or suturing (Box 4.3).

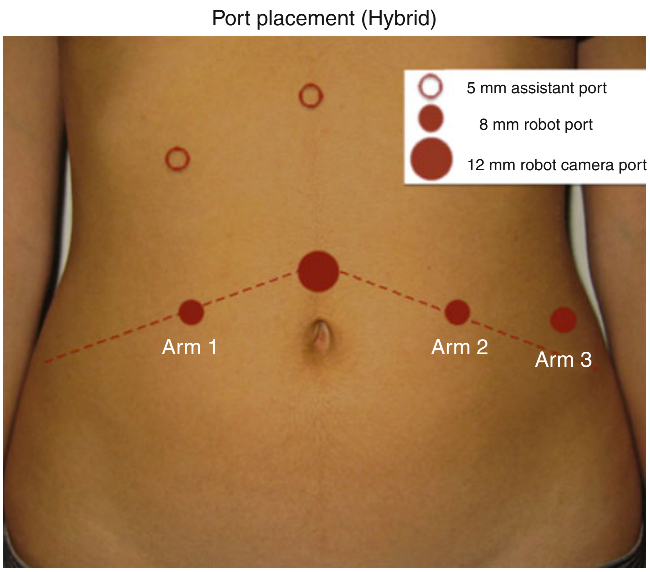

Fig. 4.10 Robotic port placement hybrid technique for rectal dissection

> **Box 4.3 Tip**
> Mastering the frequent switch between the second and third robotic arm for the left hand and actively using both for variable tissue retraction and countertraction allows the surgeon to operate with "three" hands.

Energy instruments can be used for coagulation, cutting, and dissection of tissues. These include monopolar and bipolar cautery instruments (electrical energy) and the Harmonic™ ACE (mechanical energy). Graspers can be used to manipulate various types of tissues such as the peritoneum or uterus. Retracting instruments are used to allow the surgeon to efficiently provide exposure of the surgical field. This can provide the robotic surgeon to fully control the operation field. Clip appliers are available to allow the robotic surgeon to perform vessel clipping. Needle drivers

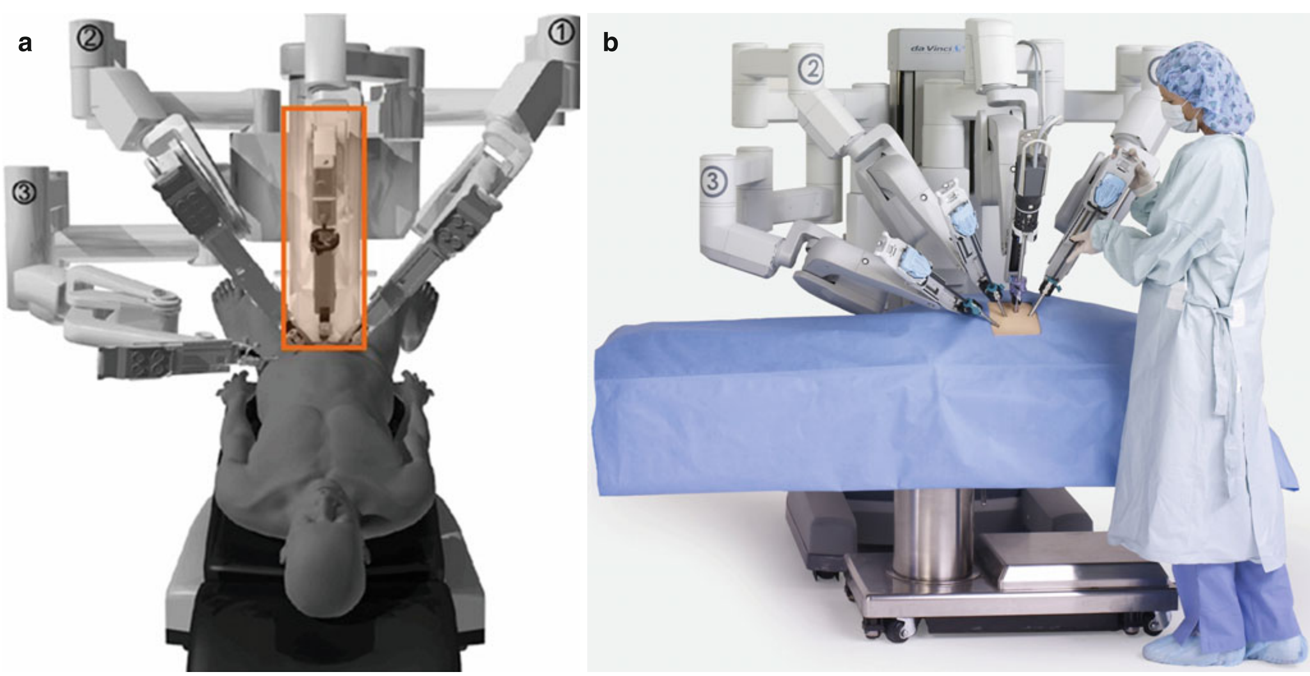

Fig. 4.11 Robotic trocar. *Black line* indicates remote sensor. For Fig. 4.11(**a**) (With permission from World Laparoscopy Hospital, Institute of Laparoscopic and Robotic Surgery © 2014). For Fig. 4.11(**b**) Provided here exclusively for promotion and/or media coverage of Intuitive Surgical and its products. This notification serves as an authorization for publications to make duplicate copies of the available high-resolution scans for editorial use only (© 2014 Intuitive Surgical, Inc. All people depicted unless otherwise noted are models)

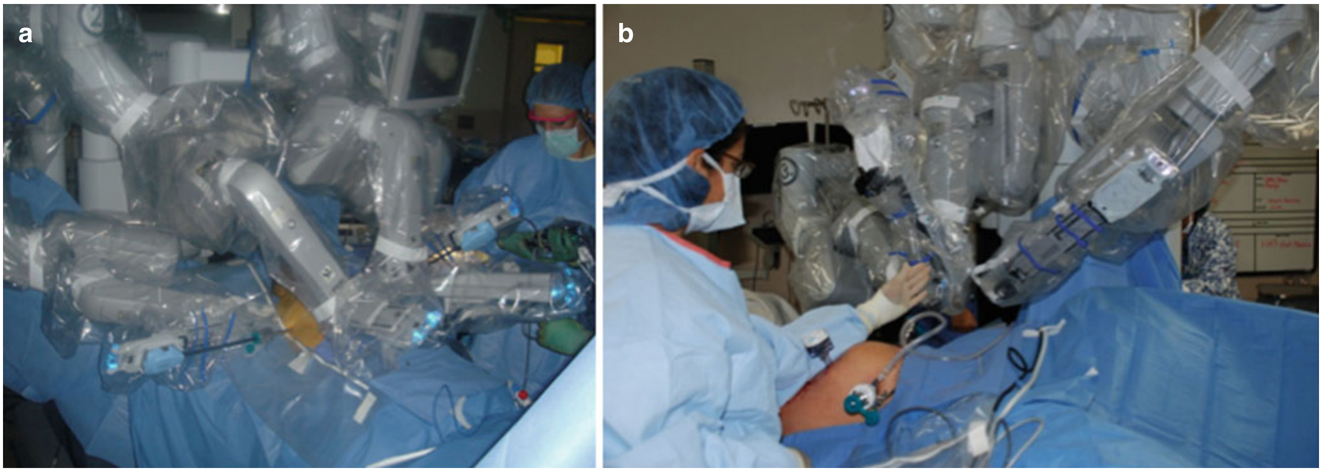

Fig. 4.12 Pictures showing pelvic and side docking. (**a**) Pelvic docking, (**b**) side docking

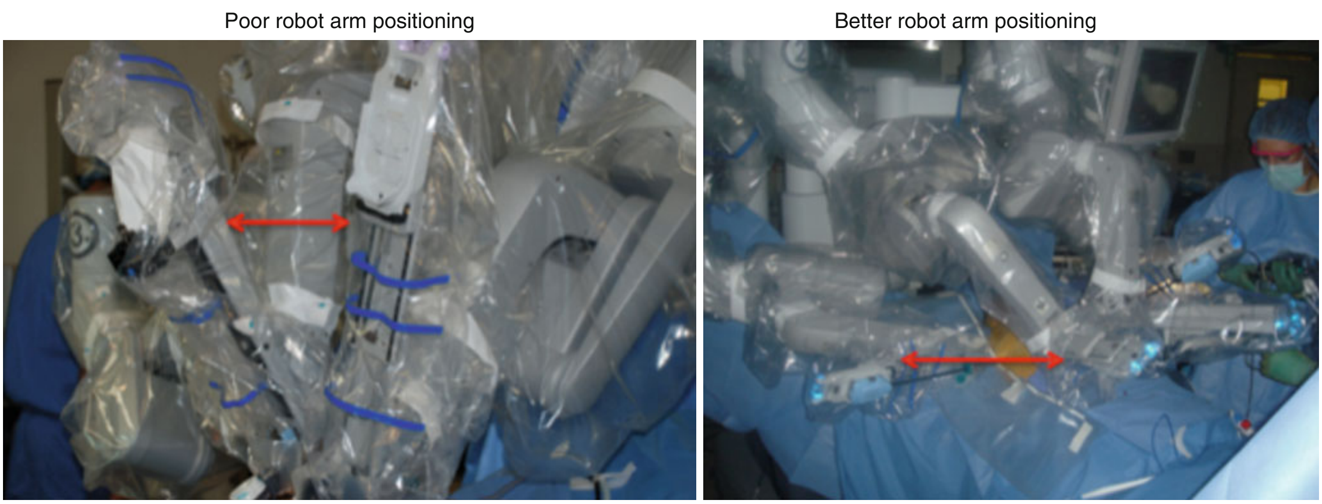

Fig. 4.13 Arm collision left vs. maximizing arm spacing right

Fig. 4.14 Sweet spot below left not ideal vs. right within the blue

can be used to suture with various types of needles such as those used in cardiovascular surgery or in repair of uterine defects. SutureCut™ needle drivers include an integral cutting blade for efficient cutting of suture after knot typing.

Needle Holding, Suturing, and Knot Tying

Precision is one of the major advantages of robotic surgery. Due to the lack of haptic feedback and the power of the instrument arms, it is possible to bend or even break a needle when grabbing it at the wrong position [4, 5].

The surgeon must create the loop totally based on the visual feedback and experience to handle the suture carefully without break or tearing of the suture. Hold the needle between the needle holder and make a single stitch near the wound. Pull out the suture to leave a small suture tail. Move the needle holder around the bent grasper tip to create a loop. Move the two instruments together so that the bent grasper grabs the tail of the suture while maintaining the loop wrapping around the bent stem. Retract the grasper to tighten the simple knot. In other methods, the surgeon begins by grasping the right end of the suture without touching the left end. The right end of suture is crossed over the left end to create a loop. The right instrument is next passed under the loop, created by the crossing right end of suture, and grasps the crossed over right end. The right end is then pulled by the right instrument underneath the left suture, which is still untouched. The left instrument grasps the left suture and the two ends are pulled apart to form the knot [6]. Another knot can be placed over it in an alternating but similar fashion without swapping arms (see Video 4.1).

Control of Electrocoagulation/Energy

The activation for electrocoagulation in robotic surgery is performed by the use of the foot pedals. If the incorrect pedal is pressed for electrocoagulation of a vessel, serious hemorrhage or damage to surrounding tissue could occur. Visual prompts are seen within the master console.

Advanced Tools for Colorectal Surgery

Robotic Bipolar Vessel Sealer

The EndoWrist One™ vessel sealer is a wristed, single-use instrument, which uses bipolar coagulation. It is designed to seal vessels up to 7 mm in diameter and tissue with a thickness that fits into the jaws of the device. Following coagulation, the instrument can then mechanically transect tissue. This instrument employs the same principles of bipolar coagulation devices designed for laparoscopic surgery, but adds the precision, mobility, control, and stability common to other robotic wristed instruments (see Video 4.2).

Robotic Stapler

The EndoWrist™ stapler is a fully wristed stapler 45 mm in length and was modeled after the human hand such that it affords dexterity and full range of motion. Using the robotic stapler, the surgeon can access narrow areas such as the pelvis, which would be extremely hard to reach with conventional staplers used in laparoscopic surgery (see Video 4.3).

Firefly Fluorescence Imaging

Firefly technology uses near-infrared imaging to detect the presence of injected indocyanine green in the blood. The robotic camera is equipped with an 803 nm excitatory laser source, which illuminates the surgical field and causes excitation of the indocyanine green, which reveals a green glow, thereby allowing identification of perfused tissue. In colorectal surgery, this technology is used to assess the perfusion of the bowel prior to transection and anastomosis, allowing the surgeon to revise the intended transection point to a region that is better perfused if necessary (see Video 4.4).

Avoiding Equipment Malfunction

The surgeon must keep ports at least 8–10 cm away from each other to allow for maximal excursion of the robot arms and avoid external collisions. The surgeon also has to adjust the arms externally so that they do not collide with each other. The robotic arms must be positioned ahead of time with proper joint adjustment, making note of the "sweet spot," to minimize external collisions (limiting range of motion) and avoid hitting the instruments internally. When collisions occur, the surgeon must be updated and repositioning of the joints and arms should be attempted if possible.

Ideally one does not lose sight of their robotic instruments during the case to minimize the chances of inadvertent injury to intra-abdominal structures. The surgeon must look for their instrument as they are passed in an out of view whenever possible. Failure to do so, and with an inexperienced bedside assistant, one may increase the risk of bowel wall tears or, more commonly, puncture injuries to mesentery, vessels, or hollow organs [7].

Robotic Preoperative Checklist

Procedure to be performed

- Total robotic versus hybrid with addition of laparoscopic component
- Addition of another procedure (e.g., robotic hysterectomy)

Patient position (expected robot dock time)

- Steep Trendelenburg positioning not recommended for >4 h continuously

Docking location (side, pelvic, etc.)
Equipment on field: trocars, end effectors, 12 mm versus 8 mm camera, and Firefly
Equipment on demand (in room): energy, clips, suction, stapler, etc.
Extraction port/plan
Medications: ICG, Marcaine, etc.
Monitors/locations of slave
Robotic console settings
Post docking plan other than closure

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Part II

Right Hemicolectomy and Ileocecectomy

Right Hemicolectomy and Ileocecectomy: Laparoscopic Approach

5

Joseph C. Carmichael and Michael J. Stamos

Introduction

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

Background

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

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

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

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

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_5. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_5, © Springer Science+Business Media New York 2015

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

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

Room Setup and Positioning

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

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

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

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

Port Placement and Extraction Sites

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

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

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

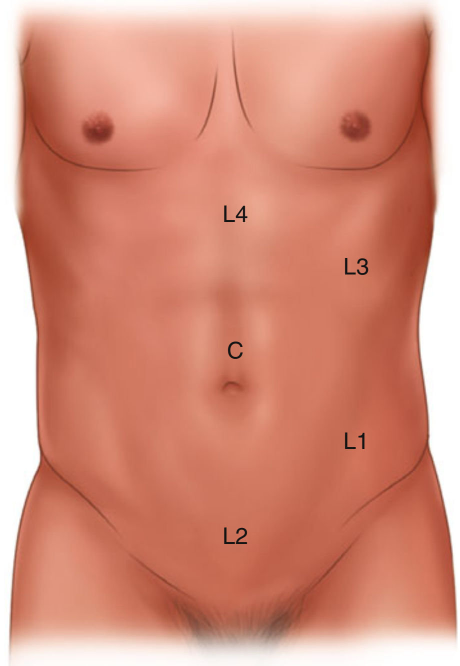

Fig. 5.1 Port configuration. *C* 5 or 12 mm camera port. *L1* 5 mm or 12 mm (for stapler) working port right hand. *L2* 5 mm working port for left hand. *L3* 5 mm assistant port (not utilized for three-port technique). *L4* 5 mm port as alternative to L2

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

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

Operative Steps (Table 5.1)

Exploratory Laparoscopy

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

Table 5.1 Operative steps and degree of technical difficulty

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

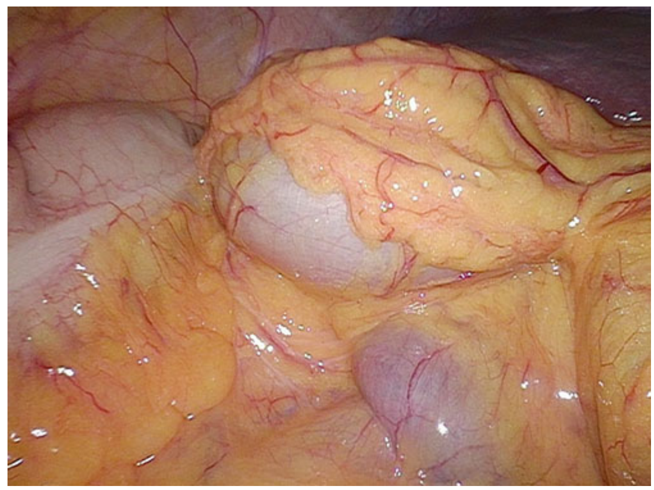

Fig. 5.2 Right colon and duodenum

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

Identification and Ligation of the Ileocolic Vessels

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

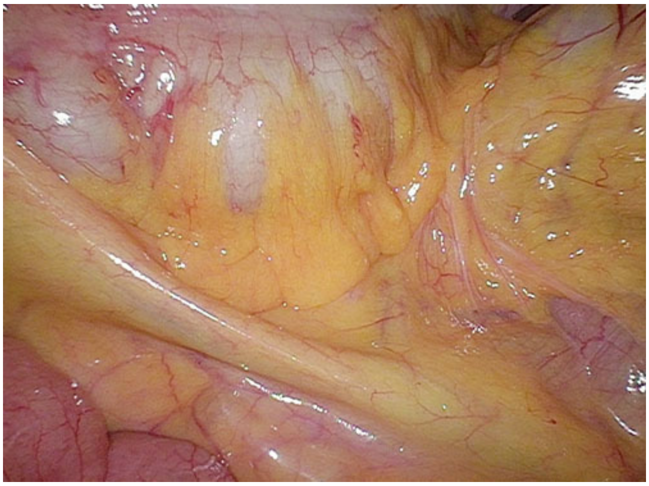

Fig. 5.3 Ileocolic pedicle under tension with cecum elevated

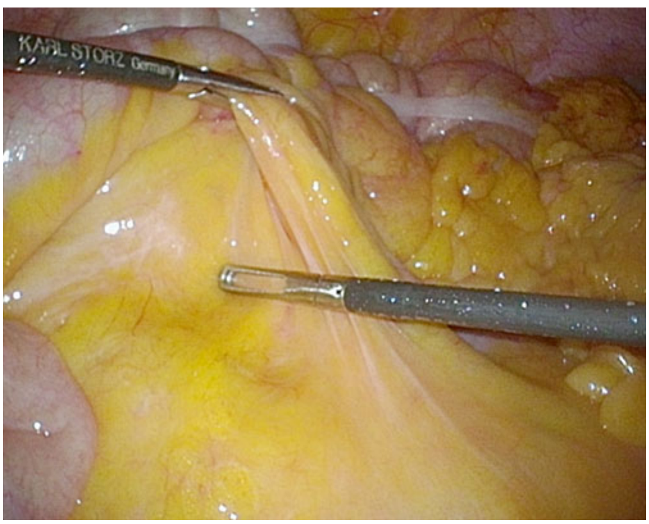

Fig. 5.4 Ileocolic pedicle under tension with mesentery elevated

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

Once the ileocolic pedicle is elevated, the peritoneum along its base is sharply incised or scored with hook cautery

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

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

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

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

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

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

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

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

Dissection of the Retroperitoneal Plane and Identification of the Duodenum

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

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

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

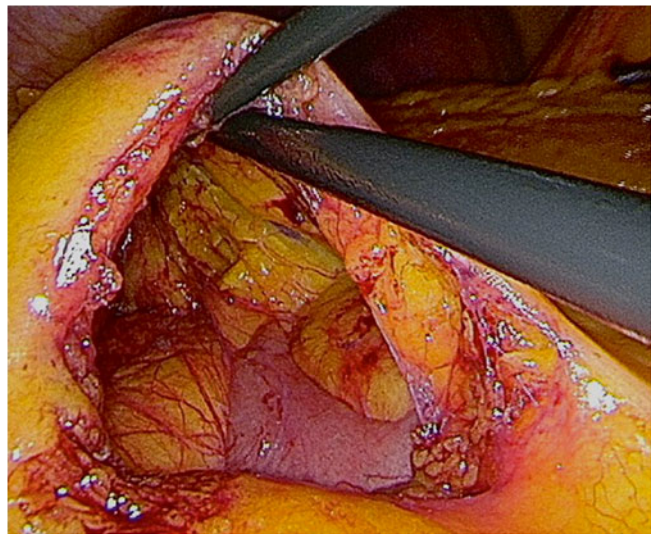

Fig. 5.6 Ascending colon retracted upward and mesentery dissected off retroperitoneum medial approach

Mobilization of the Right Colon and Terminal Ileum

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

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

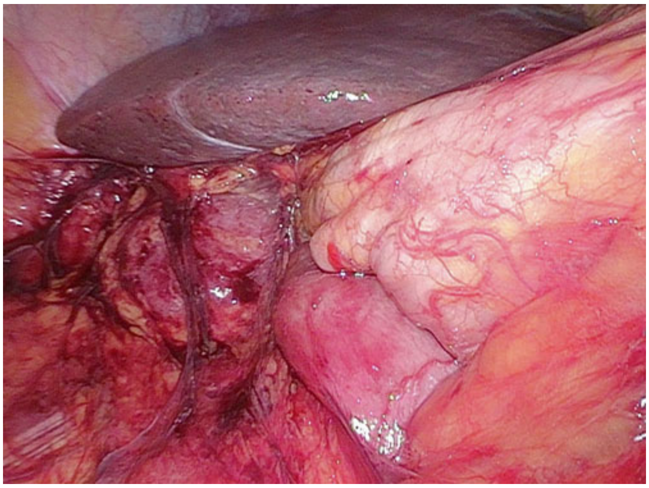

Fig. 5.7 Mobilized colon with visible retroperitoneum and duodenum from lateral approach

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

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

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

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

Mobilization of the Proximal Transverse Colon and Hepatic Flexure

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

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

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

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

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

Identification and Ligation of the Middle Colic Vessels

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

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

Extracorporeal Anastomosis, Closure, and Reinspection

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

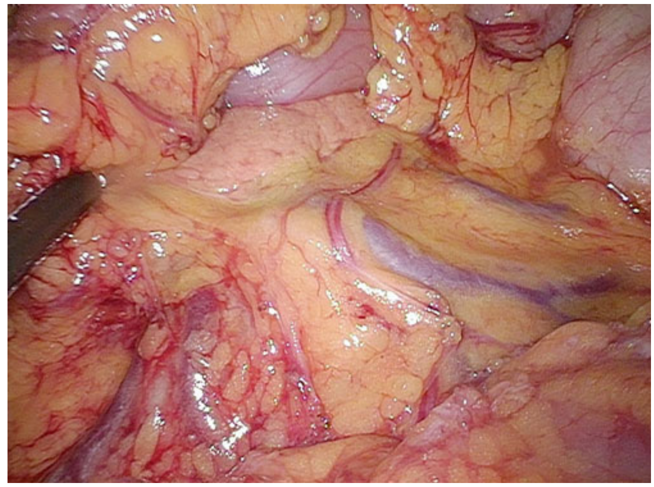

Fig. 5.8 Visualization of middle colic vessels from cephalad approach

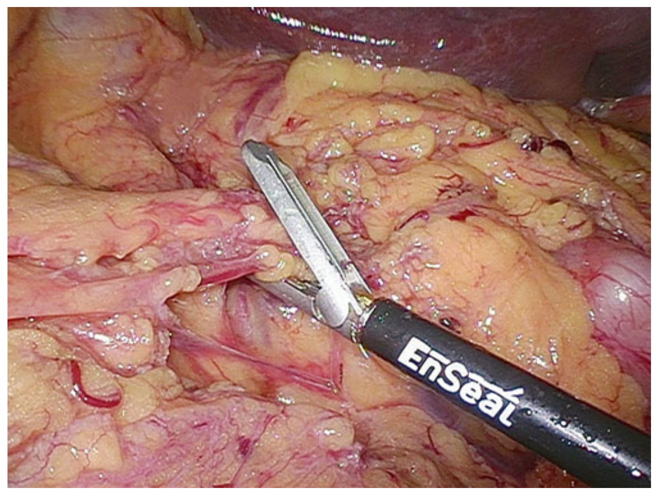

Fig. 5.9 Visualization and division of middle colic vessels from cephalad and medial approach

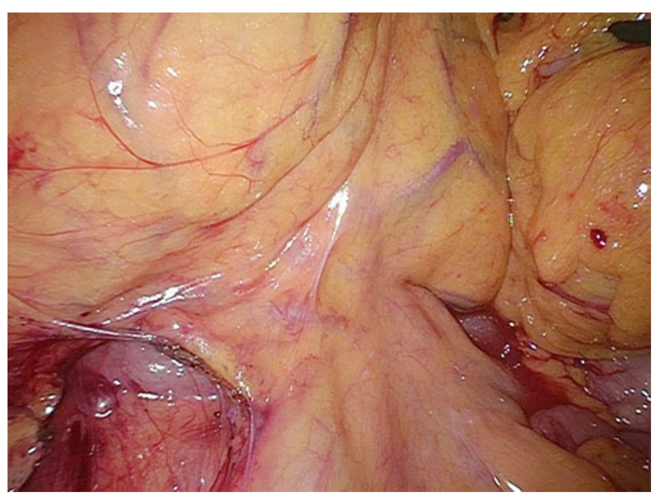

Fig. 5.10 Visualization of middle colonic vessels from caudal approach

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

Intracorporeal Anastomosis

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

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

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

Approaches

Medial to Lateral Approach

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

Lateral to Medial Approach

The lateral to medial approach is conducted using the same basic seven steps as noted above but in a revised order. In this approach, the order of the steps is 1, 4, 3, 5, 2, 6, and 7. The lateral to medial approach can be used if the anatomy around the ileocolic pedicle is unclear. This approach may also be useful in patients who have a tumor that may not be resectable due to possible involvement of the head of the pancreas. The retroperitoneum can be explored with this technique without committing to colonic resection by preserving the ileocolic pedicle. Finally, if the patient is only in need of an ileocolic resection for inflammatory bowel disease, then this technique can be used with extracorporeal vascular ligation via the extraction site. The disadvantage of this approach is that the mesenteric mobilization tends to be slower than the retroperitoneal blunt dissection in the medial to lateral approach. In addition, the duodenum is identified late in the procedure, making inadvertent injury more possible.

Inferior to Superior Approach

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

Hand-Assisted Laparoscopic Right Hemicolectomy

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

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

Special Considerations and Complications

The Reoperative Abdomen

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

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

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

Morbid Obesity

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

Crohn's Disease

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

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

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

Locally Advanced Cancer

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

Bleeding

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

Enterotomy and Duodenal Injury

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

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

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

Difficulty with Identification of Tumor or Lesion

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

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

Summary

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

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6 Right Hemicolectomy and Ileocecectomy: Hand-Assisted Laparoscopic Approach

Julie Ann M. Van Koughnett and Eric G. Weiss

Introduction

We will be illustrating the hand-assisted approach to a laparoscopic right hemicolectomy and ileocecectomy. As in the previous chapter, the seven basic steps are described, followed by the various approaches including the lateral, medial, inferior, and superior approaches. The advantages and tips of utilizing the hand-assisted approach to difficult scenarios and complications will be reviewed.

Background

With the widespread adoption of laparoscopy by most surgical specialties, colon and rectal surgery has incorporated laparoscopic techniques into many of its common abdominal procedures. Right hemicolectomy and ileocecectomy are two such procedures where the laparoscopic approach is becoming more commonplace and in some cases the standard of care. It is clear that laparoscopy has many benefits, and its beneficial role for right hemicolectomy is no exception. It is safe, cost-effective, and allows for high-quality oncologic outcomes [1–5]. Patients undergoing laparoscopic colectomies have shorter lengths of hospital stay, less usage of pain medication, and quicker recovery and return to activity at home [1, 6]. As more surgeons are trained in laparoscopy, in particular those more recently completing surgical residencies and doing advanced training in colon and rectal surgery residencies, minimally invasive colon resection continues to gain momentum. Patients are also increasingly seeking minimally invasive approaches for their care.

The use of hand-assisted laparoscopic surgery has provided surgeons with an alternate surgical approach to colorectal surgery, in addition to open and straight laparoscopic techniques. Hand-assisted laparoscopy has been applied to colorectal resections, splenectomy, and nephrectomy, among other procedures [7]. It may especially be useful in complex laparoscopic cases. Numerous studies have shown that in laparoscopic colorectal resections, the use of the hand-assisted technique reduces the need for conversion to an open approach [8–10]. It is also associated with a reduction in operative time, especially in complex colectomies, such as left hemicolectomies and difficult dissections [9, 10]. In a prospective study of hand-assisted laparoscopic colectomies, the authors found that fewer right hemicolectomies were completed using the hand-assisted technique, versus left and total colectomies, but as a whole, the hand-assisted approach was most useful for complex situations [11]. Though used for more complex colectomies, complication rates were not significantly different between the hand-assisted and straight laparoscopic procedures [11].

Though the hand-assisted technique introduces a hand into the operative field during laparoscopic dissection, this approach retains the benefits of laparoscopic surgery. As mentioned previously, it significantly reduces the need for conversion in difficult laparoscopic dissections. The size of the extraction incision is similar between hand-assisted and straight laparoscopic cases [12, 13]. Short-term outcomes, such as length of stay, time to return of bowel function, and postoperative pain, are similar between hand-assisted and straight laparoscopic colorectal surgery [8, 14, 15]. Oncologic outcomes, including margins, number of lymph nodes harvested, and pedicle length, are similar when

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_6. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_6, © Springer Science+Business Media New York 2015

hand-assisted and straight laparoscopic colectomy specimens are compared [8, 12, 15]. In addition, operative times are faster in hand-assisted laparoscopic colectomy than straight laparoscopic colectomy, though sufficient training and experience is needed before achieving time-saving benefits [14, 16, 17]. Time savings and reduced need for conversion have resulted in hand-assisted laparoscopic colectomies having similar overall costs compared to both straight laparoscopic and open colorectal resections, despite the need for a hand-port device [18–20].

For right hemicolectomies, the use of hand-assisted laparoscopic technique is not as common as for left-sided resections. In a randomized trial of hand-assisted and straight laparoscopic right hemicolectomies, no significant differences were found in operative time, conversion, or short-term outcomes such as length of stay [21]. Other studies have confirmed that hand-assisted laparoscopic right hemicolectomy offers benefits over the open approach, including blood loss, time to return of bowel function, and length of hospital stay [22, 23]. The use of the hand-assisted technique in right hemicolectomy should therefore be based on surgeon preference and comfort with laparoscopy. The use of a hand port may allow for more minimally invasive right hemicolectomies and ileocecectomies to be performed, especially in the setting of complex right-sided dissections such as locally invasive right-sided malignancies and complex inflammatory bowel disease involving the right colon and small bowel. As the most common extraction site for laparoscopic right colectomies is a midline periumbilical incision, similar cosmesis and long-term hernia formation rates should be similar between approaches, further favoring its use in specific cases.

Preoperative consultation must include the thorough review of the patient's past medical history and consultation with anesthesia. Though the frail patient with little reserve may intuitively seem to be the one who might benefit most from a laparoscopic approach, there may be cardiac or pulmonary comorbidities, which may preclude achieving adequate pneumoperitoneum. If adequate pneumoperitoneum cannot be achieved at the normal pressure level, trying a lower level of pressure may allow the patient to tolerate the pneumoperitoneum while allowing for adequate visualization through the use of the hand port. For Crohn's disease, cancer, large adenomas, and all other conditions which might necessitate a right hemicolectomy, the preoperative consultation must also include reviewing all radiographic and endoscopic studies. The surgeon must clearly understand the extent and location of disease. In the case of an unresectable adenoma or cancer, endoscopic marking using ink tattoo is encouraged. Unless the lesion is confidently in the base of the cecum, endoscopic marking with multiple tattoos helps to ensure adequate resection.

Room Setup and Positioning

The surgeon must ensure that adequate facilities are in place to proceed with hand-assisted laparoscopic right hemicolectomy. The anesthetist, assistant, and scrub and circulating staff should have a good working knowledge of the procedure and potential issues that may arise. For hand-assisted laparoscopic right hemicolectomy, two atraumatic graspers, hook electrocautery or endoshears, an advanced energy device, and a hand-port device must be available, in addition to adjunctive laparoscopic instruments. Endoscopic staplers, endoloops, and other devices should be in the room and available if needed or required. A standard set of open instruments must be quickly available in the event of conversion to open procedure. Pneumoperitoneum with carbon dioxide is most commonly used, given its inert and absorbable qualities. The choice of commercially available hand-port device is based on surgeon preference and comfort.

At least one monitor must be in good position for visualization of the operation. This should be placed at the patient's right side or right shoulder and adjusted as needed throughout the procedure. A second monitor placed at the patient's head or left shoulder may add better visualization for the scrub staff and circulators. A 30° laparoscope is standardly used to facilitate visualization and is especially important to maneuver the camera with a hand in the abdomen. Ten or five millimeter laparoscopes may be used and exchanged during the procedure, depending on port size.

Even though supine positioning is an option for a straight laparoscopic approach, the patient should be positioned in the lithotomy position so that the surgeon or assistant may stand on the left or between the legs as needed (Box 6.1). The surgeon who has either a left or right hand in the abdominal cavity is typically positioned closer to the patient and less flexible to move around. The lithotomy position allows for more scrubbed staff to be closer to the patient during the procedure without impairing visualization of the monitors. It also allows the surgeon to perform intraoperative endoscopy if the tumor cannot be visualized or palpated during mobilization. In placing the patient in lithotomy, the legs must be left low during the operation so that they do not interfere with the surgeon's arms or laparoscopic instruments. The patient must be secure on the operating table, as tilting the patient on the table is critical for visualization during various

Box 6.1. Tip
If a patient cannot tolerate Trendelenburg positioning necessary for a standard laparoscopic approach, a hand-assisted approach allows adequate traction and exposure.

steps of the laparoscopic right hemicolectomy. There are multiple methods of securing the patient to the table such as "bean bags," strapping the patient to the table, and others. The left arm, if not both arms, should be tucked to allow access to the port sites and positioning of the surgeon and assistant on the same side of the operating table. The elbows must be adequately padded. The use of "shoulder blocks" should be avoided as nerve injury has been reported.

Port Placement and Extraction Sites

The hand port can be inserted either immediately or after gaining access to the peritoneum with an open Hassan technique or Veress needle and subsequent placement of a camera port. Starting with the camera port is useful in assessing the abdominal cavity and target anatomy if the decision is to be made between a laparoscopic and hand-assisted technique. Immediate placement of the hand port avoids most of the complications of establishing pneumoperitoneum laparoscopically and allows safe placement of subsequent trocars by lifting the abdominal wall and placing the trocar by hand guidance (Box 6.2). For the first approach, the initial port is placed using the open Hasson technique under direct visualization. The Veress needle and optical access ports are acceptable alternatives. A 10 or 12 mm port is placed initially, as one will start with a 10 mm 30° angled laparoscope. A 5 mm initial port and laparoscope may be considered in certain circumstances or surgeon preference. The surgeon may require a larger port for a stapler, if the ileocolic pedicle will be stapled or if intracorporeal bowel resection is planned, which may be used through the initial port or a 12 mm port placed elsewhere. The most common locations for the initial port placement are either in the supraumbilical or infraumbilical locations.

> **Box 6.2. Tip**
> Initial placement of a laparoscopic port is useful if a total laparoscopic approach is planned and a hand port is inserted only after initial evaluation of the target anatomy.

Once pneumoperitoneum is established, the laparoscope is inserted. This allows the surgeon to perform a diagnostic laparoscopy, assess the target anatomy, and choose the best location for other working ports and for those ports to be inserted under direct visualization.

The hand port is placed in the periumbilical location. This can be shifted slightly up or down the midline depending on the planned positioning of the camera port and the technique utilizing a superior or inferior approach.

For the second approach, the hand port is placed directly. This allows entry into the abdominal cavity similar to a laparotomy (Box 6.3). The hand is inserted through the hand port, and a site for the camera port is chosen in the lower midline (LM) or upper midline (UM). The port can be then inserted safely by palpation and protecting the intra-abdominal content with the surgeon's hand. At least one additional working port for the surgeon is placed in the left lower quadrant (LLQ) or left upper quadrant (LUQ) depending on the approach chosen.

> **Box 6.3. Tip**
> Initial direct placement of the hand port is less time-consuming and avoids the potential complications of establishing pneumoperitoneum laparoscopically.

The inferior approach has the following port placement: hand port in the supraumbilical location for the surgeon's right hand, working port in the LLQ for the left hand, and a camera port in the LM (see port configuration in Fig. 6.1). The superior approach mirrors this with the hand port now in the infraumbilical location for the surgeon's left hand, working port in the LUQ for the right hand, and a camera port in the UM (see port configuration in Fig. 6.2).

The assistant will be holding the laparoscope during the procedure. Additional working ports might be inserted once the patient's anatomy is defined (Box 6.4). Additional ports

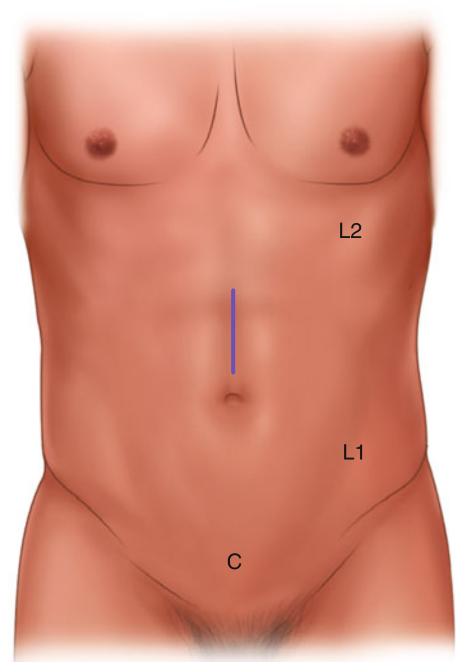

Fig. 6.1 Port configuration: inferior approach. Hand port: right hand. *C*: 5 mm camera port. *L1*: 5 or 12 mm working port right hand. *L2*: 5 mm optional assistant port

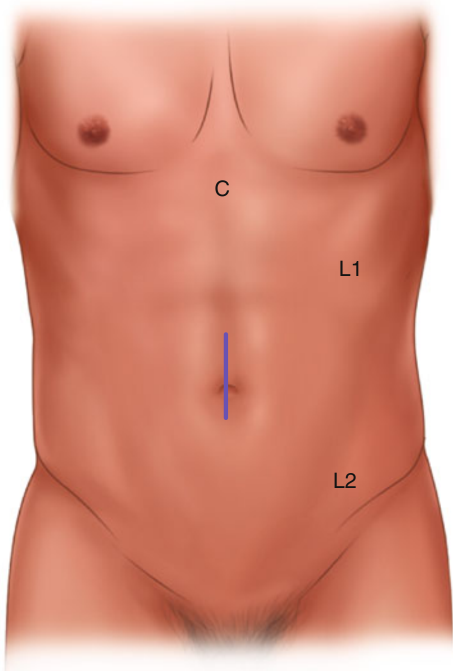

Fig. 6.2 Port configuration: superior approach. Hand port: left hand. *C*: 5 mm camera port. *L1*: 5 or 12 mm working port right hand. *L2*: 5 mm optional assistant port

may be inserted in the lower midline (LM), upper midline (UM), or right upper quadrant (RUQ) to facilitate retraction of the colon or small bowel by the surgeon's assistant. This additional port is typically 5 mm in size to permit the use of a bowel grasper by the assistant.

> **Box 6.4. Tip**
> The retraction using the hand port is superior to a laparoscopic grasper alone. Therefore, no additional working ports and no assistant to retract and coordinate are needed most of the time.

When using a hand-assisted laparoscopic technique, the specimen is extracted through the hand port. The most common site of extraction is therefore a midline periumbilical location. Alternatives include an infraumbilical midline, supraumbilical midline, or transverse umbilical site for the hand port and extraction site. The size of the hand port is based on surgeon glove size, and hand ports come with rulers and instructions for sizing the incision.

A Pfannenstiel or right lower quadrant muscle splitting incisions are typically reserved for a total laparoscopic right hemicolectomy with intracorporeal anastomosis or as part of a total colectomy. The advantages of a muscle splitting technique include reduced postoperative pain, less bleeding from muscle, and a reduction of the risk of hernias.

Operative Steps (Table 6.1)

There are common steps that must be included in a safe hand-assisted laparoscopic right hemicolectomy. Depending on the approach used, these steps will be performed in varying sequences and are described below.

Exploratory Laparoscopy and Insertion of Hand Port

Upon initial establishment of pneumoperitoneum and insertion of the laparoscope, general inspection of the abdomen ensues (Box 6.5). Adequate visualization may first require the insertion of additional working ports for retraction. This includes insertion of a hand port in the most appropriate location based on body habitus, location of diseased bowel, and chosen approach. Changes in patient position may also be useful at this time. Exploratory laparoscopy should include the peritoneal surface and omentum for possible tumor seeding. The liver must be evaluated for visible metastases, and placing the patient in reverse Trendelenburg position and using a 30° laparoscope will facilitate its inspection. In a female, the pelvis should be inspected for ovarian metastases. The primary tumor should be identified, either with palpation with a grasper, anatomic landmarks such as the

Table 6.1 Operative steps

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

> **Box 6.5. Tip**
> The hand allows for quick adequate positioning of the omentum and small bowel loops. If the patient is very obese or cannot tolerate Trendelenburg positioning, a lap pad placed at the mesenteric root can be useful.

cecum, or perhaps most definitively with localization of ink tattoo on the serosa of the colon.

Invasion of local structures such as the abdominal wall, kidney, or duodenum may be appreciated at this stage. In the setting of Crohn's disease, inspection of the small bowel and colon is performed to assess the extent of disease by running the bowel with an atraumatic grasper and the surgeon's hand. The cecum, right colon, and terminal ileum must be visualized and assessed for any complicating anatomy, namely, fistulae to small bowel or sigmoid colon, abscess formation, or contained perforation. If there are concerning features present, a trial of dissection may be performed at this time to determine if the right colon and ileum are resectable and whether one can safely proceed laparoscopically. The threshold for conversion to open procedure is different for each surgeon depending on experience with laparoscopic techniques, and consultation with a more experienced colleague may be attained if the anatomy appears challenging during exploratory laparoscopy.

Identification and Ligation of the Ileocolic Vessels

The timing of division of the ileocolic pedicle during the procedure varies depending on which approach is used for laparoscopic right hemicolectomy. Although many divide intracorporeally and as one of the initial steps, extracorporeal division is acceptable, and no data support any improved oncologic outcome using one technique over another as long as a high ligation can be achieved safely through the extraction site to yield adequate number of lymph nodes in the pathologic specimen for malignant disease (Box 6.6). The extracorporeal vessel ligation may be preferentially utilized for patients with friable mesentery in Crohn's disease.

> **Box 6.6. Caveat**
> Evaluate the mesenteric length and abdominal wall thickness. The slightly larger extraction site through the hand port might give enough exposure to perform an adequate extracorporeal high ligation of vessels without the risk of bleeding from traction.

The ileocolic vascular pedicle is a preserved structure in all patients. The pedicle is found in the mesentery of the right colon and can usually be easily identified with proper retraction on the cecum to the right iliac crest (Box 6.7). Using a grasper and the surgeon's hand, the cecum is retracted anteriorly and slightly inferiorly and the ascending colon anteriorly and superiorly. Left tilt (right side up) of the patient is performed, and the small bowel is brought to the left across the midline. Retraction of the small bowel is typically accomplished with proper positioning. The ileocolic pedicle will be visibly prominent in the mesentery of the right colon and can be grasped with the thumb and index finger of the surgeon's hand (see Fig. 6.3).

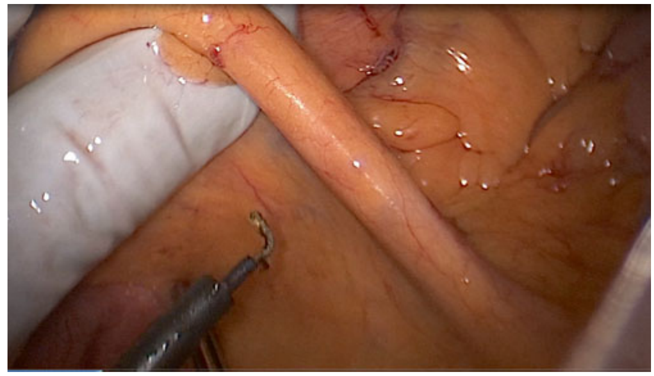

Fig. 6.3 Ileocolic pedicle

> **Box 6.7. Tip**
> The ileocolic pedicle can be frequently palpated, encircled, and lifted with the surgeon's thumb and index finger placed around the pedicle close to the root without the need to create tension first for visual identification.

A window is made in the mesentery along the inferior side of the ileocolic pedicle by first using hook electrocautery or other instruments to score the mesentery and then blunt dissection to create the window, sweeping the mesentery anteriorly and the retroperitoneal structures posteriorly including the duodenum in the medial to lateral approach. This plane is already dissected in all other approaches. Similarly, electrocautery is used to score a short length of the mesentery along the superior border of the pedicle. The superior border of the pedicle is further defined by using blunt dissection. A critical maneuver prior to division of the ileocolic vessels is to identify and separate the duodenum from the ileocolic pedicle. The pedicle can be encircled between the surgeon's two fingers to confirm its isolation before it is divided (see Videos 6.1 and 6.2).

During the superior approach, the ileocolic pedicle is identified after the right branch of the middle colic is ligated, and the transverse colon, hepatic flexure, and ascending colon are fully mobilized and rotated medially and inferiorly. The pedicle will be then grasped with the left hand from the opposite site of the ileocolic mesentery.

As in the open approach, high ligation of the ileocolic pedicle is performed to ensure adequate lymph node assessment for staging. That is, in the setting of an oncologic indication for right hemicolectomy, the ileocolic vessels are divided away from the bowel and close to their takeoff so that a complete wedge of mesentery is resected along with the colon. For inflammatory bowel disease, this is not a critical step and the vessels may be divided closer to the colon itself. To divide the pedicle, various techniques are used, including clips, laparoscopic staplers, or advanced energy devices. Isolation of artery and vein is necessary in order to place clips, with two or three clips placed on the "staying side" of the ileocolic artery and two on the vein. Isolation of artery and vein is not necessary if using a laparoscopic stapler or bipolar energy device. The surgeon's hand can be used to safely guide the working instrument into proper position. Inspect for hemostasis after division prior to moving on to step 3.

Dissection of the Retroperitoneal Plane and Duodenum

The duodenum must always be identified during laparoscopic right hemicolectomy (Box 6.8). With the use of electrocautery and advanced energy devices during colon mobilization and division of the mesentery and its vessels, the duodenum is at risk of injury at many stages of the procedure. With the creation of a window in the right colon mesentery during the medial to lateral approach, blunt dissection mainly with a grasper or occasionally the surgeon's fingers is used to identify and isolate the duodenum along its inferior border at the level of its sweep. Again, by retracting the right colon anteriorly with the surgeon's right hand in the abdomen, adequate visualization is achieved. Once a window is made in the right colon mesentery, the surgeon's fingers are placed within the defect to tent up the right colon. A grasper is then used to bluntly sweep down the duodenum and sweep up the superior edge of the mesenteric defect. This should be an avascular plane and the loose areolar tissue should easily separate with blunt dissection. There is no need to grasp the duodenum at all during its identification and isolation (see Video 6.3). Once this is done, the duodenum is used as a landmark during dissection of the hepatic flexure.

Box 6.8. Tip
The hand with the finger's spread is placed as a wide "retractor" under the ascending colon and mesentery and allows to create excellent counter traction even with more bulky and heavy colon.

For an inferior approach, this can be similarly accomplished by grabbing the cecum and terminal ileum with the right hand and retracting cephalad initially, and once the plane between the ileal mesentery and retroperitoneum is entered, the hand is place under the cecum and ascending colon.

Mobilization of the Right Colon and Terminal Ileum

The patient should be placed in fairly steep left tilt for right colon mobilization. Release of lateral attachments may proceed in either an inferior to superior or superior to inferior direction. The lateral attachments of the right colon are taken down by dividing the attachments along the white line of Toldt, while retracting the colon medially and cephalad with the surgeon's right hand and utilizing the energy device through the LLQ working port during a medial, lateral, or inferior approach (see Video 6.4). Alternatively, the colon is retracted medially and caudally with the left hand utilizing the LUQ working port. An advanced energy device once again facilitates this dissection, though hook electrocautery should also be adequate in this avascular dissection. The index finger may be used to gently push along the white line to facilitate and expedite the identification of the proper dissection plane (see Video 6.5). The dissection is already accomplished and avoided in a medial or inferior approach, which allow rapid division of the peritoneal attachments only.

As one dissects the right colon, a common pitfall may be encountered (Box 6.9). It is quite easy to enter a dissection plane too lateral, leading to a retrorenal dissection. The dissection must stay anterior to Gerota's fascia and the right kidney. Using the duodenum as a landmark helps ensure that the surgeon remains in the correct plane. The duodenum should be visualized and protected during division of the lateral attachments once the white line of Toldt is incised.

Box 6.9. Tip
A superior or medial approach avoids a potential wrong line of retrorenal dissection during the lateral approach.

The terminal ileum and appendiceal attachments are also released laterally at this point (see Video 6.6). With proper medial positioning of the terminal ileum, by medially sweeping with the surgeon's fingers, the right ureter and common right iliac artery can be visualized. These structures must be avoided during mobilization of the terminal ileum.

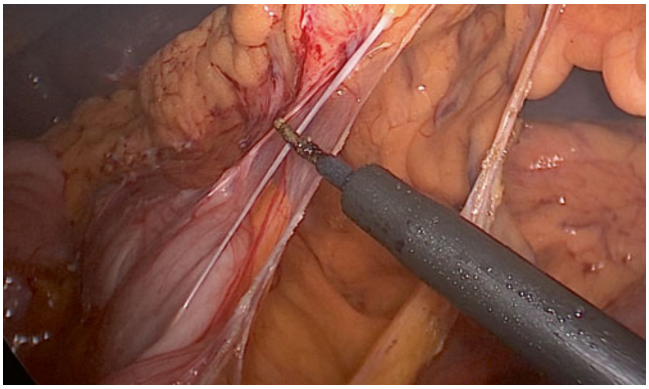

Fig. 6.4 Omentum

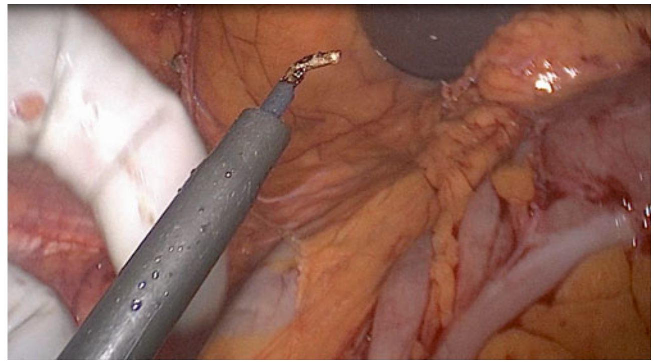

Fig. 6.5 Hepatic attachments

Mobilization of Proximal Transverse Colon and Hepatic Flexure

The falciform ligament is used as a landmark for the planned distal resection margin (Box 6.10). The middle colic artery is also useful in this regard. The greater omentum is retracted anteriorly/superiorly and divided from the transverse colon using cautery or an advanced energy device (see Fig. 6.4). The use of such a device allows for substantially faster dissection and better coagulation. Clips should routinely not be necessary for dissection of the colon if the surgeon remains in the right plane and uses a bipolar energy coagulation device. The mesentery of the colon is not divided at this stage; rather dissection proceeds above the colon, entering the lesser sac by dividing the gastrocolic ligament and reflecting the gastrocolic omentum.

Box 6.10. Tip
The LLQ port should be placed medially to the epigastric vessels if the hepatic flexure is mobilized from a lateral approach so the dissecting instrument reaches the hepatocolic ligament.

During the superior approach, the advanced energy device should be used with the surgeon's right hand through the LUQ port, working in the direction of the hepatic flexure. Mobilization continues around the hepatic flexure, incising the hepatocolic ligament reaching the most superior aspect of the ascending colon. The patient position for this step should be in reverse Trendelenburg. The transverse colon and hepatic flexure are retracted inferiorly during dissection using the left hand. Dissection may be challenging in both thin and obese patients, as the correct plane may not be visible to enter the lesser sac. Gentle blunt dissection with the surgeon's fingers may facilitate the identification of the right plane. Slow and meticulous dissection is usually adequate to find the correct plane. The transverse colon and hepatic flexure will progressively move into an inferior position as dissection proceeds (see Video 6.7).

The hepatic flexure can also be mobilized just continuing the lateral dissection during latter phases of the medial, lateral, and inferior approach (see Fig. 6.5 and Video 6.4). The ascending colon is retracted medially with the right hand, and the right index finger continually dissects below the hepatocolic ligament entering the lesser sac. The instrument through the LLQ port is reaching over the colon to divide the attachments.

Identification and Ligation of the Middle Colic Vessels

In addition to the division of the ileocolic vessels, the right branch of the middle colic artery may be divided if the patient's anatomy allows, but is not an essential step in an ileocecectomy. Placing the patient in reverse Trendelenburg position will allow the small bowel to move inferiorly into the pelvis and the transverse colon mesentery to be better visualized. There are two approaches to the transverse mesocolon: inframesocolic and supramesocolic from laterally or medially.

For the inframesocolic approach, the transverse colon is lifted anteriorly and superiorly with the surgeon's right hand to create tension on the transverse mesentery. The middle colic pedicle is usually visualized and palpated with a grasper at the midpoint of the transverse colon or slightly more proximally. If the mesentery is not filled with excess adipose tissue, the surgeon should visually appreciate a "Y" structure, where the right and left branches take off of the middle colic artery. One should preserve the left colic artery for blood supply of the upcoming ileocolic anastomosis. Electrocautery is used to score the mesentery on either side of the right branch of the middle colic artery, and blunt dissection used to create mesenteric windows. Clips and scissors or an advanced energy device is used to divide the right branch of the middle colic artery.

Occasionally the mesentery is foreshortened, and a supramesocolic approach can be used as an alternative (Box 6.11). The transverse colon is pulled caudally with the right hand toward the pelvis through the LLQ port, and the lesser sac entered with the dissecting instrument by dividing the omentum of the transverse colon. The previous cut end of the mesocolon is identified below the omentum, and the right branch of the middle colic vessels subsequently ligated from lateral. Alternatively, the left hand retracts the transverse colon inferiorly through the LUQ port, and the right branch of the middle colic is divided from medial after entering the lesser sac.

Box 6.11. Tip
The supramesocolic approach allows using the hand to palpate and control the base of the pedicle.

Extracorporeal Anastomosis, Closure, and Reinspection

It is most common to perform extracorporeal division of the bowel and anastomosis. The specimen is extracted through the hand port. Once the peritoneum is breached, pneumoperitoneum will be lost. Port sites should be left in place at this time for reinsufflation at a later point. The surgeon's hand is used to grasp the colon while the abdomen is desufflated and extract the specimen through the hand port. The right colon, hepatic flexure, and terminal ileum are exteriorized, taking care not to twist the bowel in doing so. Additional mesentery is divided if needed to facilitate an anastomosis without compromising blood supply. The right hemicolectomy bowel resection is then performed in a standard fashion. Typically, a functional side-to-side stapled anastomosis is performed.

Alternatively, an intracorporeal bowel resection and anastomosis may be performed. This will still require extraction of the specimen but allows for the hand port to be placed in a number of cosmetically advantageous locations, such as the Pfannenstiel location. The totally intracorporeal anastomosis requires additional time and laparoscopic skills but is feasible in the hands of an experienced surgeon.

Following extracorporeal resection and anastomosis, the bowel is returned to the abdomen. Reinsufflation of the abdomen is considered at this point. This is easily done with the use of a hand port. This allows the laparoscope to be reinserted for final inspection. The anastomosis is visualized and placed in an appropriate position in the abdomen. The limbs are inspected to ensure there is no twist. Hemostasis is confirmed. Closure of the mesenteric defect is not necessary for laparoscopic right hemicolectomy. The incidence of herniation and/or incarceration through the defect is now known to be very rare.

Approaches

There are advantages and disadvantages to using either the medial to lateral or lateral to medial approach, the two general approaches to laparoscopic colon surgery. In addition, inferior to superior and superior to inferior approaches have been described and are personal preferences of any given surgeon. They entail "rearranging" the steps fully described above, but in certain cases one may be more beneficial in a given case and all should be familiar to all surgeons. Hand-port location may be the same in either approach if the patient's body habitus allows enough space for the additional ports. Otherwise the hand port can be adjusted slightly superiorly or inferiorly.

Lateral to Medial Approach

The lateral to medial approach to hand-assisted laparoscopic right hemicolectomy follows the previously described surgical steps in the order of 1, 4, 3, 5, 2, 6, and 7. In this approach, following insufflation and exploration of the abdomen, the line of Toldt is incised laterally and the cecum, ascending colon, and ileum are mobilized early in the procedure. The right ureter is identified at this point in the procedure. The duodenum is identified from the lateral position, and the ascending colon is carefully mobilized, ensuring that the dissection remains anterior to Gerota's fascia. The duodenum may appear quickly in the situation of a short ascending colon, and extreme caution must be used during lateral dissection. This placement allows for medial retraction of the colon with the surgeon's hand while proceeding with lateral mobilization of the cecum and ascending colon. The patient is placed in left tilt regardless of port placement to visualize the lateral edge of the ascending colon. Next, the transverse colon and hepatic flexure can be mobilized from a lateral or a medial approach, so as to join up with the previously dissection line along the right colon. These two maneuvers allow the colon to be brought medially and the hepatic flexure brought inferiorly. The duodenum is again visualized. Once the colon is mobilized, the ileocolic pedicle is identified and ligated, and the mesentery of the right colon is divided to the right branch of the middle colic artery. The right branch of the middle colic artery may then be divided. Exteriorization and bowel resection are then performed.

The lateral to medial approach has its advantages. It more closely mimics the sequence of steps undertaken for an open right hemicolectomy, where the peritoneal reflection is incised first to then mobilize the colon. The sequence continues to mimic the open approach when mobilizing the ascending colon, the transverse colon, and the hepatic flexure. This familiarity may provide confidence to the surgeon and a good knowledge of usual planes and intraoperative anatomy. This may be especially useful to the surgeon first learning the laparoscopic approach. Another advantage to the lateral to medial approach is early identification of the right ureter. When mobilizing along the white line of Toldt at the level of the ileum and cecum, the ureter is identified laterally. The right iliac vessels are used as landmarks for its location. Once identified, the right ureter may then be protected during the remainder of the procedure, and its location may be referenced again at any point to confirm its location. Again, this step mimics the safe approach to open right hemicolectomy. This approach also allows performing extracorporeal ligation of vessels.

Medial to Lateral Approach

The medial to lateral approach is a departure from the traditional open approach to a right hemicolectomy. It has become a popular laparoscopic approach. The main difference is the early ligation of the ileocolic vascular pedicle. This approach follows steps 1–7. After exploratory laparoscopy, the surgeon turns attention to identifying the ileocolic vessels prior to lateral mobilization along the line of Toldt. Unless the ileum requires mobilization due to adhesions or inflammatory reaction from the disease process, the small bowel is moved medially to expose the medial surface of the right colon mesentery. Left tilt and slight Trendelenburg position facilitates this. The surgeon's hand is used to grasp the cecum and right colon and retract superiorly and anteriorly. This places stretch on the mesentery. The ileocolic vascular pedicle is tented up and can be palpated with the surgeon's fingers. The peritoneum is scored with electrocautery, and a window is made in the mesentery on either side of the ileocolic pedicle. Special care is taken at this point to identify the duodenum behind the ileocolic pedicle. In the medial to lateral approach, this is the first point at which the duodenum is visualized. Blunt dissection with a grasper or the surgeon's index finger is used to sweep the peritoneum to open the mesenteric window and bluntly brush the duodenum away from the mesentery. Only after the duodenum is identified and separated from the colon mesentery may the ileocolic vessels be divided.

Mobilization of the transverse colon and right colon is then performed as described earlier. The right branch of the middle colon artery may be divided as mesenteric division is performed. The omentum is divided from the transverse colon, and dissection proceeds toward the hepatic flexure and then laterally along the right colon. Since the duodenum has already been identified and bluntly dissected out, it may be used as a good guide for the proper plane of dissection. Using the anterior and lateral borders of the sweep of the duodenum as landmarks, the surgeon mobilizes the hepatic flexure and right colon without dissecting too far laterally or posteriorly behind the right kidney. Hepatic flexure mobilization is expedited, as part of the mobilization has in essence been done from the medial approach during early blunt dissection of the duodenum.

The medial to lateral approach achieves early ligation of the vascular pedicle, the most significant difference from the lateral to medial approach. In doing so, the major blood supply to the right colon is controlled before manipulation of the colon and its mesentery. If performing a right hemicolectomy for a cecal or right colon cancer, early high ligation may be desired prior to manipulation of the colon. Since the colon is grasped and retracted during its laparoscopic mobilization with the surgeon's hand, release of tumor cellular factors and neoplastic cells into the ileocolic vein is theoretically possible. This is why many prefer to ligate the pedicle prior to manipulating the colon. The approach is specifically useful when the area of significant inflammation of the cecum or ascending colon is avoided initially and dissection is performed around the pathology first.

Inferior to Superior Approach

The third approach to laparoscopic right hemicolectomy is the inferior to superior as a slight modification to the medial to lateral one. This approach follows steps 1, 3, 2, 4, 5, 6, and 7. Following exploratory laparoscopy, the patient is placed in Trendelenburg position. The small bowel is able to fall superiorly and is further carefully pushed superiorly by the surgeon's hand and an instrument. The inferior and lateral surface of the mesentery of the terminal ileum is then in view. The peritoneum of the mesentery is scored with electrocautery, and the mesentery is dissected of the retroperitoneum. The right ureter and right iliac vessels should be identified at this point. The surgeon then turns attention toward identifying the ileocolic pedicle and duodenum. With the colon lifted anteriorly, the dissection of the mesentery of the ileum in the direction of the right colon mesentery will lead to the ileocolic pedicle. Again, before dividing the ileocolic pedicle, the duodenum must be identified. It will be found behind the ileocolic pedicle when viewing the pedicle from inferiorly. A purple hue will be seen behind the peritoneum, and blunt dissection of the peritoneum with a grasper instrument will open this plane and ensure the duodenum is visualized and protected during ileocolic vessel ligation. Once these steps are completed, the remainder of the procedure is completed as described earlier (see Video 6.8).

During the inferior to superior approach, the patient must be placed in steeper Trendelenburg position than during the other approaches. This is necessary to visualize the mesentery of the ileum and achieve good retraction of the small bowel. This positioning may not be tolerated by all patients, namely, the elderly, the obese, or those with moderate to severe cardiac or respiratory comorbidities. A lower pneumatic intra-abdominal pressure may be used, and if this is not sufficient to proceed, conversion to another approach which uses left tilt with less Trendelenburg should be done. If tolerated by the patient, the best indication for an inferior to superior approach is the case of a poorly visible ileocolic pedicle. This is often found in a fatty mesentery of an obese patient. A fatty mesentery will make it difficult to see the ileocolic pedicle under tension or to palpate the pedicle with the surgeon's hand during anterior retraction of the colon during lateral to medial and medial to lateral approaches. By carefully following the ileum mesentery toward the ileocolic pedicle from inferior to superior, the pedicle is more easily identified and palpated without making uncertain windows in the mesentery.

Superior to Inferior Approach

The superior to inferior approach follows the described surgical steps in somewhat reversed order: 1, 5, 6, 3, 5, 2, and 7. The patient is placed in the reversed Trendelenburg position and with the left side up. The omentum is divided off the transverse colon and the lesser sac is entered. The colon is then retracted caudally and the right branch of the right colic artery is divided from medially and superiorly. The dissection is now continued to mobilize the hepatic flexure from medially and the duodenum is identified. This allows retracting the colon further caudally and dividing the peritoneum along the line of Toldt from superior to inferior. Now the colon can be pulled further medially and caudally, and the ileocolic pedicle is identified from superior and lateral and subsequently divided.

Ileocecectomy

There are some situations where a formal right hemicolectomy need not be performed. The most common indication for laparoscopic ileocecectomy is terminal ileum Crohn's disease. These patients are often thin and young, making them perhaps the ideal patients for a laparoscopic approach. The main steps for laparoscopic ileocecectomy are similar to those for laparoscopic right hemicolectomy. The lateral to medial and inferior to superior approaches are most commonly used, as they pay earlier attention to the identification of the right ureter and the ileum mesentery. The mesentery is then commonly divided extracorporeally. If significant inflammation is present laterally, the ureter can be identified more proximally first with a medial to lateral approach. The right branch of the middle colic artery does not need to be divided. The hepatic flexure and proximal transverse colon will likely still require mobilization, so that the eventual ileocolic anastomosis is free of tension.

Special Considerations and Complications

The Reoperative Abdomen

Previous surgery may lead to a more challenging right hemicolectomy. It is not, however, a contraindication to offering a laparoscopic approach. The initial periumbilical camera port must be inserted using direct visualization with the Hasson technique or at Palmer's point in the LUQ. A finger sweep to feel the peritoneum should be done before stay sutures and trocar are placed to avoid bowel injury. After insufflation of the abdomen, the laparoscope should be inserted to assess the amount of adhesions present. One or two working ports are then inserted in an area free of adhesions. Adhesiolysis with sharp scissor dissection or hook electrocautery is then performed, focusing attention on the right side of the abdomen. The surgeon must be able to visualize the length of colon to be resected, retract the small bowel away from the field, and have a mobile anastomosis without tension. Patient and meticulous takedown of adhesions should avoid enterotomies. There are circumstances where adhesions are too dense to continue with a laparoscopic approach and conversion to the open approach may be necessary. Little time is lost by inserting a laparoscope to assess the degree of adhesions prior to committing the patient to an open approach. Alternative access approaches may be required depending on the site(s) and nature of the adhesions.

Morbid Obesity

From patient positioning to fascial closure of the extraction site, the obese patient poses many challenges to the surgeon. All efforts should be made to place the patient in lithotomy position and to tuck at least the left arm to allow access to the patient and minimize surgeon strain. Long instruments should be available and left-sided working ports should be placed closer to midline to ensure good triangulation and reach to the right colon. Visualization during laparoscopic right hemicolectomy may be a significant challenge, with a bulky omentum and epiploic appendages. A hand port is particularly useful in this situation to facilitate retraction and visualization of critical structures. Fingers may be used to palpate the region of the ileocolic pedicle for a pulse. If the ileocolic pedicle is not well demarcated with proper retraction, an inferior to superior approach may be the safest approach to isolate the pedicle without blind blunt dissection into the right colon mesentery. The obese patient should be counseled about the probably higher chance of conversion to open procedure if necessary.

Crohn's Disease

In the setting of a bowel resection for Crohn's disease, there are particular considerations for the surgeon performing ileocecectomy. The surgeon must consider the mesentery of a diseased ileum. Special attention must be paid to vascular control of the mesentery in Crohn's disease. Early exteriorization of the ileum and extracorporeal division of the mesentery of the ileum should be considered. This will allow for suture ligation of the mesentery for better vascular control if necessary. The hand port may be particularly useful in the setting of Crohn's disease, as the bowel may be palpated, phlegmonous disease may be carefully bluntly dissected from the abdominal wall, and interloop disease may be manually divided. A hand port may reduce the need for conversion to an open approach in these complex situations.

It is not rare to identify a small bowel to colon or small bowel to small bowel fistula when one embarks upon laparoscopic right hemicolectomy for Crohn's disease of the ileum. The first priority is to delineate the anatomy by running the entire length of small bowel. If a fistula is present, the surgeon must assess whether it can be managed laparoscopically. Much like the open approach, gentle blunt dissection with an instrument or the surgeon's is carried out to gently divide the fistula if possible. The ileum will be resected in the usual fashion, but to avoid spillage of enteric contents, a laparoscopic Babcock or intracorporeal suture may be placed across the defect. The affected small bowel or colon must also then be repaired. Primary repair with intracorporeal suturing is usually effective to do so. With the patient in the lithotomy position, the repaired sigmoid colon may be air tested using a sigmoidoscope and laparoscopic visualization. If a large fistula to small bowel or colon cannot be safely repaired with intracorporeal sutures, exteriorization of the bowel may be necessary for a sound repair. A hand port is very useful in this situation, as the bowel may be repaired extracorporeally, then the abdomen reinsufflated, and laparoscopic dissection resumed.

Locally Advanced Cancer

Local invasion by a tumor is a special circumstance that poses many challenges. Preoperative staging imaging is helpful to predict local invasion, but will not preclude unanticipated findings in the operating room. In the case of lateral sidewall invasion, a margin of peritoneum and muscle can be resected en bloc with the right colon using electrocautery or an advanced energy device. This is only safe if the locations of other structures, especially the right ureter and duodenum, are clearly identified. A hand-assisted approach is very useful to palpate the degree of invasion of structures when a bulky tumor is present. The ability to proceed using the laparoscopic approach will depend on the degree and location of local invasion, as well as the surgeon's laparoscopic skill set. It is essential that oncologic principles be maintained and clear margins are achieved. This may or not be possible using the hand-assisted laparoscopic approach and converting to a laparotomy may be the only safe solution.

Bleeding

The hand port significantly eases the ability to quickly control bleeding. The surgeon has immediate control by occluding the potential bleeding vessel with the thumb and index finger. Occasionally the pedicle and specifically a vein may retract into the retroperitoneum. The hand in conjunction with a laparotomy pad, which is already positioned in the abdominal cavity, allows for quick and wide compression. The laparotomy pad is also superior to a laparoscopic suction device in cleaning the surgical site from bleeding. An advanced energy source, clips, or staples may be utilized to control bleeding once proper exposure is achieved (see Video 6.9).

Enterotomy

Injury to the small intestine may occur at various points of a laparoscopic right hemicolectomy. During trocar insertion, direct visualization must be maintained and two hands are used to guide trocar entry externally. Ports must be placed in areas free of abdominal wall adhesions, often away from previous incisions. Once one working port is safely inserted, adhesions should be taken down. A grasper may be used to retract small bowel away to leave room for trocar insertion. During retraction and positioning of the small bowel during the procedure, often sweeping the bowel with an instrument is sufficient without requiring excessive grasping of the bowel. Atraumatic graspers are used throughout the procedure. If an enterotomy is made, the degree of tissue damage must be assessed. If small, intracorporeal suture closure may be performed. The surgeon must beware of a cautery injury, which may first appear small, but lateral burn necrosis may develop with time and sound repair must be performed when it is recognized. A larger enterotomy may require resection or transverse closure. Contamination must quickly be controlled. The bowel may be brought out through the hand port for repair and then placed back in the abdomen for continuation of the laparoscopic approach.

Duodenal Injury

The duodenum is at risk of injury during laparoscopic right hemicolectomy, as much of the dissection during the procedure occurs in close proximity to the duodenum. Key steps to avoid a duodenal injury include using blunt dissection when defining its location, viewing the duodenum before ligating the ileocolic vessels by creating a window through the right colon mesentery, and again identifying the duodenum during hepatic flexure mobilization. An unrecognized duodenal injury contributes substantial postoperative morbidity to the patient. The second portion of the duodenum at the ampulla is relatively protected, as dissection occurs at the anterior and lateral surfaces of the duodenum. This make primary repair of a small duodenal injury relatively safe and be performed laparoscopically if technically feasible. A significant injury to the duodenum would likely require conversion to an open procedure for full assessment of damage, palpation of the ampulla, and sound repair. A drain may be left in the region of the duodenum to monitor for a postoperative leak if an injury had been repaired.

Identification of Tumor

The hand port is especially useful if a lesion is not visible on laparoscopy, as it adds the ability to manually palpate the bowel to localize the lesion without conversion to an open procedure. A bulky or transmural tumor is often quite easy to identify with laparoscopic visualization alone. A tumor of the cecum, appendix, or ileocecal valve is in an anatomically preserved position. However, smaller tumors or large polyps of the right colon and hepatic flexure may not be visible from the serosal surface. Preoperative planning is critical to achieve adequate margins in these instances. Preoperative localization is done through imaging with a CT scan, contrast enema, and reliable colonoscopy. Colonoscopy uses landmarks to identify tumor location and, again, excludes other pathologies that may warrant more extended resection. The most effective way to localize a mass preoperatively for the future surgical procedure is to use ink during colonoscopy. This is not essential for a cecal tumor but can be invaluable if the location of the tumor is not clear and for more distal right-sided lesions (Box 6.12).

> **Box 6.12. Tip**
> Placing a clip colonoscopically allows radiographic confirmation if a lesion is located in the proximal versus distal transverse colon.

Should a lesion not be adequately localized and the surgeon is unsure of where to plan the resection, the serosal surface of the colon is inspected for dimpling, puckering, or other evidences of mass effect. Using the hand-assisted approach, the surgeon's hand may be used to palpate the bowel. If these maneuvers are unsuccessful, an intraoperative colonoscopy is performed to locate the lesion. While viewing with the laparoscope, transillumination of the colon at the site of the tumor is noted, and laparoscopic resection may then proceed. If there is uncertainty after resection, the specimen may be opened and examined before being sent to pathology to assess for both tumor localization and adequacy of margins. A proactive and preoperative localization strategy will save much time during laparoscopic right hemicolectomy.

Inadequate Assistance

During a total laparoscopic right hemicolectomy, the surgeon relies on an assistant for successful completion of the procedure. The assistant holds the laparoscope and may also retract the colon during mobilization. If the assistant is not familiar with laparoscopic techniques, the procedure may become frustrating and possibly unsafe. A skilled assistant will facilitate good visualization of the working area, anticipate the direction of dissection, and provide steady retraction as instructed by the surgeon. The hand-assisted approach allows the surgeon to fully perform necessary retraction and dissection alone, relying on the assistant to control the camera only. If an assistant is not available, there are commercial instruments, which may be anchored to the operating table to hold the laparoscope during the procedure. These are not commonly used, as they need to be periodically adjusted to the location of dissection. The assistance of a colleague or skilled scrub staff must be sought before beginning a laparoscopic right hemicolectomy. A full set of laparoscopic equipment and trained operating room staff must be available before embarking on laparoscopic colon resection.

Summary

Hand-assisted laparoscopic right hemicolectomy and ileocecectomy provide another tool to surgeons performing bowel resections. The addition of a hand port to a traditional laparoscopic right hemicolectomy is useful in complex situations and acts as a bridge between open and straight laparoscopic approaches. Hand-assisted laparoscopic colorectal resections have been shown to have decreased conversion rates while maintaining the benefits of minimally invasive surgery, including quicker recovery time and good oncologic outcomes. The principles and steps of hand-assisted laparoscopic right hemicolectomy are similar to those of straight laparoscopic right hemicolectomy. The surgeon's hand, however, acts as a grasper and dissector and adds tactile feedback to the procedure that is not possible in traditional laparoscopy. This is especially useful when mobilizing the colon, isolating the ileocolic pedicle, and palpating a tumor or vital structure. The hand port also serves as the extraction site for the specimen and allows for easy reinsufflation after extraction if desired. A hand-assisted approach is an optional technique to performing a minimally invasive right hemicolectomy, but it is one that is at times exceptionally useful during difficult dissections to achieve a safe laparoscopic outcome for the patient.

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7 Right Hemicolectomy and Ileocecectomy: Single-Port Laparoscopic Approach

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Introduction

In this chapter, we aim to describe the single-port laparoscopic (SPL) or single-incision laparoscopic surgery (SILS) technique as it applies to right hemicolectomies and ileocecectomies. We will discuss the history of SPL, the development of this technique, and various approaches and applications used today specific to colectomies. We will describe the results and outcomes currently available in the literature today as well as difficult scenarios, complications, and tips and tricks.

Background

Since first described in 1991 [1], laparoscopic surgery has been shown to have benefits with reduced surgical trauma, minimal abdominal wall incisions, shorter hospital stay, faster return to bowel function, reduced wound complications, and less postoperative pain. Recurrence and survival have also shown comparable results with open surgery [2]. Other advantages include decreased risks associated with port placement and reduction in the incidence of incisional hernias [3]. Success with laparoscopy has led to further attempts to reduce the invasiveness of laparoscopic surgery. As each incision is associated with risks such as port-site herniation, damage to viscera, abdominal wall bleeding, and scarring, attempts to minimize entry have resulted in the development of NOTES™ and SILS. NOTES, or natural orifices transluminal endoscopic surgery, uses natural orifices such as the stomach, vagina, or bladder, aiming to result in an "abdominal scarless" technique. To date, there are no commercially available instruments specific for NOTES™ [4]. SILS, or single-incision laparoscopic surgery, utilizes a single laparoscopic incision, through which the camera and laparoscopic instruments are placed to carry out the procedure.

Since the introduction of SILS in 1997 for laparoscopic cholecystectomies and appendectomies, it has been applied to a wide variety of other surgical fields, namely, urology, bariatric surgery, adrenalectomies, and hernia repairs [5]. The application of SILS to colorectal procedures has not occurred as rapidly, perhaps owing to the technical difficulty and complexity of colectomies. Unlike cholecystectomies and appendectomies, for example, colectomies involve multiple quadrants. Colectomies also require multiple stages, such as mobilization of the colon, resection with adequate margins, and the creation of a tension-free anastomosis [6, 7]. Despite these apparent difficulties, comparative studies between SILS colectomies and conventional laparoscopic colectomies have shown no difference in conversion to open laparotomy, morbidity, or operation time, but has shown shorter total skin incision sizes and shorter postoperative length of stay [7–9].

In colorectal surgery, SILS has been utilized for everything from benign conditions to malignancies. It has been described for right and left colectomy, sigmoid colectomy, total proctocolectomy, and low anterior resection. Current randomized prospective trials have shown no difference in postoperative mortality and morbidity rates, return to bowel function, or ease of operation, with similar operative times, number of lymph nodes harvested, extent of resection, and tumor-free margins [10, 11]. Right hemicolectomy using SILS was first described in 2008 [12], and has since been shown to be safe and feasible even from an oncological point

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_7. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_7, © Springer Science+Business Media New York 2015

of view, and on consecutive unselected patients [3, 13–21]. One small retrospective review showed that it may be applied to a broader spectrum of patients, showing no mortality and a complication rate of 37 % (comparable to randomized trials comparing open and standard laparoscopic colectomy and SILS case series with more selective patients) in a sample size of consecutive patients, some more complex, including patients with previous abdominal surgery, higher BMI, larger and more advanced tumors, and older patients [14, 17]. Other case-matched series found comparable results with conversion rates and postoperative morbidity rates between conventional laparoscopy and SILS colectomies. Some found a significantly shorter median operative time (130 vs. 180 min) and hospital stay (6 vs. 7 days) [16, 17, 19].

Although cosmesis is touted as one big advantage to SILS, one criticism is the risk for incisional hernia due to the size of the single incision, which ranged from 3 to 4 cm. The preferred site is usually the umbilicus, which is the thinnest portion of the abdominal wall. Incidences of incisional hernias ranged from 0 to 10 % in case-matched series with limited sample size [16, 17].

From an oncological standpoint, short-term outcomes from a few small case-control studies were similar to conventional laparoscopic colectomy. Initial oncologic results had resulted in equal length of margins number of resected lymph nodes, and TNM stage. The median follow-up ranged from 10 to 27 months. Recurrence data have yet to be published, as studies assessing long-term outcome are still ongoing.

For postoperative recovery, no differences have been observed with return of bowel function, usage of narcotics, and posoperative hospital stay. There is currently a lack of strong evidence supporting a large benefit to SILS from conventional laparoscopy apart from cosmesis. Limitations of the current studies are small sample size (most with less than 50 patients) and nonrandomized design, although prospective observational studies comparing SILS right hemicolectomies for cancer resection to conventional laparoscopy, such as the SILVERMAN1 trial, are ongoing. The issue of cost-effectiveness for SILS colectomies performed with specialized instrumentation has also been discussed, as trocars, specialized ports, curved instruments, and robotic-assistance decrease cost-effectiveness for this approach without any as yet defined benefit over conventional laparoscopic surgery [11], although it is possible to perform with standard laparoscopic instrumentation and without extra cost [18, 22, 23]. Therefore, to truly assess the advantages, if any, of SILS right hemicolectomy over conventional laparoscopy on postoperative morbidity, pain, and short- and long-term outcomes, larger, multicenter prospective randomized trials are recommended.

Room Setup and Positioning

Room setup and patient positioning follow the same guidelines as a conventional laparoscopic technique. It needs to be emphasized that during a single-port laparoscopic approach countertraction often relies on gravity. The patient should be therefore well secured as described before.

Port Placement and Extraction Sites

Multiple types of ports are often used. The SILS port™ (Covidien, Norwalk, CT) is a disposable device that has a CO_2 connection for insufflation. It allows for three additional trocars, either two 5 mm and one 10–12 mm or three 5 mm, to be inserted.

The GelPoint Advanced™ or GelPOINT Mini™ (Applied Medical) is a single-incision port type with a combination of a rigid ring with a GelSeal cap. This port allows for ports and instruments of various sizes to be inserted directly through the gel in different configuration and with excellent seal. One disadvantage might be its tendency to balloon out during insufflation, resulting in the instruments being pushed further out of the operative field and loss of the fulcrum [24]. This device also mandates to observe instrument exchange and introduction of an instrument through the trocar needs to be followed closely by the camera to aim for the abdominal incision.

Another port type is the Endocone™ (KARL STORZ GmbH, Tuttlingen, Germany), a reusable, rigid port with multiple channels. This port allows four different instruments to be used simultaneously and comes with two 5 mm, one 10 mm, and one 12 mm insertion point. The entry points can be exchanged using coaxial curved reusable instruments [13, 25]. A small retrospective observational study assessing outcomes with SILS right hemicolectomy using standard laparoscopic instrumentation found it to be safe and feasible and recommended a low-profile port with a wide intra-abdominal range of motion [26].

The port configuration (Fig. 7.1) typically used is a 5 mm 30° or flexible camera and two working instruments in a triangular fashion.

The site for the single-port device and subsequent extraction is often times chosen to be right through the umbilical stalk. This hides the incision with the aim of better cosmesis. It is unclear in the literature if this can result in an increased incisional hernia rate. The incision size depends on the bulk of the colon and tumor, but typically starts around 3–4 cm. Alternatively, the port can be placed in the supraumbilical location, which is typical for a conventional laparoscopic approach.

Fig. 7.1 Port configuration. Three 5 mm ports through single-port device

Operative Steps (Table 7.1)

The surgeon stands on the right side of the patient using two working instruments, which typically cross at the level of the fascia (Box 7.1). One hand is retracting the colon while the other is performing the dissection. Countertraction is achieved by gravity and anatomic fixation of the tissue such as the attachment of the colon to the peritoneum along the line of Toldt or the omentum to the stomach. The assistant stands away and to the right of the surgeon and is adjusting the camera to balance centering on the target and avoiding collision with the instruments.

Box 7.1 Tip
Keeping the target at the side of the camera's field of vision avoids instrument collision.

Table 7.1 Operative steps

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

Insertion of the Single Port and Exploratory Laparoscopy

The incision and initial access is very similar to a Hasson technique. The length of the skin incision can be usually less than the fascial incision size of about 3–4 cm. Once access into the peritoneum is achieved, the surrounding fascia is checked with a finger sweep to rule out any adhesions and the single-port device with preplaced trocars is inserted. The abdominal cavity is then explored in a standard fashion to rule out metastatic disease. Adhesiolysis can be performed (see Video 7.1).

Identification and Ligation of the Ileocolic Vessels

The surgeon's right hand is using a bowel grasper and retracting the cecum or the mesentery close to the cecum towards the right abdominal wall. This allows visualizing the ileocolic pedicle. The left hand is using a dissecting instrument such as a bipolar vessel sealer or monopolar hook or scissors to isolate the ileocolic pedicle and start the medial to lateral dissection separating the colon mesentery from the retroperitoneum. As the instruments cross, maximum fulcrum effect is achieved. Once the duodenum is identified, the pedicle can than be divided (see Video 7.2). In the alternative approach ("rollover technique"), the ileum and small bowel mesentery is divided first, and the ileocolic pedicle can be visualized by continuously alternating between lateral colon mobilization and mesenteric division until the duodenum and the base of the pedicle are identified.

Dissection of the Retroperitoneal Plane and Identification of the Duodenum

After division of the ileocolic pedicle, the right hand continues to lift the cecum and the left hand dissects between the ascending colon mesentery and the retroperitoneum. The extent can be limited by the reduced ability to tent up the colon. During the alternative approach the dissection of this plane is from lateral and inferior.

Mobilization of the Right Colon and Terminal Ileum

The left hand now grasps the cecum with a bowel grasper and retracts medially and cephalad. The right hand is using an energy device or a monopolar hook or scissors to mobilize the colon along the line of Told and separating the remaining mesentery off the retroperitoneum. The instruments again cross to avoid instrument collision (see Video 7.3).

During the alternative rollover technique, this is the first step. The ileum is identified 10 cm proximal to the ileocecal valve, a mesenteric window is created, and the ileum divided using a laparoscopic stapler (see Video 7.4). The distal ileum is now tented up with the left hand in a medial and cephalad direction and the small bowel mesentery divided towards the base of the ileocolic pedicle. Once the division is close to the retroperitoneum, the cecum and colon mesentery is mobilized laterally for a section and the mesentery subsequently divided (see Video 7.5). The cecum and ascending colon "rolls over" medially and cephalad and the cycle is repeated until the duodenum and ileocolic pedicle is isolated.

Mobilization of the Proximal Transverse Colon and Hepatic Flexure

The right hand now retracts the transverse colon inferiorly to achieve adequate tension of the omentum. The left hand divides the omentum to enter the lesser sac and the hepatocolic attachments (see Video 7.6).

During the rollover technique the lateral to medial dissection is continued around the hepatic flexure with ongoing retraction of the ascending and transverse colon medially and then inferiorly to divide the omentum from the right lateral side.

Identification and Ligation of the Middle Colic Vessels

The division of the middle colic vessels is difficult from the inframesocolic approach because only one retracting instrument is available, and the transverse colon can often times not be lifted enough to have adequate exposure. The right branch can be divided though safely from superior and right lateral using the rollover technique.

Fig. 7.2 Ileal extraction

Extracorporeal Anastomosis, Closure, and Reinspection

Once the dissection is completed, the specimen is extracted through the single-port incision site. The limiting factor is often times the bulk of mesentery and/or the size of the tumor (Box 7.2). With the rollover technique the small bowel mesentery and terminal ileum are already divided intracorporeally and the specimen can be therefore extracted easier through a smaller fascial incision. The divided distal ileum is grasped and the specimen extracted as a tube and not a loop (see Fig. 7.2). The extracorporeal anastomosis is fashioned in a standard way and the abdomen reinspected prior to closure (see Video 7.7).

Box 7.2 Caveat
When extracting the divided proximal ileum, ensure that the mesentery is not twisted for an extracorporeal anastomosis.

Approaches

Medial to Lateral Approach

A medial to lateral approach is the most common utilized approach in a conventional laparoscopic right hemicolectomy is a logic choice. This follows steps 1–7. It should be emphasized that extra care should be taken for safe vessel ligation of the ileocolic pedicle as intraoperative bleeding is difficult to control with availability of only two working instruments and limited mobility.

Rollover Technique or Modified Lateral to Medial and Inferior Approach

A very safe and easy alternative to the standardized medial to lateral approach is a modification and combination of the lateral to medial and inferior approach (Box 7.3). It specifically addresses the often times difficult dissection of the ileocolic pedicle, which is the first step of the medial to lateral approach.

> **Box 7.3 Tip**
> The rollover technique can be very useful for conventional laparoscopic right hemicolectomies in the morbidly obese with a very short and thick colon mesentery and ileocolic pedicle.

This alternative is also called the "rollover technique" because the cecum, ascending colon, and hepatic flexure are progressively rolled over in a clockwise fashion during different parts of dissection. This allows having adequate tissue exposure with traction through the instrument and countertraction through the attachment of the colon to the peritoneum along the line of Told and the hepatocolic ligament, mesenteric attachments to the root, and omental attachments to the stomach. The approach follows steps 1, alternating 3 and 4, 2, 5, 6, and 7. It should be emphasized that the procedure starts with creating a mesenteric window and dividing the terminal ileum first, followed by continuous division of the small bowel, and then colon mesentery alternating with dissection of the mesentery of the retroperitoneum and later duodenum.

Special Considerations and Complications

One of the disadvantages to SILS colectomy is technical difficulty. There is a loss of triangulation and decreased range of motion to maneuver instruments. Other pitfalls with SILS colectomy include the learning curve [11]. With single-incision right colectomy, increasing experience can lead to shorter operative times with data suggesting that an experienced laparoscopic surgeon can overcome the learning curve within the first ten cases in an unselected patient population [14, 27, 28]. Median operative times ranged from 50 min to 191 [6, 14, 26, 29].

SILS can result in difficulty with triangulation. Some surgeons prefer to use articulating instruments or angled optical devices or both. These can be useful in mobilizing the flexures and in lysis of adhesions, but the instruments can collide internally unless the surgeon crosses hands. Other issues include difficulty in maintaining traction on the colon. To circumvent this, some surgeons opt to use instruments of varying length to operate in different planes and minimize hand collisions [6]. One group in South Korea devised a number of maneuvers to overcome these limitations, including inverse triangulation (the formation of an inverted triangle from the operator's point of view), pivoting, hanging suture (elevating the peritoneal fold or uterus with an intracorporeal stitch through the abdominal wall), and transluminal traction [30].

Conversion rates ranged from 0 to 16.7 % in a number of case series for SILS right hemicolectomy, either to traditional laparoscopy or to open [26, 29]. Visceral obesity, leading to difficulty in the identification of the correct surgical plane, was thought to be the primary cause for conversion for some studies. Some surgeons recommend obtaining preoperative CT scans to identify visceral fat in selecting patients for SILS right hemicolectomy [6, 25, 29, 31].

Another concern is loss of pneumoperitoneum after extending the incision for specimen extraction. Some surgeons have overcome this through the use of the Alexis O wound retractor and drape, placing the SILS Port through this and securing with umbilical tape to reestablish pneumoperitoneum [19].

Complications

Perioperative complications ranged from 16.6 to 37 % in a number of small case series compared to 9.5 % for conventional laparoscopic right hemicolectomies. These included ileus, cardiovascular disease, and wound infection [29].

In a recent systematic review pooling 38 studies on SILS colectomies, the complication rate was 10.8 %, namely, wound infections (2.5 %), postoperative ileus (1.6 %), and other minor complications including respiratory infections, urinary retention, and pleural effusions. Major complications were found in 3.2 % of patients and included mainly anastomotic bleeding and leakage. Deaths reported were few and included one mortality from pulmonary embolus 10 days after the surgery. Two deaths occurred specifically following palliative SILS right hemicolectomies for metastatic cecal carcinoma, one of which resulted from respiratory complications.

A recent review of 32 studies specific to SILS right hemicolectomies found that reported complications were limited to conversion, postoperative wound infection, intra-abdominal abscess, anastomotic bleeding, pulmonary complications, wound hematoma requiring evacuation, urinary tact infection, ileus, chest infection, seroma, and obstruction due to adhesions [26, 27].

Summary

Single-port laparoscopic right colectomy has been shown to be feasible and safe from an oncological point of view and short-term morbidity compared to multi-port laparoscopy, but larger randomized studies are needed to compare potential benefits, other than cosmesis, with conventional laparoscopic resections.

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8 Right Hemicolectomy and Ileocecectomy: Laparoscopic Intracorporeal Anastomosis

Morris E. Franklin Jr, Song Liang, and Miguel Angel Hernández Moreno

Introduction

A laparoscopic approach is increasingly regarded as a gold standard for resection of benign and malignant colonic lesions. Laparoscopic right hemicolectomy can include either an extracorporeal or intracorporeal anastomosis. The extracorporeal anastomosis is performed similar to an open approach and is therefore utilized more frequently. In this chapter, we will discuss the potential advantages and technical nuances of the intracorporeal approach.

Background

The first laparoscopic-assisted right hemicolectomy was described in 1992 and since then several authors have published their techniques. This approach has several distinct advantages in comparison to open surgery, including lesser use of analgesics, earlier return of bowel motility, a shorter hospital stay, faster perioperative recovery, and lower incidence of wound infections and hernia rates. Extracorporeal anastomosis is the technique preferred by several authors. This technique requires an extensive and unnecessary mobilization of the colon in order to exteriorize the bowel through the minilaparotomy, but the twist of the mesentery is a well-known and well-described event that can occur without the direct visualization of the orientation of the bowel. Some anastomotic leaks can be explained by the technical difficulty of performing the anastomosis through a small mini-laparotomy, especially in patients with a bulky and short mesentery, as it is difficult to exteriorize the bowel adequately in order to perform an ideal tension-free anastomosis without traction. Laparoscopic intracorporeal anastomosis has been proposed in order to overcome these disadvantages. It is technically challenging with straight instruments, it requires an adequate training, and the rate of anastomotic complications may be as high as 5 %. To decrease the incidence of major complications, surgeons must be sufficiently trained to skillfully carry out laparoscopic suturing and be able to use mechanical staplers. This ability is necessary to keep the incidence of conversion to laparotomy as low as possible due to the high morbidity and cost for patients who undergo conversion to open surgery. A completely intracorporeal technique implies a reduced manipulation of the abdominal organs because the specimen is removed as the anastomosis is completed. The reduced manipulation of the bowel can explain potential better recovery of the gastrointestinal tract, faster bowel movement, faster first flatus, and shorter time to a solid diet. This improves the patients' postoperative state and most likely explains potential advantage in terms of further reduced hospital stay.

Indications of a right hemicolectomy and ileocecectomy with intracorporeal anastomosis include adenomatous polyps not suitable for removal by colonoscopy, inflammatory bowel disease, bleeding of arteriovenous malformations, obstruction, Crohn's disease (and complications), ischemia, and any other condition for resection. Lesions can be resected from the ileum to mid colon. Based upon recent reports in management of colon cancer, surgery for malignant disease can be performed safely including palliative resection for incurable carcinoma and potentially curable entities [1–15].

Preoperative Planning

Preoperative planning is a very important issue for a successful result in laparoscopic colon resection. A thorough history and physical examination with special emphasis on cardiac and pulmonary problems as well as previous surgeries is mandatory. The patient and the operating team must be adequately informed of, and familiar with, the

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_8, © Springer Science+Business Media New York 2015

laparoscopic procedure. The patient should be informed that there is a possibility that the laparoscopic procedure may have to be converted to an open procedure. It is very important to perform a complete workup of the colon to allow preoperative localization of the tumor by means of a barium enema, computed tomography (CT) scan, or colonoscopy with India ink marking when indicated. A baseline chemical profile including complete blood count, carcinoembryonic antigen in malignant disease, preoperative electrocardiogram, and chest radiograph should be performed as needed. The cardiac and pulmonary status of the patient should be very carefully evaluated to ascertain the patient's ability to withstand a potentially longer procedure with abdominal distention and often a steep Trendelenburg and exaggerated lateral postures with increased pressure on the diaphragm. For the bowel preparation multiple options through various bowel preparation regimens are available. The authors recommend 5 days prior to surgery a low-fiber diet, 3 days prior a full liquid diet, and 2 days prior clear liquids, adding four tablespoons of milk of magnesia in the middle of the day and another four tablespoons 6 h later. The day prior to surgery, the authors recommend continuing with clear liquids and magnesium citrate (60 mL PO q12h), with saline enema 6 and 2 hours before surgery. This uniformly results in a clean colon, which is mandatory for intracorporeal anastomosis and intraoperative colonoscopy and as well as monitoring fluid balance preoperatively and monitoring nutritional status. The patient is usually given IV antibiotics preoperatively.

Room Setup and Patient Positioning

The equipment needed includes at least two monitors placed in accordance with the portion of the colon upon which the operation is planned. The operating table must allow for steep Trendelenburg positioning and for left and right tilting; additionally, anal and vaginal access should be preferred for intraoperative colonoscopy and specimen retrieval when needed. 0- and 30-degree scopes; a three-chip high-resolution, high-definition video camera; and high-flow insufflator are very helpful. Standard graspers and special instruments including long bowel instruments, 5-mm laparoscopic scissors with cautery attachment, bipolar instrumentation, and those with cautery capabilities are needed, as are advanced vessel sealers. Clips or other devices may be used to control smaller blood vessels. Effective suction and irrigation devices (5 and 10 mm) with extra-long wands are recommended as well. Endo-GIA linear staplers with multiple reloads are in order.

An ultrasound device enhances evaluation of the liver as well as para-aortic nodes and should be available when needed. Other instruments include special dissectors to dissect and free individual vessels. Laparoscopic bulldog Glassman clamps for bowel content control are frequently helpful. An instrument table for opening of the patient also needs to be immediately available should occurrences arise that could demand an open procedure. Colonoscopy equipment is recommended. As discussed later in this chapter, the use of colonoscope for laparoscopic colon resection is a must since it helps evaluate the anastomosis site and leaks as well as the presence of synchronous lesions.

Correct patient positioning can greatly enhance a laparoscopic procedure. A supine position with ready anal access with the hips slightly flexed, 15° angle, aided by Lloyd-Davis or Allen stirrups and the buttocks near the edge of the table is extremely helpful. Taping the patient at the shoulders without restricting the pulmonary function is a very adequate method of stabilizing the patient for the positional changes and Trendelenburg that may be needed; however, beanbags and other restraining devices are also effective. Shoulder stripes or pads should be avoided as a sole means of preventing slippage as this can result in brachial plexus injury. It is also important to protect all exposed nerve surfaces, particularly those around the elbows and knees. The arms need to be secured by the patient's side (if at all possible) to allow maximum tilt and mobility of the surgical team, as arms spread in the classic position will be an obstruction to movement around the operation table.

Sequential compression devices are placed on the patient's legs to help avoid venous stasis and an increased risk of deep vein thrombosis. A warming blanket should be available to help prevent cooling of the patient, which most certainly can occur in longer procedures. Provisions should be made for warming of intravenous fluid and irrigation fluids, as this can also be a source of patient cooling. Warming the inspired gas is strongly recommended, and many authors recommend also warming the CO_2. Wrapping the lower extremities in plastic bags is also advised and may prevent at least 1° temperature loss per hour in a 2-h or longer procedure. A Foley catheter and an orogastric tube are routinely inserted. Placing an arterial line and central line in any patient undergoing laparoscopic colorectal surgery is recommended, at the discretion of the anesthesiologist, particularly in the presence of cardiac and/or pulmonary compromise or with the expedition of a longer procedure.

It is very important to emphasize that before embarking upon laparoscopic colon resection of any type, the surgeon should have a proper background in advanced laparoscopy that includes intracorporeal suturing, intra-/extracorporeal knot tying, good use of both hands, and experience with stapling devices to avoid unneeded conversions to open procedures. Intricate knowledge of anatomic relationships between colonic vasculature, ureter, duodenum, superior mesenteric artery, stomach, common bile duct, kidney, and omentum is mandatory.

Port Placement and Extraction Sites

Trocars should be 5 mm, 10 mm, or universal 5/12 mm; these enhance the ability of a surgeon to place instruments of all sizes without changing reducers on the ports. A general rule is to "use as many trocars as needed" but standard is four trocars (see port configuration in Fig. 8.1). Generally, a half circle around the target organ is the best setup for trocar placement. The camera port is in the periumbilical location and the working ports are in the right lower quadrant (RLQ) L1 and right upper quadrant (RUQ) L2. At least one 12-mm port is necessary for the use of stapler, a 12-mm port in the right lower quadrant (LLQ) L3 or alternatively in L2.

The intracorporeal anastomosis allows the extraction site not only to be typically smaller than needed for an extracorporeal technique, it also allows the extraction site to be off the midline or through a Pfannenstiel incision, which both have a decreased incidence of an incisional hernia compared to a midline incision.

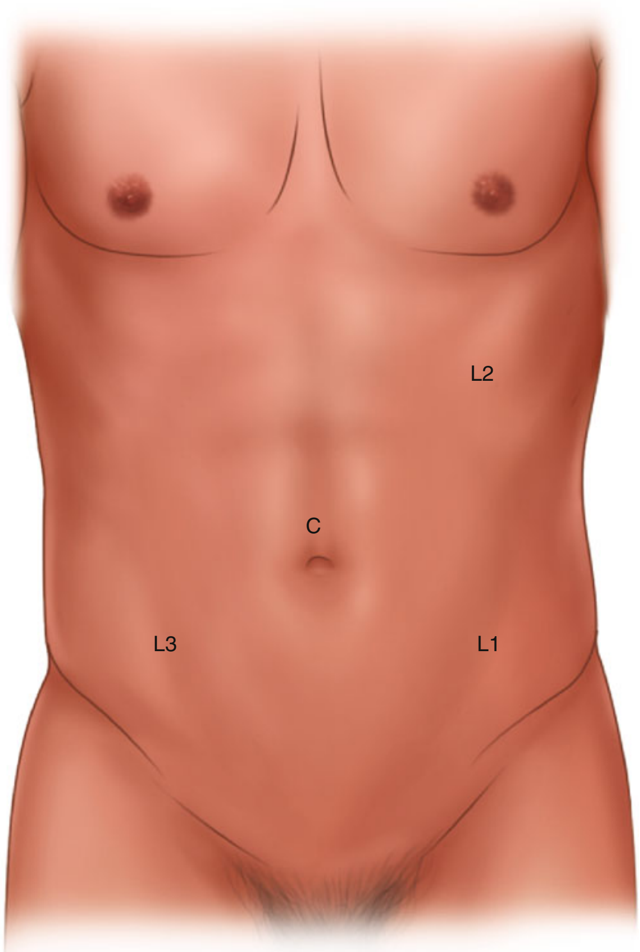

Fig. 8.1 Port configuration. *C* 5 mm or 12 mm camera port, *L1* 5 mm working port, *L2* 5 mm working port, 12 mm (for stapler) using side-to-side isoperistaltic anastomosis, *L3* 12 mm working port for stapler using side-to-side retroperistaltic anastomosis

Operative Steps (Table 8.1)

Exploratory Laparoscopy

Pneumoperitoneum is established by use of the Veress needle or Hasson technique and the abdomen is insufflated with carbon dioxide gas to a pressure of 15 mmHg. In most cases the Veress needle is placed in the left mid flank; however, an alternate site, such as upper midline, left upper quadrant, is often selected in patients who have had prior abdominal surgery. Following adequate insufflation and trocar placement, the abdomen is thoroughly inspected for signs of metastatic diseases or other disease processes, which may alter the anticipated procedure. Adhesions to the anterior abdominal wall are taken down carefully in a stepwise fashion and the remainders of the working ports are placed under direct visualization. Once all trocars are placed and the diseased segment is identified, a careful "no-touch" technique for handling the colon and the tumor is rigidly enforced.

Identification of Duodenum and Ligation of the Ileocolic Vessels

Most surgeons are very familiar with the anatomy involved with virtually every type of colon resection performed. Laparoscopy offers a different view with which laparoscopic surgeons must recognize. Laparoscopy provides a better, magnified view of surgery, but it is sometimes difficult to identify the origin of the vascular supply intended in the resection with this procedure. In right-sided colon

Table 8.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy	1
2. Identification of duodenum and ligation of the ileocolic vessels	3 (medial to lateral) 4 (lateral to medial)
3. Mobilization of the right colon and terminal ileum	4 (medial to lateral) 2 (lateral to medial)
4. Mobilization of the proximal transverse and hepatic flexure	4 6 (with vessels)
5. Intestinal division and specimen bagging	5
6. Intracorporeal anastomosis	6
7. Anastomotic leak testing with colonoscope	3
8. Specimen extraction	2 (transabdominal) 5 (transvaginal)

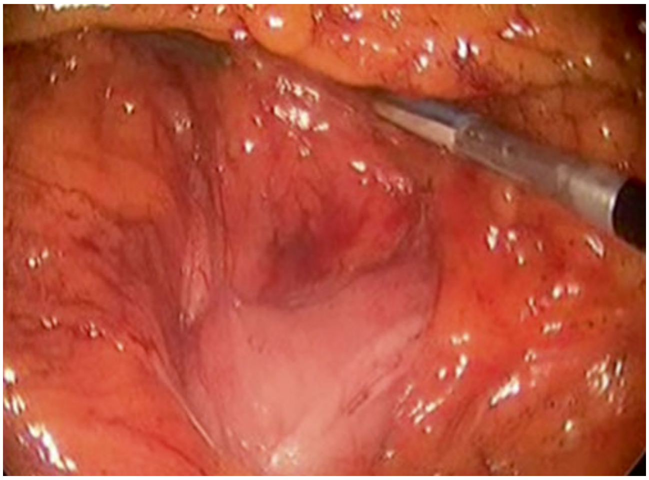

Fig. 8.2 Identification of the duodenum

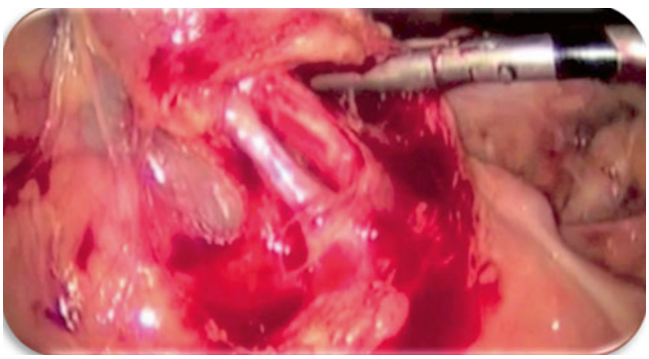

Fig. 8.3 Identification of the ileocolic vessels

cancer, there are three major vessels, the ileocolic, right colic artery, and superior mesenteric artery, with wide range of variations of vascular architecture. A laparoscopic lymphadenectomy intracorporeally performed may therefore be more difficult for right-sided colon cancer than for left-sided tumors. The duodenum should be clearly identified as the colon is reflected inferiorly of through the mesenteric window of the hepatic flexure early in the dissection (see Fig. 8.2). While some authors prefer division of ileocolic vessels prior to identification of the duodenum, identification of the latter structure can be the first step of a right hemicolectomy. The ileocolic artery can be divided with staples, ligation, clips, or a coagulator device such as the harmonic scalpel or the LigaSure device. It is helpful to retract the mesentery of the ileocecal complex anteriorly, opposite the root of the mesentery, which will tent up, and the ileocolic vessels should be reactively mobile (see Fig. 8.3). During a lateral to medial approach, the duodenum is identified behind the colon, and a window is created in the mesentery. At this point, this mesentery thickness should be one layer and can be expanded inferiorly to identify the colic vessels, immediately caudal to this opening. Care should be taken to ensure the integrity of the superior mesenteric artery and blood supply to the small bowel.

Mobilization of the Right Colon and Terminal Ileum

The cecum and the ascending colon, along with lateral attachments, are the most easily exposed segments of the colon during the laparoscopic approach and allows for a very easy mobilization of the right colon once the anatomic relationships of the right mesolocon has been established. It is very important during the mobilization to use gravity to an advantage rather than a disadvantage. Use of the Trendelenburg position, and reverse Trendelenburg and especially right tilt, can allow visualization and mobilization of almost any right colon with much less effort than with nonuse of gravity. It is recommended to push the colon and other organs out of the way rather than pull, as pulling, particularly with torque, tends to injure the colon and other organs. The surgeons should methodically avoid grasping the bowel that is not to be resected and very carefully avoid grasping the tumor in cancer cases. Blunt dissection is always better than sharp dissection unless one can actually see through the tissue being dissected. If inadequate visualization does not allow for clean dissection, change the scope or the position of the scope until the anatomy can be clearly delineated. Often it is helpful to dissect in another angle until anatomy becomes clear.

Two options are available for right colon dissection, lateral-to-medial and medial-to-lateral approach. The medial-to-lateral approach follows the continuous dissection of the retroperitoneum off the colon mesentery from medially. In the case of lateral-to-medial dissection, the terminal ileum and cecum are the first mobilized, followed by the ascending colon through the line of Toldt. The mobilization is done with upward traction of the colon with a nontraumatic instrument and sharp dissection is used for mobilizing the abdominal wall attachments (see Fig. 8.4). Progressive dissection to the terminal ileum may be carried out utilizing sharp dissection with scissors and controlling bleeding or with the use of the abovementioned coagulation devices.

Mobilization of the Proximal Transverse Colon and Hepatic Flexure

The hepatic flexure and proximal transverse colon are freed from hepatocolic and gastrocolic ligaments as far as needed to ensure adequate distal margins and a tension-free anastomosis.

Immediately superior to the duodenum is the right colic vein, and the right colic artery can be identified as a branch

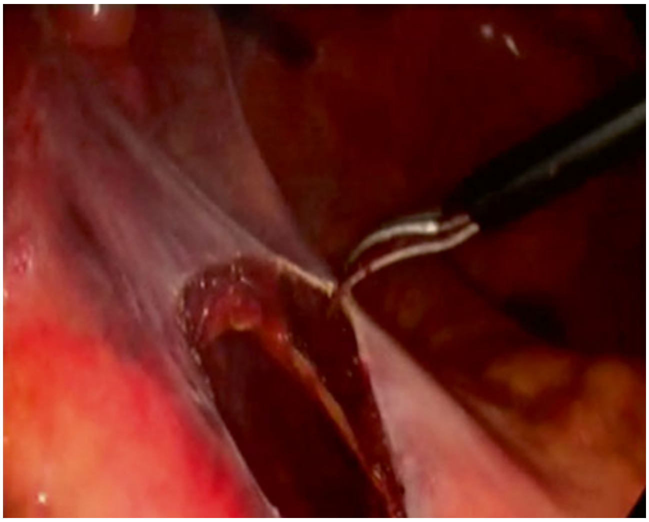

Fig. 8.4 Lateral mobilization of the cecum

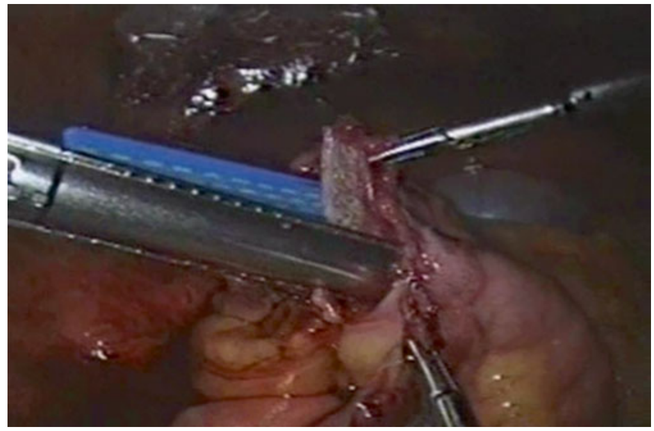

Fig. 8.5 Side-to-side anastomosis

Fig. 8.6 Closure of the common enterotomy

or as a branch of the middle colic artery and should be divided if a wide resection is needed.

Intestinal Division and Specimen Bagging

The first step of an intracorporeal anastomosis is the complete division of the small bowel mesentery with an advanced energy device up to the proximal resection margin of the ileum, typically 10 cm proximal to the ileocecal valve. Patients who are to undergo totally intracorporeal anastomosis should have laparoscopic division of the colon at the distal end of the mesenteric window. The division of the bowel may be performed using the endoscopic stapling device after inspection of the region to ensure that an adequate blood supply is present. The omentum is properly divided along the avascular plane between the omentum and the colon. This may be divided with the harmonic scalpel, bipolar devices, or scissors. It is important to divide the ileum and colon in line with the mesentery, so that a corner of the staple line is on the antimesenteric border. The terminal ileum is divided at the desired level with a stapler and the specimen is then placed in a large specimen bag, which is sealed and stored above the liver for extraction after intestinal continuity is restored. Care should be taken to properly place the stapler to allow consistency in the division in order to prevent twisting of especially the small bowel during anastomosis.

Intracorporeal Anastomosis

Side-to-Side Retroperistaltic Anastomosis

An ileotransverse colostomy is then constructed with the endoscopic stapling device in the following manner as a side-to-side retroperistaltic anastomosis: first, a small enterotomy is made on the antimesenteric border of the colon at the edge of the previous staple line. This is then drawn over the staple side of the stapler which is introduced through the RLQ trocar L3 and held in place while this maneuver is repeated on the ileum side; while placing the stapler care must be taken to ensure proper orientation of the bowel, and continuous checking of the mesentery protects the small bowel from rotation and ensures that the mesentery is not twisted. With the colon drawn over the lower jaw of the stapler and the terminal ileum in a similar position on the upper jaw, the stapler is closed, and fired, creating a 6-cm anastomosis (see Fig. 8.5); if a longer anastomosis is required, a second firing could be performed in the same fashion. The common enterotomy can by closed by an additional firing of the Endo GIA stapler across the opening (see Fig. 8.6). For this the two ends of the previous staple line are identified and either pulled apart with laparoscopic graspers through the working ports L1 and L2 in the LLQ and LUQ or with placement of two stay sutures. This lines up the two walls of the common enterotomy with the stapler through the RLQ port L3. The common enterotomy can be closed alternatively with suturing. Various suture-closing techniques exist. A suture reinforcement of the angle of the anastomosis is routinely used.

Side-to-Side Isoperistaltic Anastomosis

Side-to-side isoperistaltic anastomosis is an alternative to the above technique. The endoscopic stapler will be introduced through the L2 port in the LUQ. Instead of using the two antimesenteric staple line corners of the previously divided bowel, the ileum is the first lined up parallel to the transverse colon in an isoperistaltic fashion. A stay suture can be placed with a transabdominal Keith needle securing the small bowel at least 8 cm proximal to the distal staple line with the end of the transverse colon (Box 8.1). An antimesenteric colotomy is made at least 8 cm distal to the transected transverse colon and an enterotomy 2 cm proximal to the transected ileum. One jaw of the endoscopic stapler is then inserted through the colotomy toward the proximal end and the other into the ileum. Once the anastomosis is created, the common enterotomy can be again closed with the endoscopic stapler or suturing.

> **Box 8.1 Tip**
> The location of the small bowel enterotomy 2 cm proximal to the staple line of the prior transection allows easier closure of the common enterotomy.

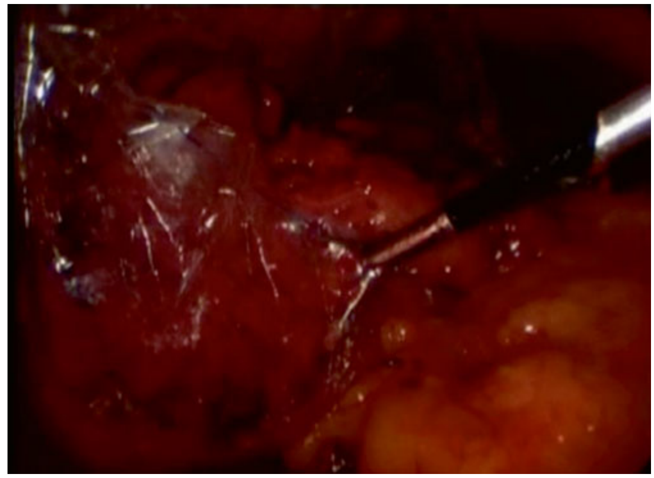

Fig. 8.7 Specimen positioning in bag

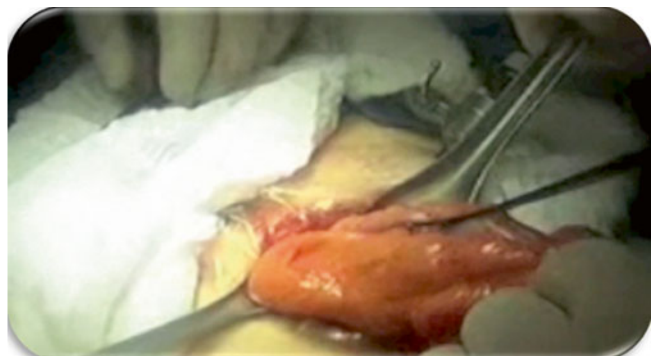

Fig. 8.8 Transabdominal specimen removal

Fig. 8.9 Transvaginal specimen extraction

Anastomotic Leak Testing with Colonoscope

Next, a clamp is applied to the terminal ileum, utilizing intestinal bulldogs or handheld Glassman clamps. An intraoperative colonoscopy is performed to ensure that the target lesion has been removed, to inspect for synchronous lesions, and to check the anastomosis for leakage; in the unlikely case of a leak, this should be repaired immediately.

Specimen Removal

The proximal and distal portions of the specimen should be isolated as quickly as possible with stapling devices and immediately placing the segment of the colon in a bag (Fig. 8.7). Inadvertent handling, chipping, or perforating of a tumor site is to be strictly avoided. A bag for specimen removal can be used, whether it is transabdominal (see Fig. 8.8) or transvaginal (see Fig. 8.9). This prevents contamination, not only with stool but also with tumor cells in cases of colon cancer. If transvaginal removal is to be utilized, direct passage thru the vaginotomy under direct laparoscopic vision can enhance the safety of this method of extraction.

After the specimen removal, the abdomen is then inspected a final time, with particular attention paid to previous dissection sites, ureter, mesentery, leaks, and the integrity of the anastomosis. The mesenteric defect is carefully inspected to assure no translocation of small bowel through the defect.

Summary

The use of an off midline abdominal incision site or natural orifices for the extraction of specimens may yield to a lower wound complication rate, less postoperative pain, and better cosmesis and is a rapidly developing field, and increasingly with this, intracorporeal anastomosis may be within the reach of every laparoscopic surgeon.

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Right Hemicolectomy and Ileocecectomy: Robotic Approach

9

Vamsi Ramana Velchuru and Leela M. Prasad

Introduction

In this chapter, we will review the potential advantages and disadvantages of the robotic approach to a right hemicolectomy and discuss the technical differences to the laparoscopic approach.

Background

Robotic surgery is the new frontier in advanced minimally invasive surgery and is utilized in numerous facets of surgery. It is gradually becoming an important tool in the surgeon's armamentarium. The daVinci surgical system offers excellent 3-D visualization, minimal access, endowristed movements of the instruments, and 7° of freedom encompassing the most important aspect – similarity to the natural dexterity of the surgeons' hands. The disadvantages of the robot is its bulky presence in the operating room, restriction of movements of the patient position once the robot is docked, lack of haptic feedback, and inability to work in multiple abdominal quadrants without changing the patient position.

The safety and feasibility of the robotic assistance has been well established in colorectal surgery [1–4]. In a recent systematic review [3], most studies had less estimated blood loss, reduced hospital stay, and lower complications following robotic colorectal surgery. A 5-year comparative study of robotic- and laparoscopic-assisted colectomies showed no difference in outcomes with regards to estimated blood loss, hospital stay, postoperative complications, and time to return to bowel function [5]. Conversion rates can be in the range of 3.7–8.8 % depending on the experience of the surgeons [1, 6]. Longer operative times compared to the laparoscopic approach were noted in robotic assistance [4, 7]. Current evidence suggests that robotic assistance in colorectal surgery is oncologically safe with comparable outcomes to laparoscopic surgery [8].

Robotic assistance for right hemicolectomy has been established as a safe and a feasible option [9]. Forty robotic-assisted right hemicolectomies were retrospectively compared to 135 laparoscopic procedures, and there was no significant difference in estimated blood loss, conversion rates, hospital stay, and complications. Longer operative time and higher cost were associated with the robotic approach [9].

Both extracorporeal and intracorporeal anastomoses have been used for robotic right hemicolectomy with comparable results. Intracorporeal hand-sewn anastomosis with robotic assistance has been shown to be safe, with no conversions and no leaks. The median operative time was 223 min (180–270 min) [10]. Extracorporeal anastomosis akin to open surgery was safe and can be easily performed [9].

A case-matched comparative study compared robotic assistance (n-33) to open right hemicolectomy (n-102), showed significant less blood loss, and reduced hospital stay in the robotic group, and postoperative complications were comparable [11]. A recent study of 20 cases of robotic right hemicolectomy with intracorporeal anastomosis showed no conversions confirming feasibility and safety [12]. Oncological efficacy with high yield of lymph node harvest has also been established [10, 11].

Mobilization of the right colon with robotic assistance can be either lateral to medial or medial to lateral depending on surgeon's preference [9, 13]. The lateral to medial

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_9. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_9, © Springer Science+Business Media New York 2015

approach is the traditional open technique and would be easier for surgeons who adopt robotic technique directly from open surgery. The medial to lateral approach is well described in the laparoscopic literature and is safe and effective. A comparative study of both techniques (eight patients in each group) both lateral to medial and medial to lateral approach had similar outcomes [14]. Total surgical times were similar in both groups. No difference was noted in the lymph node yield. None of the patients had anastomotic leaks.

Robotic right hemicolectomy can be a simple and a good teaching tool for surgical residents and colorectal surgeons keen to take up robotic surgery. deSouza et al. suggested that it can be the ideal procedure to start and learn before proceeding to complex rectal cancer surgeries [9, 15]. Robotic assistance is safe and feasible. Advantages are reduced blood loss, reduced hospital stay, and comparable oncological outcomes. Operative time and cost are higher; however, these would lessen with increased uptake and experience amongst surgeons.

Robotic assistance for right hemicolectomy can be used for both malignant and benign conditions, and indications are similar to a laparoscopic approach. There are no absolute contraindications apart from inability of the patient to tolerate pneumoperitoneum or previous multiple laparotomies with extensive adhesions.

Room Setup and Positioning

Robotic assistance is a major undertaking and the surgeon should ensure that his team – anesthesiologist, surgical assistant, experienced scrub nurse, and circulating staff – are well versed with the technique and requirements. Most important is an experienced robotic nurse or technician who has an excellent working knowledge of the robot and troubleshoot issues. A standard set of open instrumentation should be quickly available in the operating room should the need arises.

The daVinci robot consists of four arms, a surgeon console and a monitor stack. A large operating room is essential to fit these three large apparatus. The operating room team activates the console and primes and calibrates the robot before sterile draping of the robotic arms. This is undertaken well before the patient is brought to the operating room. For robotic right hemicolectomy, the most basic setup is to use only three out of the four arms: a camera arm and the first and second arm for retraction and dissection. A fourth arm can also be used for additional retraction; however, as the field of surgery is limited, there might be external arm collisions.

The patient is placed routinely in a supine position for robotic right hemicolectomy. Lithotomy can also be used alternatively. Robotic colorectal surgery requires precise positioning of the patient similar to laparoscopic surgery. A meticulous ritual is undertaken to secure all patients by the operating surgeon and the assistant. Acute vertical tilts and prolonged operating times can lead to complications such as postoperative peripheral neuropathy, skin pressure necrosis, and rarely patient sliding off the operating table. Once the robot is docked, it can be cumbersome and time consuming to adjust the patient's position. Hence, time taken to secure and position the patient for surgery would prevent complications and reduce operative time. The following steps are taken to fasten the anesthetized patient safely. The patient is secured in a suction operated bean bag with arms tucked at the sides. The upper limbs are placed mid prone with the thumbs facing the ceiling. Both arms are well padded, with particular care taken for the bony prominences of the elbow and the wrist. Padded shoulder harnesses are placed to support the patient to prevent sliding in steep Trendelenburg position. Chest strapping is carried out with 4″ tape going across the chest thrice. A trial safety and stability check is carried out with supervised tilts on all cases after securing the patients and making the necessary adjustments before prepping the patient.

Port Placement and Extraction Sites

Routinely three robotic arms including the camera port for robotic right hemicolectomy are used. This is supplemented with one port for the assistant who is to the left of the patient. Correct port placement is paramount in minimally invasive surgery particularly robotic surgery as it prevents external arm collisions and reduces operative time. A 12 mm port for the robotic camera is placed at the umbilicus. The 12 mm camera port is placed slightly lateral to the umbilicus or in the left flank if the patient is petite and is of small stature to increase the distance of the camera to the target structures, specifically the ileocolic vascular pedicle.

To avoid external arm collisions, the port sites can be tailored according to the size and shape of the abdomen (see port configuration in Fig. 9.1). The first arm port (R1) can be placed anywhere from the left lower quadrant (LLQ) to the suprapubic region; similarly the second arm port (R2) can be placed from the left upper quadrant (LUQ) to the epigastric region. The two 8 mm working ports are placed at least 8–10 cm apart from the camera port. A 5 mm port (L1) is then inserted under vision in the left lower quadrant between the camera and the second arm. This port should be placed at least 5 cm from all other ports. This serves as an extra port for the assistant to retract, to use a suction device, or to use an energy device for ligation of the ileocolic vessels. If a smaller patient's body habitus does not allow this port configuration alternatively, the second arm port can be placed in the left lower quadrant and the

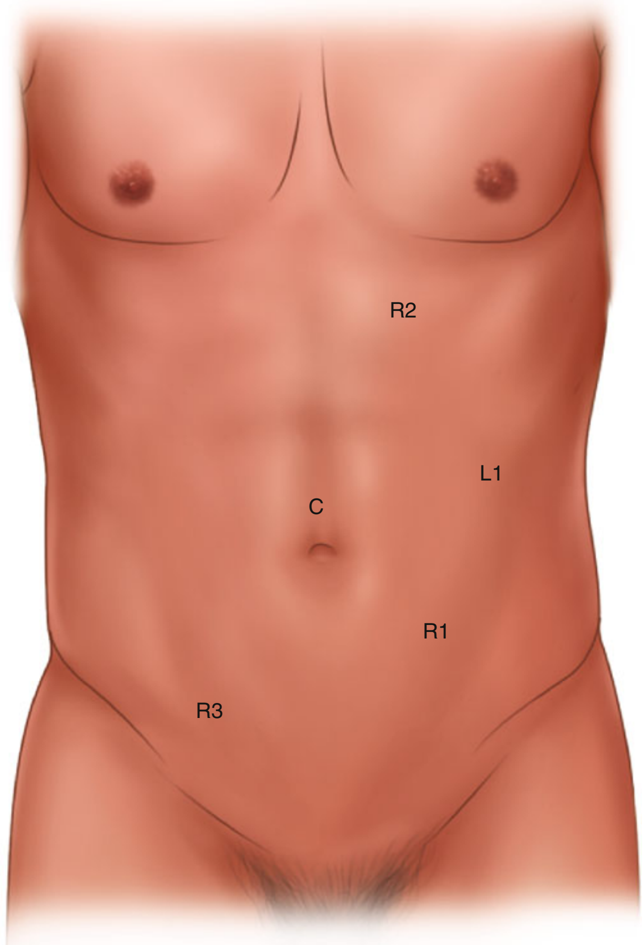

Fig. 9.1 Port configuration. *C* 12 mm camera port, *L1* optional 5 mm assistant port, *R1* and *R2* 8 mm working ports for arm 1 and 2, *R3* optional 8 mm working port for arm 3

5 mm assistant port in the left flank in line with the camera port. As the camera with the robotic arm is typically aiming in a more perpendicular angle to the abdominal wall, instrument collision does not occur with the assistant's instrument.

An additional 8 mm port (R3) can be placed in the right lower quadrant (RLQ). This would enable docking of the third robotic arm to use an additional fenestrated grasper for retraction. Typically, a 30-degree camera, robotic hook cautery, or endoshears on the left robotic arm (R1) and a bipolar fenestrated grasper on the right robotic arm (R2) are employed.

Extracorporeal anastomosis is most commonly performed and therefore the extraction site is typically above the umbilicus by extending the 12 mm camera port superiorly. If the 12 mm camera port is located left lateral to the umbilicus, this can also be enlarged to a transverse incision for extraction.

Table 9.1 Operative steps

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

Operative Steps (Table 9.1)

The steps of a robotic right hemicolectomy are similar to the laparoscopic approach. Depending on the availability of robotic equipment, a various degree of steps are preformed robotically and some laparoscopically, hence resulting in a hybrid procedure. A total robotic approach includes robotic ligation of vascular pedicles, bowel transection, and intracorporeal anastomosis, which will be described in more detail in a separate chapter.

Exploratory Laparoscopy and Docking

Pneumoperitoneum is established through the Veress needle in the LUQ or above the umbilicus and subsequent direct insertion of the 12 mm port or using Optiview technique in the periumbilical location. The 12 mm port can be placed also through the Hasson technique. It is important to use a bariatric length trocar to allow enough space for attaching the robotic arm. The two 8 mm robotic ports and the 5 mm assistant ports are inserted under direct vision. Diagnostic laparoscopy is performed. Following port placements, the patient is placed in the Trendelenburg position (15–20°) with a left tilt; sometimes no Trendelenburg is helpful if small bowel loops can be left in the pelvis. The terminal ileum and the ascending colon are exposed; the remainder of the small bowel is placed towards the left upper quadrant of the abdomen or the pelvis.

The robot is typically docked from the right side of the patient. The robotic field of dissection is typically less than 180° wide. Therefore, small bowel loops may have to be lysed if adhesed to the pelvis first laparoscopically. Similarly, if dissection needs to be extended towards the mid transverse

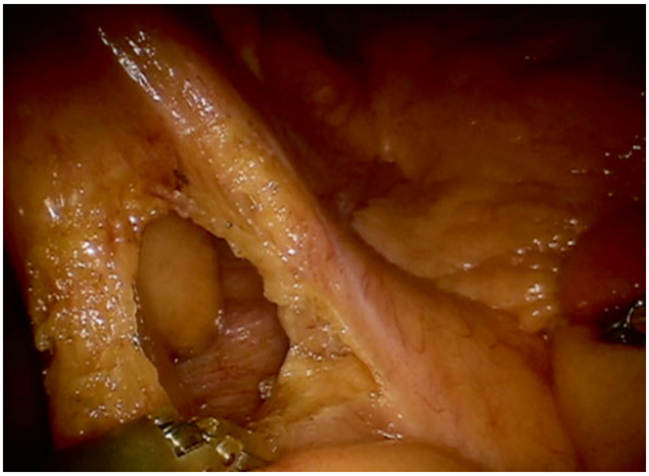

Fig. 9.2 Isolation of ileocolic pedicle

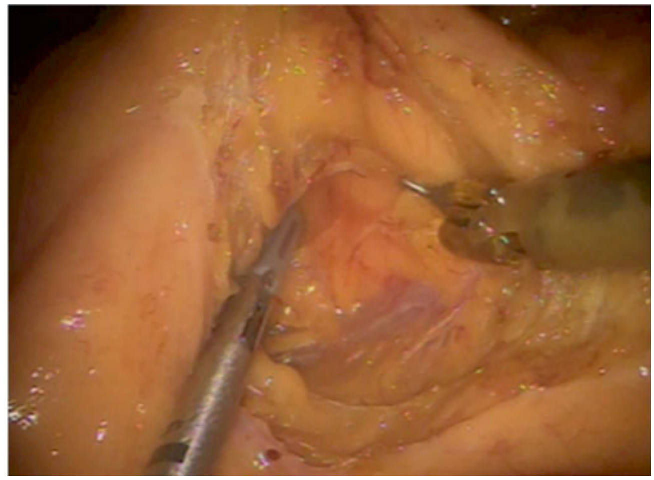

Fig. 9.3 Medial to lateral dissection

colon, the robot can be docked more from the right upper quadrant. The surgical assistant is on the left of the patient.

Identification and Ligation of the Ileocolic Vessels

The cecum is held and tented up through port R2 and the ileocolic pedicle dissected at the base and isolated through R1 (see Fig. 9.2). The assistant via the 5 mm port uses an energy device to transect the ileocolic pedicle at the origin (see Video 9.1). The other possibility is to use a robotic energy sealer, which is exchanged for the monopolar instrument in R1 (see Video 9.2). Alternatively, both artery and vein can be dissected out and ligated using hemoclips through R1. Extracorporeal vascular control of the ileocolic pedicle can be undertaken after the lateral to medial approach in benign cases.

Dissection of the Retroperitoneal Plane and Identification of the Duodenum

The dissection of the retroperitoneal structure is continued as far from medially as possible after identification of the duodenum (see Fig. 9.3). The assistant tents up the ascending colon mesentery through the laparoscopic port L1.

Mobilization of the Right Colon and Terminal Ileum

The cecum and the ascending colon are grasped both by the fenestrated grasper in R2 as well as the assistant, retracted medially and superiorly and the dissection started along the white line of Toldt in the right paracolic gutter (see Video 9.3). If a fenestrated grasper in R3 is used through the RLQ port, it can facilitate retraction, by either pushing the cecum or ascending colon medially or lifting the peritoneum lateral to the line of Toldt. The dissection is carried out in the avascular plane from the cecum to the hepatic flexure with continuous gentle traction medially. Care should be taken to identify and to stay anterior to the second part of the duodenum if not identified previously. Identifying the anterior aspect of the second part of duodenum in the lateral approach denotes sufficient mobilization of the right colon and the mesentery with the pedicle (see Fig. 9.4).

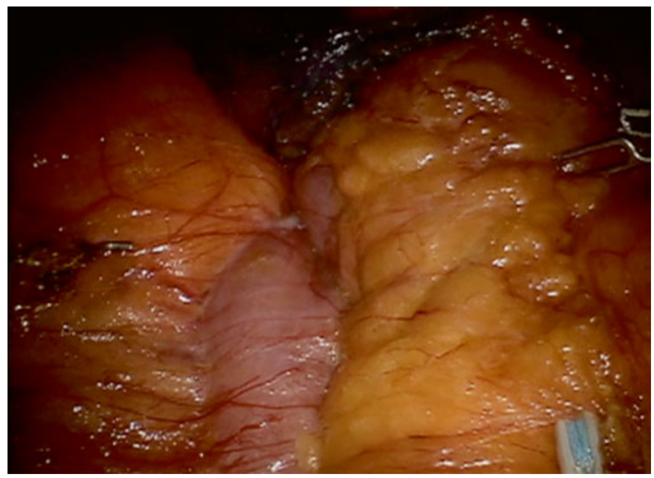

Fig. 9.4 Lateral to medial dissection

Mobilization of the Proximal Transverse Colon and Hepatic Flexure

Facilitation of this might need undocking the robot and changing the patient position to a reverse Trendelenburg

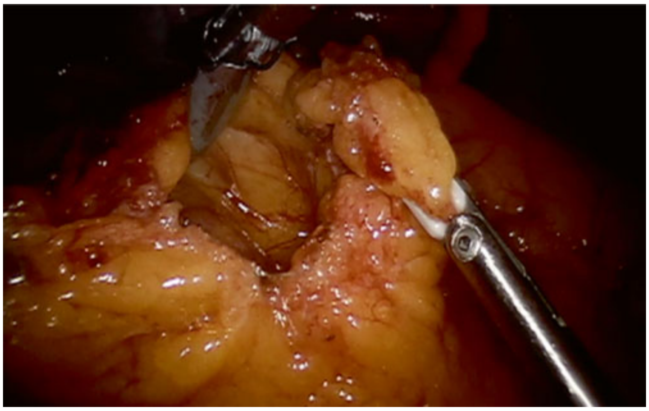

Fig. 9.5 Entry into lesser sac

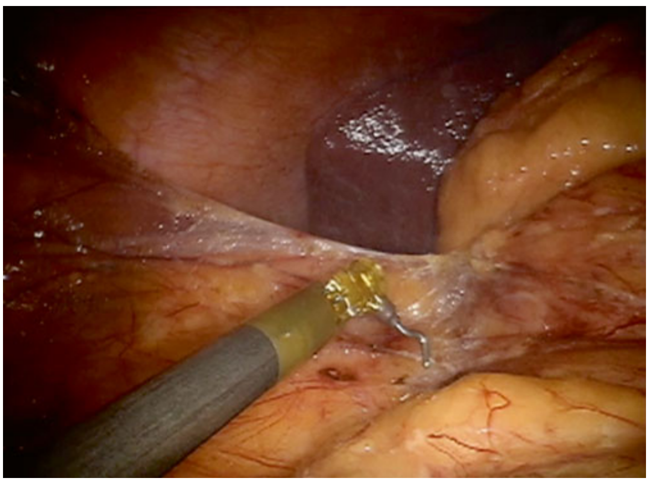

Fig. 9.6 Hepatic flexure mobilization

position with left tilt. Hook diathermy or endoshears are now used through R2 and a fenestrated grasper in R1. The gastrocolic omentum is taken down to enter the lesser sac (see Fig. 9.5 and Video 9.4). R1 retracts the transverse colon caudally while R2 dissects the omentum off the colon wall. The assistant helps with retracting the transverse colon while R3 (if used) can provide countertraction by retracting omentum or the gallbladder cephalad. The hepatocolic ligament is taken down similarly, and complete mobilization of proximal transverse colon and the hepatic flexure is accomplished. The hepatic flexure also can be taken down from the lateral to medial approach (see Fig. 9.6 and Video 9.5).

Identification and Ligation of the Middle Colic Vessels

The right branch of the middle colic vessels can be similarly ligated by either using the assistant's 5 mm port or using a robotic vessel sealer through R2. The approach is similar to the supramesocolic approach described in previous chapters.

Extracorporeal or Intracorporeal Anastomosis, Closure and Reinspection

Extracorporeal anastomosis is done routinely and hence this culminates the robotic dissection of the procedure. A robotic stapler or a hand-sewn intracorporeal anastomosis is possible and described as a more advanced technique in a separate chapter. The cecum is held by the 5 mm assistant's grasper to aid delivery into the midline wound. The robot is undocked and removed from the field. A small (4–5 cm) midline incision at the umbilicus is made, and a wound retractor is placed in the wound. Terminal ileum/right colon along with remainder of the pedicles is delivered through the wound. The right hemicolectomy is then completed with an extracorporeal anastomosis of the surgeon's choice. The reinsufflation and inspection of the abdomen is performed laparoscopically as described in a previous chapter if desired.

Approaches

Lateral to Medial Approach

The approach follows steps 1, 4, 3, 5, 2, 6, and 7. This is a commonly used for a robotic approach as it avoids the initial risk of potential significant bleeding of the ileocolic pedicle, which typically needs to be controlled by the assistant. The technique is therefore less dependent on a more experienced assistant. This approach is very similar to open surgery and it is easy to perform for surgeons who are new to robotic surgery.

Medial to Lateral Approach

This can be utilized similarly to the laparoscopic approach. The sequence of the surgical steps is 1–7 as described above. Due to the positioning of the robotic camera, the base of the ileocolic pedicle appears to be too close sometimes and the placement of the camera port needs to be adjusted. With the introduction of the robotic vessel sealer, the surgeon has similar control as in a laparoscopic approach.

Inferior to Superior Approach

This is an alternative technique as described in the previous chapter in patients with a short ileocolic pedicle or significant inflammatory changes. It may be limited for a robotic approach as it frequently needs steep Trendelenburg to incise the ileal peritoneum and change to a reverse Trendelenburg position later during the procedure would necessitate redocking.

Special Considerations and Complications

The Reoperative Abdomen

Previous abdominal surgery is not a contraindication for robotic surgery. Challenges are twofold, initial port placement and intraoperative adhesions. Either way the procedure can be challenging and can be longer. The Hasson technique or the optical port placement should be undertaken further away from the previous incisions. Port placement ideally at the Palmer's point in the LUQ is safe. Once through the peritoneum, a finger sweep is undertaken to bluntly push away the bowel to avoid injury. After CO_2 insufflation of the abdomen, laparoscopy is undertaken to assess the adhesions and if feasible robotic ports are placed in areas free of adhesions. If extensive adhesions are noted, proceeding to an open technique is the sensible option. Adhesions can also be taken down by the laparoscopic approach before docking the robot. If only right-sided adhesions are noted, these can be easily taken down with robotic dissection. Adhesiolysis should be meticulous and aim is to avoid enterotomies. The bowel should be inspected at the end for any potential thermal burns.

Morbid Obesity

The OR team should be well equipped for such patients with correct operating table, extra large instrumentation and ports, etc. For the surgeon, this group of patients constitutes a challenge at all levels. In the obese patient, patient positioning should be undertaken meticulously and bony prominences are well padded as these group of patients are prone for postoperative neuropathy probably due to nerve compression. Shoulder and strapping of the patient is undertaken to prevent slippage in extreme tilts. Before docking the robot, it is always prudent to do a trial run of tilting of the operating table with personnel around the patient before proceeding with the procedure. Extra long ports are mandatory. Higher CO_2 insufflation pressures might be needed to keep the abdomen inflated and this might be a concern to the anesthesiologist, and a direct dialogue during insufflation would reduce any complications associated with this. In the abdomen, thick mesentery and the large omentum can hinder good visualization and dissection; however, an experienced assistant can easily overcome it with additional retraction. Identifying and dissecting the bulky ileocolic pedicle can be challenging and can be dealt with by adequate traction and pedicle isolation in the correct anatomical plain with diathermy. In the initial few cases and rarely, the ileocolic pedicle may needed to be taken extracorporeally; however, this can be more challenging in obese patients and would lead to a larger incision.

Small Patient

Robotic assistance in a small patient can be a challenge with regard to port placements and arm collisions. The camera port can be placed in the left flank at the level of the umbilicus further away from the pedicle. Similarly the two 8 mm ports should also be well away from the initial port to reduce arm collisions. Once the robotic arm is fixed to the port, the assistant should make sure that there is free range of movements of the arms avoid collisions.

Locally Advanced Cancer

Robotic assistance can be very helpful in locally advanced cancer during right hemicolectomy. Preoperative planning with staging CT and discussion with the radiologist would prepare the surgeon for these complex procedures. If the tumor is big and extending posteriorly, a ureteric stent might help to identify the ureter easily during dissection. Lateral wall or anterior wall invasion can easily be dealt with robotic dissection. Limitations exist with a large tumor extending posteriorly and medially, and conversion to an open procedure may be the sound option.

Robotic Docking Complications

Complications during robotic assistance are very similar to any minimally invasive surgery. The surgeon should be well versed and practiced with nuances of the robot and the consoles in order to troubleshoot issues during surgery. A good operating room team with first-rate knowledge of the robotic mechanisms would help run the session smoothly. Arm collisions can happen with improper port placements, multiquadrant dissection, and in petite patients. A standardized technique of port placements tailored to individual patients depending on their body shape can overcome this complication. In right hemicolectomy, two arms along with camera port are usually used and most of the dissection takes place on the right side of the abdomen; hence, instrument clashing and arm collision are considerably less. In petite patients the port placements should be very far away as possible from the camera port as discussed.

Bleeding

Hook diathermy or the fenestrated bipolar forceps can easily deal with minimal oozing or bleeding. However, major bleeding from the pedicle can be a major issue. Prevention of this complication is paramount. Bipolar energy sealers have been used to obtain control of the vessels. It is good practice to isolate the vein and the artery before taking it down. If major bleeding occurs, the fenestrated grasper can be used to occlude the vessel. Alternatively, if the bleeding is not controllable, the robotic arms should be pulled away on an emergency basis and the abdomen opened to achieve hemostasis. The assistant should be trained to act immediately in an emergent situation to remove the robotic arms with ports and immediately set up for a laparotomy.

Enterotomy or Duodenal Injury

Iatrogenic injury can occur during introduction and instrument exchange through the ports, and care must be taken to visualize the entry and exit of instruments on the screen. Thermal injury can occur to the small bowel or the duodenum.

Small bowel injury – Most of the dissection is carried out via cautery. A traction injury or a thermal injury can occur and small thermal burns can easily be missed. All diathermy dissection should be performed only under direct vision. Small burns should be repaired with by intracorporeal suture, to prevent a perforation after a few days. A large enterotomy can be repaired with by intracorporeal suturing and in rare cases resection anastomosis after exteriorization of the bowel.

Duodenal injury – During mobilization of the right colon, duodenum is at risk of an injury as it is in close proximity. Blunt dissection and reasonable cautery usage can avoid thermal burns. During takedown of ileocolic pedicle at the base, care must be taken to avoid injury to the duodenum. Small superficial thermal burns can cause significant morbidity postoperatively and hence need to be repaired with by primary suture with robotic assistance. A large duodenal injury needs a conversion to a laparotomy to assess the nature and extent of damage before repairing the enterotomy. When the hepatic flexure is being taken down, care must be taken not to injure the duodenum, particularly in petite and normal BMI patients.

Summary

Robotic assistance for right hemicolectomy adds a new technique and tool in the hands of the twenty-first century colorectal surgeon. The technique described can be simple and akin to an open right hemicolectomy, which would help the novice robotic surgeon to directly start adaptation coming from the open approach. The robotic right hemicolectomy can be a teaching tool before embarking on complex pelvic surgeries. Current evidence suggests that this technique is safe and feasible and has comparable oncological outcomes. Principles and steps in this technique are similar to the open or the laparoscopic procedures and most importantly can be easily modified according to surgeon's experience, i.e., intracorporeal or extracorporeal anastomosis. Robotic setup can be complex; hence, experienced operating room staff is essential for the smooth running of the operating room.

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Right Hemicolectomy and Ileocecectomy: Single-Port Robotic Approach

10

Vincent Obias and Scott Sexton

Introduction

Single-incision robotic surgery is utilized in many procedures including but not limited to colectomies, prostatectomies, cholecystectomies, and hysterectomies. The greatest advantage of single-incision robotic surgery compared to laparoscopic is ergonomic superiority and return of triangulation via the cross-arm technique on the da Vinci robot, enhanced three-dimensional acuity, camera stability, and better assistant positioning. Disadvantages such as increased operative and docking time and cost of robot utilization may be offset by more experience and decreased length of stay, respectively. Further studies with larger sample size and cost-benefit analysis will help guide the future of robotic surgery.

Background

Dr. Philip Turner first documented a case of double inguinal hernia in which both sacs were removed through a single transverse suprapubic incision over 90 years ago. Since then there continues to be advancements in the spectrum of single-site techniques [1]. Single-incision surgery has been performed and documented in nearly all surgical domains, including but not limited to colectomies, cholecystectomies, adrenalectomies, splenectomies, appendectomies, lobectomies, herniorrhaphies, hepatectomies, hysterectomies, and oophorectomies. To date, there have been over 1,100 citations in the literature regarding single-incision laparoscopic surgery alone – with single-incision cholecystectomy and single-incision colectomy as the most cited (>250 and >115 citations, respectively) [2].

Prior to trocar placement – whether single or multiport – vascular injury, bowel injury, and incisional hernia must be considered. In general, laparoscopic surgery complications occur in 0.1–10 % of procedures. Nearly 50 % of trocar-related injuries to bowel and vessels occur in the initial entry and are not diagnosed at the time of injury in 30–50 % and 15–50 %, respectively. Literature suggests that the most common complications are bowel and vascular injuries while incisional hernias are rare, with a reported incidence of <1 % [3]. Most reports of incisional hernias have been made with port sites >10 mm; however, hernias with 5 mm trocar placement, although rare, have been noted by several authors [4–10]. Thus, 5 mm ports are not truly "free" and single-port/incision surgery may reduce some of these trocar complications.

Single-incision laparoscopy has several advantages to its multi-incision counterpart as a result of reduced intraperitoneal access via a single laparoscopic port. In addition to fewer incisions and cosmetic benefits, advantages include minimal abdominal wall trauma, decreased postoperative pain and incisional hernia formation, reduction in morbidity, and potentially less narcotic use contributing to shorter duration of postoperative ileus and decreased length of hospital stay [11–14].

Comparisons between single-incision and conventional laparoscopic procedures have been extensively reviewed, with reports of the first laparoscopic colectomy case dating back to 1991 [11]. In one case-controlled study of segmental colectomies, it was found that operative times were longer for single-incision versus multi-incision laparoscopic colectomy (134 vs 104 min, $P=0.0002$), while morbidity and length of hospital stay remained similar. In addition, 4 of 29 cases were converted to multiport while 1 of 29 cases was converted to open. The study concluded that while single-incision laparoscopic colectomies are feasible and

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_10. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_10, © Springer Science+Business Media New York 2015

safe, procedures tend to take longer [15]. A similar study case matched for age, gender, BMI, ASA score, previous abdominal surgery, and splenic flexure mobilization concluded that operative time, conversions, estimated blood loss, and readmission rates were the same when comparing single-incision versus multiport laparoscopic sigmoid colectomies. The authors also noted that length of stay (3.7 vs 5.0 days, $p < 0.05$) and visual analog pain score on postoperative days 1 and 2 for single-incision procedures were significantly less [16]. Another study by Wolthuis et al. comparing single-port colectomies to the conventional laparoscopic approach reports similar median operative times, estimated blood loss, pain scores, analgesic requirements, inflammatory response, and length of hospital stay [17]. Nonetheless, review of the literature suggests that single-incision laparoscopic colectomies can be performed safely and successfully [18, 19]. Additional studies validate single-incision hemicolectomy as an oncologically feasible and safe procedure with suitable mesocolic excision [20, 21].

In an early multi-institutional study with single-incision laparoscopic colectomies, it was found that surgeons felt the following areas to be more difficult with single-incision laparoscopic surgery: exposure to clinical structures, ease of instrumentation, ease of camera operation, flexure mobilization, surgical ergonomics, and instrumentation conflict. The study also exhibited a 12.8 % conversion rate and associated 7.7 % complication rate in 39 single-incision laparoscopic colectomies performed [22].

While single-incision laparoscopy offers numerous advantages, the procedure also presents several disadvantages. Single-incision laparoscopy, in itself, is technically challenging: instruments crossing, poor positioning with assistant, poor ergonomics, camera instability, and two-dimensional view. The visual axis is often altered as it becomes more axial. There have also been varying reports of length of operative time in the literature with the majority suggesting an increase. Length of hospital stay also varies with literature review though consensus tends to be decreased length. Could robotic surgery offset these technical challenges?

With the advent of robotic surgery, multiple arms may be operated remotely from a stable three-dimensional video-assisted visualization console, which may notably minimize many of the aforementioned disadvantages. The greatest advantage of robotic procedures may be the elimination of instrument conflict with ergonomic superiority. The da Vinci system utilizes a cross-arm technique in which the system's right and left controls are reversed and the extracorporeal robotic arms are crossed. With this method, the surgeon is no longer required to mentally reverse the function of his/her right and left hands [23]. The robot's wristed instruments enable emulation of wrist action leading to greater range of motion and ability to operate in tighter spaces in a single-port setting. The robot's additional degrees of articulation and cross-arm technique also deliver a triangulated field for dissection. This technique takes the conundrum of assistant positioning out of the equation as the assistant is situated between the arms of the robot and becomes an integral component to the procedure itself.

Currently, single-incision robotic surgeries include but are not limited to colectomies, prostatectomies, cholecystectomies, and hysterectomies [24]. One of the first reports of robotic-assisted single-incision right colectomy included three patients utilizing a 4 cm incision with three ports (12 mm, 8 mm, 8 mm) in a medial to lateral approach with extracorporeal resection and anastomosis. It was found that operative time was 152 min with a 33 % conversion rate due to air leak [24]. Lim et al., on the other hand, reviewed 22 cases of robotic single-incision anterior resection for sigmoid colon cancer and reported that it is a safe and viable option for patients. Lim et al. continued to state an estimated blood loss of 24.5 mL mean operating time of 167.5 min, median skin incision size of 4.7 cm, and mean lymph node harvest of 16.8 [25].

In a similar robotic single-port experience at George Washington University (GWU), 11 patients with unresectable polyps and colon cancer requiring right hemicolectomies were observed. Initial results indicated no conversions to open, three conversions to laparoscopy, and three cases of postoperative complications (ileus, wound infection, and anastomotic bleed). In contrast, a similar population of ten patients who underwent laparoscopic right hemicolectomy and ileocectomy resulted in one conversion to open due to adhesions and one postoperative complication (postoperative bleed). In comparing robotic versus laparoscopic procedures, it was found that there were no differences in operative time, estimated blood loss, length of hospital stay, lymph node harvest, and complications; however, there was one conversion from laparoscopic to open with the conventional laparoscopic method.

Nonetheless, robotic single-port surgery does have its disadvantages. While increased operative and docking time may be unattractive to some, with greater surgeon and ancillary team experience, both operative and docking time seem to be comparable to that of non-robotic single-port surgery. Loss of tactile sensation through the robotic arms may be compensated for as the surgeon gains experience with the controls and may be negated by the enhanced three-dimensional visual acuity and camera stability of the robot. Cost of robot utilization must be considered prior to robotic approach initiation and may be offset with procedures that may be more difficult and/or require longer operation time. Decreased length of hospital stay may, in fact, offset the cost of robot utilization and ultimately benefit the patient. Further studies with larger sample size and cost-benefit analysis will help guide the future of robotic surgery and provide more insight into the technicalities of the procedures performed.

Room Setup and Positioning

The patient is placed in the supine position on the operating table on a beanbag. Following induction of general anesthesia and insertion of an oral gastric tube and Foley catheter, both legs are placed in yellow fin stirrups. Both arms are then tucked at the patient's side and then the beanbag is aspirated. If obese patients will not fit on the OR table, the left arm is left out from the side. The abdomen is then prepared with antiseptic solution and draped routinely.

The primary monitor is placed on the right side of the patient at the level of the shoulder. The secondary monitor is placed on the left side of the patient at the same level, which is primarily for the assistant or observers. The assistant is on the left side of the patient. The operating nurse's instrument table is placed to the right of the patient's legs. A 30° upward facing camera lens is preferred.

Port Placement and Extraction Sites

The single-port device is typically placed in the midline and periumbilical location, which also serves as the extraction site. Only two robotic arms are used in addition to the camera port. The robotic arms #1 and #2 are crossed at the fascia and a 30° up scope goes below the two arms (Fig. 10.1). A 5 mm assistant port can be used through the GelPOINT. The robotic arms are then switched on the console manually so the surgeon controls what he or she views as the correct instrument internally.

Operative Steps (Table 10.1)

Single-port Insertion and Exploratory Laparoscopy

A 4 cm vertical incision is made through the umbilicus. The incision is deepened down to the linea alba, which is then grasped on each side of the midline using Kocher clamps. Cautery is then used to open the fascia between the Kocher clamps and a Kelly forceps is used to bluntly open the peritoneum.

Upon confirming entry into the peritoneal cavity, the SILS® Port (Covidien, Mansfield, MA, USA), GelPOINT® Advanced Access Platform (Applied Medical, Rancho Santa Margarita, CA, USA), or even a sterile glove over a small alexis wound retractor is inserted. One 12 mm port and three 5 mm laparoscopic ports are inserted into the single port; two of the 5 mm ports will be removed at the time of the switch to the robotic ports.

The assistant now moves to the patient's left side and stands caudad to the surgeon. The patient is then rotated with the right-side up and left-side down, to approximately 15–20° tilt, and often as far as the table can go. This positioning helps to move the small bowel over to the left side of the abdomen. The patient is placed into mild Trendelenburg position. This positioning facilitates gravitational migration of the omentum and transverse colon away from the operative field. The surgeon then inserts two atraumatic bowel clamps. The greater omentum is reflected over the transverse colon so that it rests on the stomach. If there is no space in the upper part of the abdomen, it must be confirmed that the orogastric tube is adequately decompressing

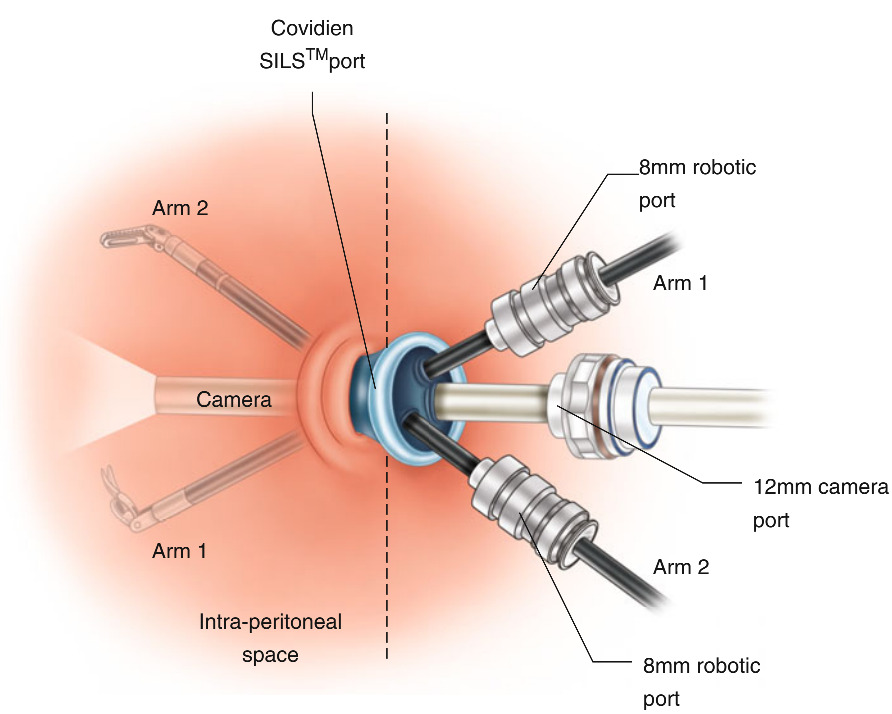

Fig. 10.1 Robotic arm crossing

Table 10.1 Operative steps

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

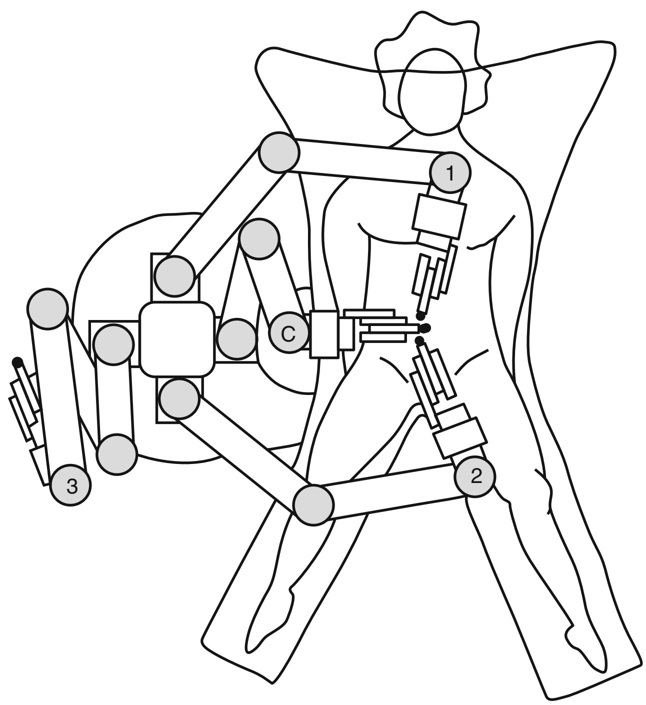

Fig. 10.2 Robotic single-port docking (**C**) camera, (**1**) robotic arm 1 (R1), (**2**) robotic arm 2 (R2)

Fig. 10.3 Robotic port and arm positioning

the stomach of gas. The small bowel is then moved to the left side of the patient with some remaining in the upper abdomen and pelvis, allowing visualization of the ileocolic pedicle.

Single-Port Docking

The robot approaches from the right side of the patient at a perpendicular angle (Box 10.1). Two 8.5 mm robotic ports are placed through the GelPOINT® for the two robotic arms #1 and #2 (R1 and R2). R1 and R2 are crossed at the level of fascia (see Figs. 10.2 and 10.3). The left arm of the robot crosses and becomes the right instrument inside and vice versa. A 30° scope in the up position is placed below the two arms. One 5 mm port remains, which is to be used by the assistant. Robotic arms #1 and #2 are switched manually on the robotic console such that the surgeon controls what he or she views as the correct instrument internally.

Box 10.1. Tip

When having collisions with the robotic arms or if there is an inability to reach certain areas, try switching up the arms so that the lower arm is now the upper arm. This may facilitate or reduce collisions.

Identification and Ligation of the Ileocolic Vessels

A robotic non-crushing bowel clamp through R1 is placed on the mesentery at the ileocecal junction (Box 10.2). This area

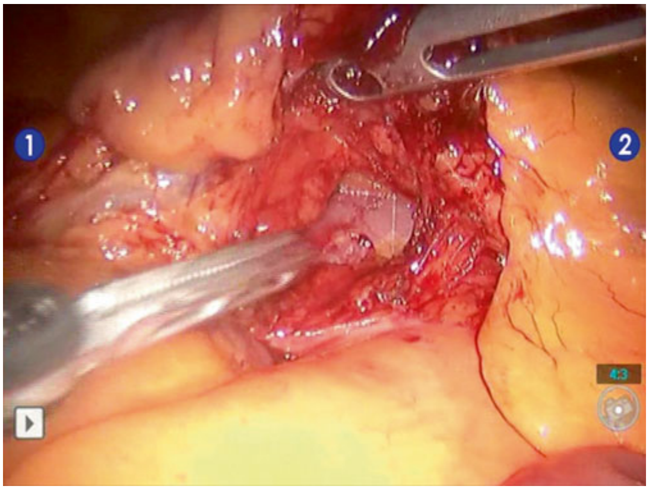

Fig. 10.4 Ileocolic transection

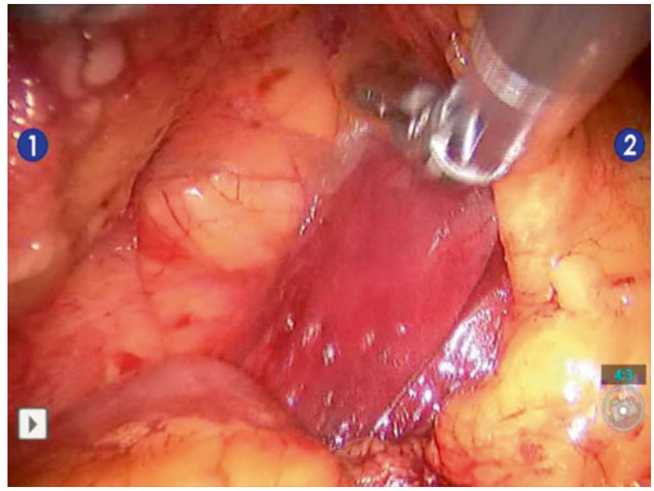

Fig. 10.5 Medial to lateral mobilization

is then stretched up towards the right lower quadrant port, stretching the vessel and lifting it up from the retroperitoneum. A sulcus between the medial side of the ileocolic pedicle and the retroperitoneum is demonstrated in nearly all cases. Monopolar cautery through a hook or scissors is then used through R2 to open the peritoneum along this line. Blunt dissection is used to lift the vessel away from the retroperitoneum, opening the plane cranially up to the origin of the ileocolic artery from the superior mesenteric artery (see Fig. 10.4). Monopolar cautery is then again used to open a window in the peritoneum lateral to the vessel. Care is taken to ensure that the plane of dissection is anterior to the congenital layer of peritoneum lying over the retroperitoneum, duodenum, and ureter. As long as this layer is preserved and the dissection is anterior to the duodenum, the ureter on the right does not need to be displayed routinely. The vessel is then divided and the origin of the vessel is clamped as a precaution if the clips or other energy source do not adequately control the vessel (see Video 10.1). Clips or energy sources may be used to divide the vessel with the assistant or can be done by the surgeon if the robotic cut-seal is unavailable. Staplers can also be used but require a 12 mm assistant port.

Box 10.2. Tip
One limitation while dissecting may be the camera preventing arms #1 and 2 from dissecting or grasping a certain area. It may be helpful to move the camera away from the area in question and dissect or grasp this area in the peripheral portion of the surgeon's view.

Dissection of the Retroperitoneal Plane

Having divided the vessel, the plane between the ascending colon mesentery and the retroperitoneum is developed laterally out to the lateral attachment of the colon, and superiorly, dissecting the bowel off the anterior surface of the duodenum and pancreas and often dissecting up to the liver (see Fig. 10.5 and Video 10.2) (Box 10.3).

Box 10.3. Tip
When performing the medial to lateral mobilization of the ascending colon mesentery, draw the mesentery medially and anteriorly to stretch out the areolar attachments to facilitate and accelerate your dissection.

Mobilization of the Proximal Transverse Colon and Hepatic Flexure

The assistant now grasps the ascending colon with the atraumatic bowel clamp and draws it inferiorly. The surgeon grasps the proximal transverse colon with a robotic atraumatic bowel clamp in his left hand through R1 and exerts traction on the ascending colon medially and inferiorly. This maneuver puts the hepatic flexure under tension and permits division of the gastrocolic ligament using scissors and cautery in the surgeon's right hand through R2. The surgeon continues to progress along this mobilization plane to drew the hepatic flexure inferiorly and medially (see Video 10.3). Care must be taken to avoid injury to the gallbladder and second part of the duodenum that is encountered as the hepatic flexure is mobilized. The line of traction as the gastrocolic ligament is divided changes to provide elevation of the transverse colon by the assistant and medial rotation of the proximal colon by the surgeon. The assistant helps with retraction, suction, or dissection with an energy source.

As this dissection continues, the area of prior retroperitoneal dissection after division of the ileocolic pedicle is visualized. Once this area has been entered, the only remaining attachment is the lateral peritoneal attachment along the ascending colon. This area, the white line of Toldt, is divided using cautery. This line is divided right down to the base of the cecum, and it is possible to completely mobilize the appendix and base of the cecum to the midline from this direction. The colon is then completely dissected free from the underlying duodenum and retroperitoneum and reflected entirely to the midline. The hepatic flexure mobilization using the superior to inferior approach is now completed.

Identification and Ligation of the Middle Colic Vessels

After the hepatic flexure has been mobilized, attention is turned to the transverse colon mesentery (Box 10.4). The right branches of the middle colic vessels are defined and can be divided with clips or an energy source of choice. This enables complete removal of the specimen at the conclusion of the case with easy reach of colon for an adequate resection and easy anastomosis.

Box 10.4. Tip
It is often easier to leave division of the right branch of the middle colic artery until after full mobilization of the hepatic flexure, especially in more obese individuals.

Mobilization of the Right Colon and Terminal Ileum

The majority of the ascending colon mobilization will already be accomplished from a superior approach. The small bowel is reflected superiorly and the base of the attachment between the small bowel and terminal ileal mesentery and retroperitoneum is then visualized. The mesentery of the terminal ileum is then raised to expose the junction of the visceral peritoneum and the retroperitoneum. Scissors and cautery are used to dissect the terminal ileum off the retroperitoneal structures. Usually there is only a thin layer of peritoneum that remains that needs division. This line of dissection extends from the ileocecal junction towards the origin of the superior mesenteric artery. Though the beginning of this dissection began with cautery, the more proximal aspect of the mobilization should be performed with scissors alone. This serves to avoid injury to the third part of the duodenum, which appears near the end of the dissection (see Fig. 10.6 and Video 10.4). The plane between the retroperitoneum and the terminal ileum is developed and the terminal ileum reflected medially and cephalad. The iliac vessels, right ureter, and gonadal vessels all remain under the parietal peritoneum. It is essential that the medial dissection be completed to the level of the duodenum in order to enable eventual delivery of the complete specimen at the end of the case. All of this dissection is performed with the atraumatic bowel clamp in the surgeon's right hand through R2 and the scissors/or vessel sealer in the left through R1. The assistant may use the atraumatic bowel clamp to help raise the terminal ileum as it is reflected superiorly.

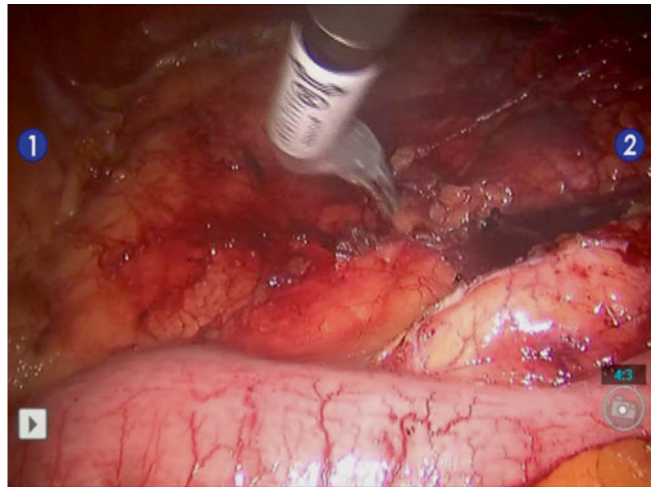

Fig. 10.6 Lateral mobilization

Extracorporeal Anastomosis

Prior to extracting the specimen, the surgeon should grasp the right colon and draw it to the left side and make sure that it is now mobilized to be entirely a midline structure (Box 10.5). In some cases, there are remnant areolar attachments that may be divided. It is essential that the root of the ileal mesentery is as mobile as possible to permit easy retraction of the small bowel through the midline incision. A final check on complete mobility of the entire specimen, including the transverse colon, and hemostasis is made before extracting the specimen.

Box 10.5. Tip
Mobilizing the greater omentum and transverse colon to or beyond the midline facilitates specimen extraction, particularly in more obese individuals.

The appendix or cecum is grasped firmly with a locking grasper through the assistant port. After the pneumoperitoneum is deflated through the ports, the port site is extended into a 4–5 cm midline incision. This may be made larger if necessary to remove larger phlegmons or tumors. The GelPOINT® has a built in wound protector for cases associated with cancer.

The right colon is then exteriorized. The distal small bowel is assessed and the small bowel mesentery divided extracorporally using 0 polygylcolate ties for hemostasis. In cases of a bulky ileal mesentery, then suture ligation of the mesentery may be used. For obese cases, the small bowel is divided with a GIA 75 stapler and its associated mesentery and an Allis clamp placed on the proximal end of the small bowel so that it is not lost back into the abdomen. The right colon is then pulled through. This keeps the extraction site somewhat smaller. For less obese cases, the complete specimen is extracted, and mesentery prepared, but division of the intestine left until the last moment to minimize the risk of twisting.

Attention is now turned to the area for division of the colon. The colonic mesentery is divided with an energy device or between clamps. Pulsatile mesenteric bleeding is confirmed and the vessel is ligated with 0 polygylcolate ties. After the colon is divided with the GIA 75 the specimen is now removed from the field and examined to confirm the pathological findings and the adequacy of proximal and distal margins. A side-to-side anastomosis is fashioned with a GIA 75 stapler, buttressing the crotch of the anastomosis with an interrupted 3/0 polygylcolate suture. The resulting opening from the GIA 75 stapler insertion site is then closed with a TA 60 stapler. The anastomosis is checked for hemostasis and returned to the abdomen. Injection of indocyanine green and use of the robotic Firefly system can also be done at this point to ensure proper perfusion of the anastomosis. The mesenteric window is not closed.

Summary

Single-incision colon resections have garnered great interest, but attempts at doing it laparoscopically are difficult and have not been universally adopted. Robotics can offset the difficulty of laparoscopic single-incision colectomy by returning triangulation, assistant help, and adding advanced technology such as 3D visualization, Firefly, vessel sealing, and stapling. Future technology from other robotic companies and new models such as the SP robot from Intuitive will lead the way in single-incision surgery.

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Right Hemicolectomy and Ileocecectomy: Robotic Intracorporeal Anastomosis

11

Stephen M. Rauh, Margaret De Guzman, and Steven J. Ognibene

Introduction

Right colectomy may be most beneficial when utilizing an intracorporeal anastomosis. The advantages of minimally invasive surgery for neoplastic and nonneoplastic disease are well established. Unfortunately, some benefits are lessened when extracorporeal reconstruction is performed. The use of an incision to accommodate any extracorporeal technique is associated with increased risks of such undesirable outcomes: hernia, superficial wound infection, pain, and suboptimal cosmesis. Also, there are added technical difficulties when performing extracorporeal anastomosis in the obese. The techniques elucidated in this chapter address such issues by utilizing the robotic platform to perform intracorporeal ileocolostomy.

Background

Minimally invasive surgery has been commonly performed for decades. Laparoscopic surgery, in particular, has been shown to have many benefits, including shorter hospital stay, less postoperative pain, earlier return to bowel function, and earlier return to work than with open surgeries. Short-term outcomes in patients undergoing colorectal cancer resections have shown no differences between laparoscopic and open approaches [1–3]. These successes have led to greater technical advances in laparoscopic surgery and the ability to perform more complicated surgeries. Despite these advantages, laparoscopic colectomies have still not become the gold standard and are not commonly performed compared with open colectomies [4]. Some explanations for this include limited exposure in residency, longer learning curve, and more extensive training.

To overcome this, robotic surgery, specifically right hemicolectomy, has been proposed as a way to allow more patients to undergo minimally invasive colorectal procedures [5–9]. Right colon resections, in particular, are relatively straightforward and can serve as a training tool for novice surgeons [10, 11]. Although a recent survey of colorectal surgeons found that laparoscopic right hemicolectomy with intracorporeal anastomosis is one of the most difficult procedures to perform laparoscopically [12], use of the robot may simplify this technique [13, 14]. In a recent systematic review comparing laparoscopic right colectomies, intracorporeal and extracorporeal anastomoses were found to have similar outcomes in terms of anastomotic leaks, overall postoperative morbidity, and 30-day postoperative mortality [15]. In robotic right colectomies, intracorporeal anastomosis can be advantageous in that it involves smaller abdominal incisions for specimen extraction, decreased trauma due to stretching of bowels and mesentery when externalized, and possibly better cosmesis, reduction of pain, and decreased incidence of hernias [16]. Robotic right colon resection with intracorporeal ileocolic anastomosis in patients with cancer has been shown to be feasible and safe for patients in terms of intraoperative oncological outcomes, including robot time, overall operative time, hospital stay, return of bowel function, intraoperative complications, conversion to laparoscopic or open, number of harvested lymph nodes, quality of mesocolic excision, and 30-day mortality and morbidity [17, 18]. With regard to technical steps, accurate node dissection, suturing for intracorporeal anastomosis, and natural orifice specimen extraction have been shown to be safe and feasible for robotic right colectomies as well [19].

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_11. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_11, © Springer Science+Business Media New York 2015

Room Setup and Patient Positioning

A dedicated operating room team is essential. The split leg table is used, enabling an assistant another option accessing low abdominal ports. The robotic patient cart is placed to the patient's right midflank. This provides access to the terminal ileum and midtransverse if colon for most clinical presentations. If it is known that more extensive pelvic dissection or extended transverse colectomy is required prior to docking, the position of the cart is biased to the right lower or upper quadrant or even cephalad "over the shoulder." Modest Trendelenburg, left decubitus table orientation is preferred most often; this is confirmed or adjusted laparoscopically as the final step of pre-docking preparation.

Port Placement and Extraction Sites

The camera port is placed in the left midclavicular line (see port configuration in Fig. 11.1). The degree of laterality for the camera port is proportional to the intracorporeal domain achieved with CO_2 insufflation. Thus, low BMI patients typically have camera port placement lateral to the epigastric vessels, keeping visualization of the progressively mobilized right colon possible. A guide for camera placement is based on the location of the umbilicus relative to the xyphoid and pubis. The camera is placed in the quadrant with the longest vertical dimension. When the patient has a "high" umbilicus, the lower quadrant is used; if the patient has a "low" umbilicus, the camera trocar is best in the upper quadrant.

The right-hand port site R2 is anywhere along a line drawn transversely from midcostal margins bilaterally as far cephalad from the camera as practical, noting the costal margin.

A suprapubic midline 15-mm port is always used. This is an extremely versatile step for all robotic colectomies as this is the ideal extraction site. And the 15-mm trocar can be used as an assistant site: an 8-mm robotic port R1 is telescoped into the 15-mm port for the left arm. This reduces the number of incisions by one. This extra-large port accommodates the stapler and later serves to deliver the extra-large specimen bag.

Alternatively, most useful prior to gaining proficiency in robotic right colectomy, the left arm R1 is needed elsewhere. A right lower quadrant 8-mm da Vinci trocar is possible. This location is least useful for dissection in the pelvis. The option of a left-hand port R1 in the left lower quadrant (as lateral as feasible) facilitates pelvic dissection such as for mobilization of tethered or deep terminal ileum.

The 5-mm assistant port L1, also essential, is left sided, as lateral as feasible to accommodate instrument insertions without interference from the unseen intestine. This 5-mm trocar can be in the upper or lower quadrant based on the location with the most space between camera and robotic arm.

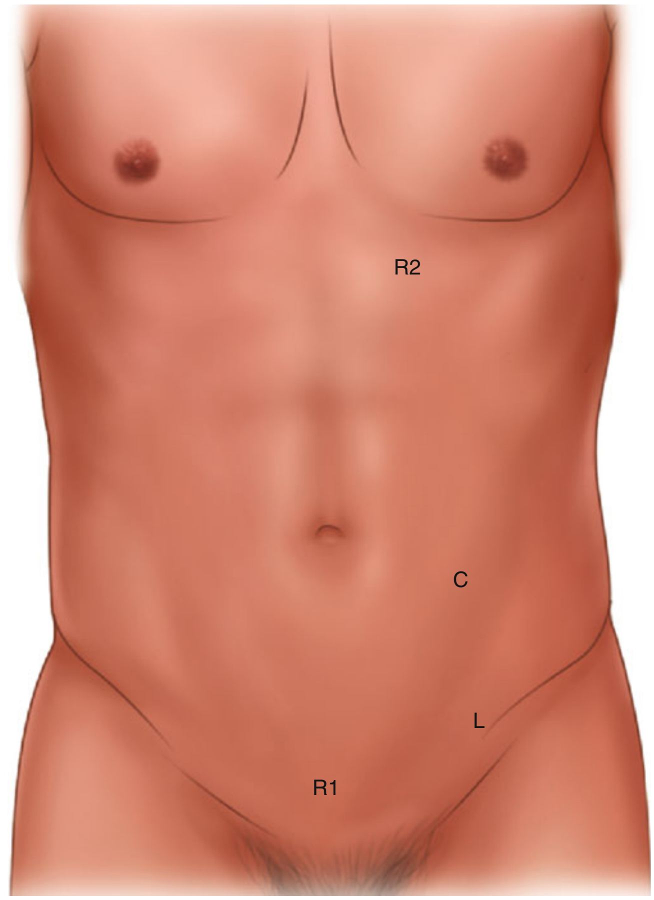

Fig. 11.1 Port configuration. *C*: camera port. R1 and R2 working ports for arm 1 and 2. *L*: assistant port

Intracorporeal anastomosis has the benefit of giving the surgeon the choice to move the extraction site off midline by a small Pfannenstiel incision or enlarging one of the lateral port sites.

Operative Steps (Table 11.1)

It is imperative to mobilize sufficient ileum and colon *more than* that required for a tension-free anastomosis. There must be sufficient proximal and distal length to freely align the ileal and colonic segments as intracorporeal reconstruction must be very efficient regarding the need to retract and stabilize the limbs to be joined by stapling, suture, or both.

The following steps are the same as for extracorporeal anastomosis as described in the previous chapter:

1. Exploratory laparoscopy
2. Identification and ligation of the ileocolic vessels
3. Dissection of the retroperitoneal plane
4. Mobilization of the right colon

Table 11.1 Operative steps

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

5. Mobilization of the proximal transverse colon and hepatic flexure
6. Identification and ligation of the middle colic vessels

Division of the Ileal Mesentery and Transverse Mesocolon

The ileal and colonic mesentery is divided completely intracorporeally. The specimen is then placed over the liver or in the pelvis. Later it will be placed in a specimen bag to be delivered through the suprapubic 15-mm fascial defect or a lateral extraction site, which has been enlarged to 3 cm or as needed.

Intracorporeal Anastomosis

Most surgeons prefer utilizing the ever-evolving stapling instruments for minimally invasive intracorporeal anastomoses. Three stapler-based options are now presented serving the majority of ileocolic intracorporeal robotic reconstructions. The three options include two isoperistaltic referred to here as the “I” and “M” anastomoses and an antiperistaltic approach “V” anastomosis.

There are multiple configurations, stapler types, and suture types and techniques – too numerous to detail as no individual surgeon is aware of the entirety of choices. There are aspects shared by all.

Commonalities of Constructing Intracorporeal Anastomoses

1. The ileocolostomy may be fully sutured, stapled, or a combination of both.
2. The stapling instruments may be surgeon (console) or assistant controlled.
3. Staple height is typically 3.5 mm (blue load) unless special in circumstances.
4. Luminal dimension is surgeon’s preference.
5. Stay suture(s) are placed, allowing sufficient length of ileum to create the desired common channel. These sutures also serve to orient anti-mesocolic transverse colon juxtaposed to antimesenteric terminal ileum.
6. Anchoring sutures are used to temporarily anchor the nascent reconstruction to the falciform ligament or parietal peritoneum to stabilize and retract; this is the equivalent of placing an extra port for a bedside assistant-controlled grasper. These are released subsequently.
7. When creating enterotomies for stapling, avoid oversizing to reduce spill and facilitate final closure.
8. The robotic stapler requires extra care to avoid puncturing bowel wall with the tip of a stapler limb due to lack of surgeon tactile feedback; significant robotic forces are easily generated from the surgeon console. Use visual cues and alert operators to avoid injury.
9. The diameter of the anastomosis is constructed of sufficient length to avoid problematic narrowing when closing the common channel with the bulky stapler.
10. The remaining common channel enterotomy is closed with the stapler or suturing.

Antiperistaltic “V” Anastomosis

The neoterminal ileum is oriented with staple line to the patient’s right. The distal colonic segment is placed in contact with the ileum cephalad with staple line also to the right. Stay and anchoring sutures are placed as described above (see Video 11.1).

The enterotomies for stapler entry can be at either end of the reconstruction based on point of stapler entry. Enterotomies are created allowing length from the limb-closing staple lines for optimal anastomosis. Inspect the intraluminal staple line.

The remaining common channel enterotomy is closed with the stapler or suturing oriented to maximize distance between the just created staple lines.

Isoperistaltic “I” Anastomosis

The neoterminal ileum is oriented with the staple line to the patient’s left. The distal colonic segment is placed in contact with the ileum cephalad with the staple line to the right.

Stay and anchoring sutures are placed as described above (see Video 11.2).

An enterotomy away from the prior staple line and adjacent colotomy are created with cautery. Both ends of the planned reconstruction (near the ileal staple line or nearer the colonic staple line) are suitable; choose the orientation that most readily aligns with the port of entry of the stapler. Use care to prevent occult injury to the contralateral intestinal wall. The linear cutting stapler is advanced starting with whichever limb is the more difficult to visualize. The internal staple line is usually accessible to visualize for bleeding.

The remaining common channel enterotomy is closed by suturing or with the linear cutting stapler maximizing the distance between the just created staple lines. It is optimal to avoid any of the three previously placed staple lines from being in contact with each other when adding this final staple line. The portion of tissue excised by this stapling must be removed immediately or placed with the colectomy specimen in the extra-large bag.

Isoperistaltic "M" Anastomosis

This technique utilizes a clockwise 180-degree bend in the terminal ileum juxtaposed with a counterclockwise 180-degree bend in the transverse colon. Such an orientation accommodates stapling from the suprapubic port, which later is the extraction site. Stay and anchoring sutures are placed as described above.

Enterotomies are made to open the staple lines at the corners opposite mesentery. It is handy to leave the staple line freed by these two incisions rather than cutting off the corner as is common practice extracorporeally. This way no loose bits of intestine are unintentionally lost in the abdomen and are later removed with the final staple line. Also, these "tabs" of suture line created by not cutting off the corner are handles facilitating grasping to retract when closing the common channel enterotomy. The linear cutting stapler limbs are advanced into neoterminal ileum and colon with the larger/longer limb placed first in the bowel segment most difficult to visualize when the stapler is in the field. Use care to prevent injury to the contralateral intestinal wall. Inspect the intraluminal staple line.

It is optimal to avoid any of the three previously placed staple lines from being in contact with each other when adding this final staple line. The portion of tissue excised by this stapling must be removed immediately or placed with the colectomy specimen in the extra-large bag.

Common Steps Immediately Subsequent to Anastomotic Construction

1. The staple (suture) lines may be serosalized with running or interrupted sutures.
2. Leak testing of the reconstruction is possible, preferably using CO_2 colonoscopy.
3. Closure of mesenteric defect is surgeons' preference.

The specimen is placed in an extra-large bag. It is delivered through the suprapubic fascial trocar defect, which has been enlarged minimally at skin, fascia, and peritoneum.

Summary

Robotic intracorporeal ileocolic anastomosis eliminates many of the potential difficulties and reduces time required. The risk of wound infection and hernia is reduced. It should be an acquired skill of all minimally invasive surgeons to be utilized as frequently as appropriate for maximizing patient outcomes.

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12 Transverse Colectomy: Laparoscopic Approach

David E. Rivadeneira and Scott R. Steele

Introduction

Even for the most experienced surgeons, mobilization and resection of the transverse colon along with ligation of the middle colic vessels can be a daunting task. This can be even more unnerving when using a minimally invasive approach. Understanding the tissue planes and having several techniques for managing a large omentum, adherent stomach and potential bleeding will minimize morbidity and maximize outcomes. In this chapter, we will discuss the surgical approach to laparoscopic mobilization and resection of the transverse colon and focus on the appropriate handling of the middle colic vasculature.

Background

The most common disease processes that the surgeon will encounter necessitating a transverse colectomy are malignancy of the colon, large sessile polyps, polyps with high-grade dysplasia, strictures, and diverticulitis. In addition, a transverse colectomy will be required as a part of a total abdominal colectomy for slow transit constipation, ulcerative colitis, or polyposis syndromes. Regarding malignancy, the appropriate operation for a transverse colon cancer has often been a controversial topic of discussion. The oncologic basis of colon surgery dictates that the regional lymphatic drainage along with the adequate healthy colon margins be removed. The transverse colon with its lengthy distribution across the abdomen and its multiple sources of blood supply pose a significant decision process for the surgeon about to undertake a resection. Depending on the tumor location, lymphatic drainage may occur via the middle colic vessels, particularly for centrally located tumors. However, lymphatic drainage may occur via the right colic vasculature for tumors located near the hepatic flexure and conversely may drain into the left colic branches for tumors near the splenic flexure. Further confounding the situation, the anatomy of the middle colic arteries is extremely variable [1]. Surgeons may encounter one to five different variations in its anatomy ranging from dual independent takeoffs of the right and left branches, a lengthy sole pedicle prior to branching, and all variations between. Middle colic vessels may also present as branches of the superior mesenteric vasculature in a multitude of ways. The surgeon must be prepared to deal with any of its variations. It is this variability of the anatomy that often leads to different decision processes for the surgeon in dealing with resections of the transverse colon for malignancy. This lack of consensus in treating these patients with just one type of resection along with its baseline technical difficulty has resulted in numerous randomized trials looking at laparoscopic colon surgery to exclude patients with transverse colon cancers. With this being said, a multitude of studies have been published that show that a laparoscopic approach to transverse colectomy is safe and feasible and is comparable to other laparoscopic resections [2–7]. It provides the same oncologic benefit as an open procedure when performed properly and decreases blood loss, hospital stay, and pain medication requirements.

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_12. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_12, © Springer Science+Business Media New York 2015

Preoperative Planning

Patients that are candidates for a transverse colon resection should have their pathology located in the transverse colon or have a transverse colectomy a standard part of the operation (i.e., total proctocolectomy). As the transverse colon is often elongated and freely mobile on its mesentery, inherent pathology in this location may be locally more aggressive (Box 12.1). This may be very apparent with a large, bulky tumor that can be visualized on CT scan or barium enema study. On the other hand, however, those patients with smaller tumors or small polyps usually will be better served with a preoperative colonoscopy and localization technique, such as submucosal injection with India ink solution. It is best to inject via a colonoscopy with a sclerosing needle several cc's of ink solution several centimeters away from the lesion. This should be done in four different quadrants of the colon and typically on the distal side of the lesion. This tattoo marking will allow the surgeon to correctly identify the exact segment to be removed. The proximal transverse colon (i.e., the hepatic flexure) and the distal part of the transverse colon corresponding to the splenic flexure are notorious for being difficult areas to visualize the marking of tattoo on the colonic serosal surfaces. This is often due to the colon being located in the high recess of the abdominal cavity, but also due to surrounding structures such as liver and spleen, as well as the large amount of intraabdominal fat and omentum, which often obscures the view. Often the flexure needs to be mobilized completely in order to visualize the marking. The patient undergoing a laparoscopic transverse colon resection should receive all the appropriate preoperative testing with routine blood work and, if appropriate, chest imaging and cardiac testing. The patient should also undergo full mechanical bowel preparation the day prior with a PEG-like product and clear liquid diet. In spite of data suggesting improved or equivalent outcomes with obviating this process, it might be best to have the bowel lumen prepped for a possible intraoperative colonoscopy evaluation, specifically with potential difficulties locating a preoperative tattoo for a laparoscopic transverse colectomy. In addition, bowel preparation eases the mechanical aspects of handling the bowel with 5-mm laparoscopic instrumentation—something that is more difficult with a heavy colon packed with stool. All patients should receive appropriate antibiotic and DVT prophylaxis. There should not be any direct contraindications that are inherent to laparoscopic transverse colectomy. When the indication for resection is malignancy, all the tenets of appropriate oncologic surgery should always be maintained, including negative margins of resection, wide excision of lymph node-bearing tissues, and en bloc resection of any and all appropriate surrounding structures and organs. If this cannot be accomplished via a laparoscopic approach, the surgeon should proceed with an open approach.

Box 12.1. Tip

Preoperative placement of a clip at the same time as tattooing followed by an abdominal x-ray will demonstrate the exact location within the transverse colon—proximal, mid, or distal—and will often times show the anatomy of both flexures and the colonic redundancy.

Room Setup and Patient Positioning

The patient is in lithotomy or modified Lloyd-Davies position in padded stirrups or split-leg table with sequential compression stockings. It is imperative to have the legs apart in order to allow the surgeon stand in between the legs to have better access to mobilize the hepatic and splenic flexure. Another advantage in placing the patient in this position is that the surgeon has access to do an intraoperative colonoscopy, if needed, and also allows for a low pelvic-stapled anastomosis (depending on the operation).

Port Placement and Extraction Sites

The port/trocar site positioning may vary due to body habitus or site of the lesion; however, the standard 5-port box configuration, periumbilical camera port with two upper and two lower lateral, is very adequate (see port configuration in Fig. 12.1) (Box 12.2). All 5-mm ports are recommended if possible. This assumes the use of a 5-mm camera and energy-based vessel-sealing device. This approach also allows for access throughout the abdomen and allows for the surgeon to use two ports for retraction and dissection as well as the assistant to use two ports for retraction. In addition, when possible, a second assistant can help with maneuvering the laparoscope/camera. The use of an assistant using two laparoscopic atraumatic bowel graspers/instruments cannot be overstated. Appropriate traction-countertraction, retraction, and triangulation of tissue planes are paramount for tackling the transverse colon and mesocolon. The importance of this proper retraction will become more apparent in the description of the operative steps.

Box 12.2. Tip

Placing another 5-mm trocar can often provide additional retraction and make the laparoscopic approach much easier. Whether it is a bulky omentum or small bowel loop that will not stay in place out of the way, the added retractor will go a long way facilitating success.

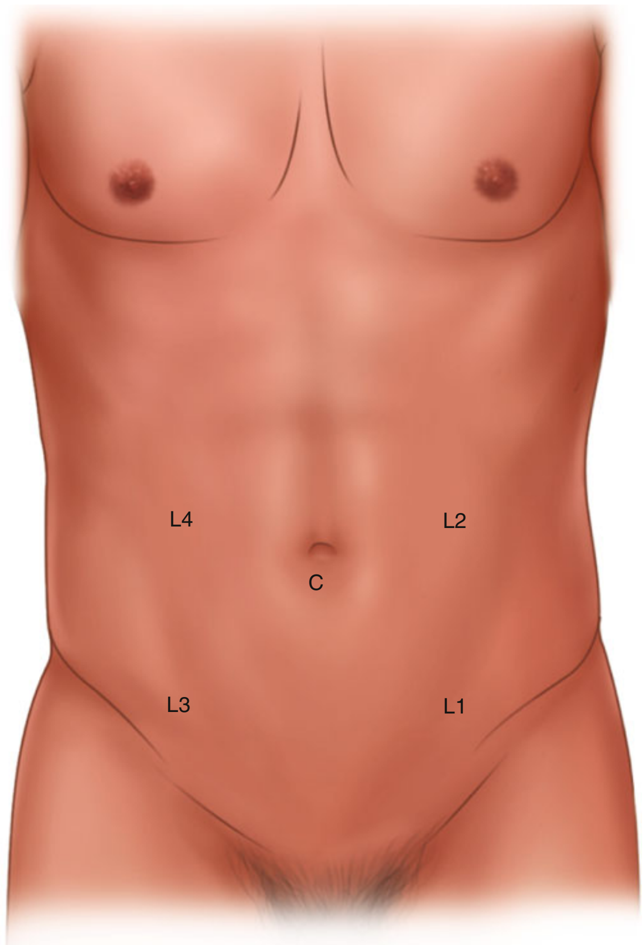

Fig. 12.1 Port configuration. *C*: 5-mm or 12-mm camera port, *L1-4*: 5-mm working ports (inferior approach), *L1-3*: 5-mm working ports (superior approach)

Given the complexity and difficulty of a laparoscopic transverse colectomy, some have advocated using a hand-assisted laparoscopic approach to facilitate the operation [8, 9]. This can be accomplished by placing the hand-assisted GelPort™ (Applied Medical, Rancho Santa Margarita, CA) device through a periumbilical midline incision or a Pfannenstiel incision, if an extracorporeal transverse colon to rectum or ileorectal anastomosis is performed. The surgeon's hand placed inside the GelPort™ device can aid significantly in the retraction and blunt dissection of the colon. Reports have demonstrated a decrease in operative time compared to straight laparoscopic approaches [8, 9].

Operative Steps (Table 12.1)

Exploratory Laparoscopy

Upon entry and adequate insufflation, a thorough inspection of the abdomen should be performed with emphasis on

Table 12.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy	1
2. Omental division or resection	3
3. Hepatic flexure mobilization	4
4. Splenic flexure mobilization	5
5. Identification and ligation of the middle colic vessels	6 (inferior) 5 (superior)
6. Extracorporeal anastomosis, closure, and re-inspection	1

identifying the area of interest. Only when a transverse colectomy is the only operation should the ports be changed relative to this structure. Otherwise, the ports should be placed based on the entire operation as above and the operation will commence. The patient should be placed in a reverse Trendelenburg position to facilitate small bowel to fall into the pelvis and help isolate the transverse colon. Based on the flexure, the patient may be placed in a right-side down (splenic) or left-side down (hepatic) position. An oral gastric tube is placed by anesthesia and kept on low intermittent suction, as this will cause the stomach to collapse and provide better visualization.

Omental Division or Resection

The greater omentum may be resected with the specimen or removed off the colon and preserved (Box 12.3). For the latter, it is best to place it over the top of the transverse colon in the upper abdomen. Occasionally the falciform ligament will obstruct this and may need to be partially divided. The colon is retracted caudally and the omentum is held up to facilitate exposure of the avascular plane adjacent to the bowel wall. This may be divided with an energy device or endoscissors/electrocautery. When it is resected with the specimen, it can be divided from the greater curvature of the stomach with the use of an energy-based vessel-sealing device, such as a Ligasure, Enseal, or Harmonic scalpel, by going directly through the omentum itself (see Fig. 12.2). In this situation, the omentum should be left draping over the bowel wall initially. After identifying the transverse colon and anterior stomach, an energy device or electrocautery can be used to divide the omentum, leading directly into the lesser sac. Care should be made to avoid inadvertent damage to the gastroepiploic vessels.

Box 12.3. Tip
A large redundant colon will be very difficult to keep oriented properly. Divide the omentum first and follow with resection of the mesentery in a stepwise fashion.

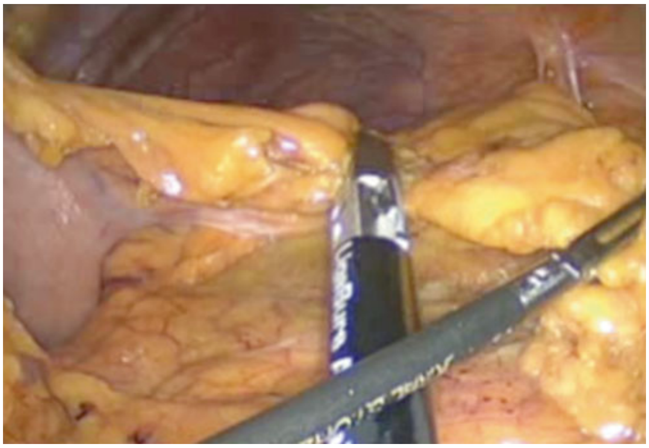

Fig. 12.2 Entering lesser sac

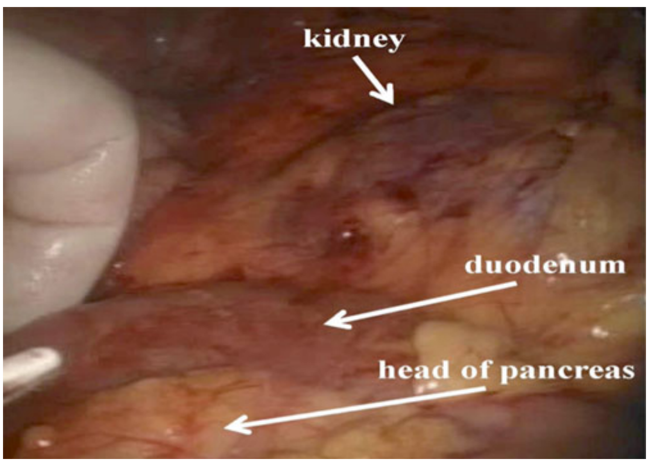

Fig. 12.3 Hepatic flexure mobilization

Hepatic Flexure Mobilization

The hepatic flexure is mobilized by having the surgeon stand on the patients left side or in between the legs. The surgeon will have an atraumatic bowel grasper in the inferior left port and a dissector or bipolar vessel-sealing device in the upper left port. The assistant will have two atraumatic bowel graspers and will provide the appropriate exposure and retraction by standing on the patient's right side or in between the legs. Using a lateral approach, the right lateral peritoneal edge around the hepatic flexure is divided and proceeds along the upper boarder of the transverse colon. Care must be taken to divide any adhesions to the gallbladder. The surgeon who is standing on the patient's left side is grasping the colon carefully or preferably an epiploica and retracting the hepatic flexure towards the left lower quadrant via the left lower trocar. As the retraction continues and the hepatic flexure becomes more redundant, care must be taken to identify the underlying "C-loop" of the duodenum (see Fig. 12.3). This is of utmost importance that the duodenum be visualized clearly and kept away safely from any energy source and potential of injury.

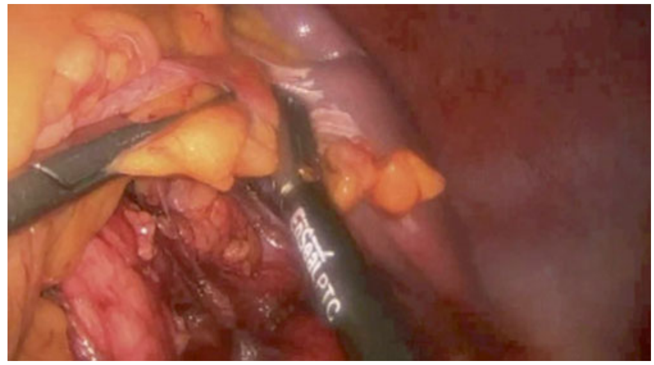

Fig. 12.4 Splenic flexure mobilization

Splenic Flexure Mobilization

The splenic flexure is mobilized in a similar manner. The surgeon now stands on the patient's right side or in between the legs and uses both right-sided ports for retraction and dissection. The assistant is on the opposite side, the left side of the patient, with two bowel graspers holding and retracting the colon appropriately. The surgeon starts out by mobilizing the lateral peritoneal attachments along the left colon. The lienocolic attachments can be carefully divided with the energy-based vessel-sealing device. The surgeon and the assistant must always be on the lookout not to vigorously retract the splenic flexure as this will lead to tears of the splenic capsule and can often cause significant bleeding and the potential of necessitating an emergent splenectomy. All adhesions to the spleen should be carefully ligated with minimal traction (see Fig. 12.4). As the splenic flexure is mobilized and becomes redundant, the surgeon should be able to visualize the tail of the pancreas. Visualizing the boarder of the tail of the pancreas will be an important landmark, as the duodenum was with the hepatic flexure (see Fig. 12.5).

Identification and Ligation of the Middle Colic Vessels

The isolation and ligation of the middle colic vessels is the most critical part of the operation. Especially during this step, the surgeon and entire team need to be aware of the importance and potential complications that can lead to devastating and life-threatening situations. Difficulty with hemostasis of these vessels can lead to exsanguination from the stump or superior mesenteric vessels. Additionally, inappropriate ligation at higher (more proximal) levels can lead to catastrophic ischemia of intraabdominal organs or duodenal and pancreatic injuries. For division of the right branch and pedicle, the surgeon stands on the patient's left side and have the assistant retract from the right. The most important maneuver is to have the assistant retract the transverse colon in a straight up-and-down fashion. This allows the entire mesentery or transverse mesocolon to be seen as a vertical wall colon at the top of the wall and all mesentery on the middle and bottom of the wall. It has also been described by many as looking as "Matador cape" (see Fig. 12.6), and this maneuver is often known as the "Ole maneuver" for that reason (see Video 12.1). This is accomplished by having the assistant grasp the transverse colon with atraumatic bowel graspers from both right-sided port sites. It is imperative that the transverse colon be completely fanned out as to see the entire base of the mesocolon. The duodenum must be clearly seen. The dissection of the mesentery proceeds from the surgeon who is positioned on the patient's left side or in between the legs (Box 12.4). The surgeon scores the mesentery and gently dissects each branch individually (see Figs. 12.7 and 12.8). The surgeon must have the adequate view at all times, and this is only created with the proper tension provided by the assistant. Once the right and middle branches have been appropriately ligated, the surgeon and assistant switch sides and tackle the left branches that feed the splenic flexure of the transverse colon. Here the surgeon stands on the right side and the assistant provides the "Ole maneuver" from the left-sided ports. The surgeon must again clearly see the pancreas and duodenum and keep both of these structures in view during the entire mobilization and ligation of the left branches of the middle colic vessels (see Fig. 12.9). Failure to do so could lead to catastrophic duodenal, pancreatic, and superior mesenteric artery injuries.

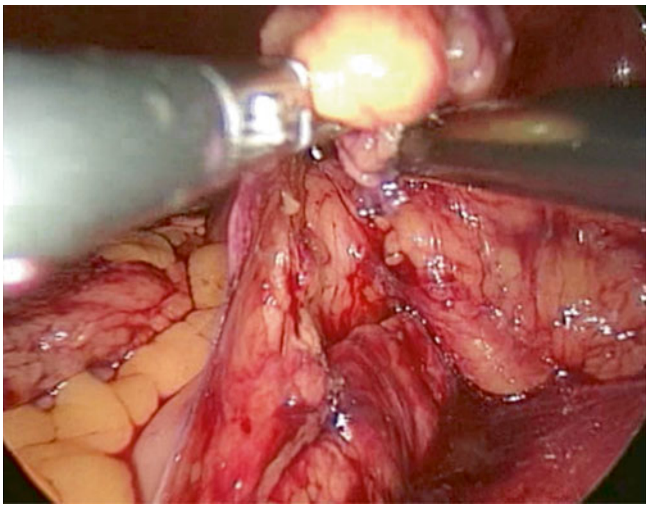

Fig. 12.5 Tail of pancreas

Box 12.4. Caveat
Control the middle colic vessels with a grasper at the pedicle prior to ligation. Leaving the pedicle a little longer (while preserving oncologic principles) will allow a clip, ENDOLOOP (Ethicon Endo-Surgery, Cincinnati, OH), or repeat seal to be used for inadequate bleeding.

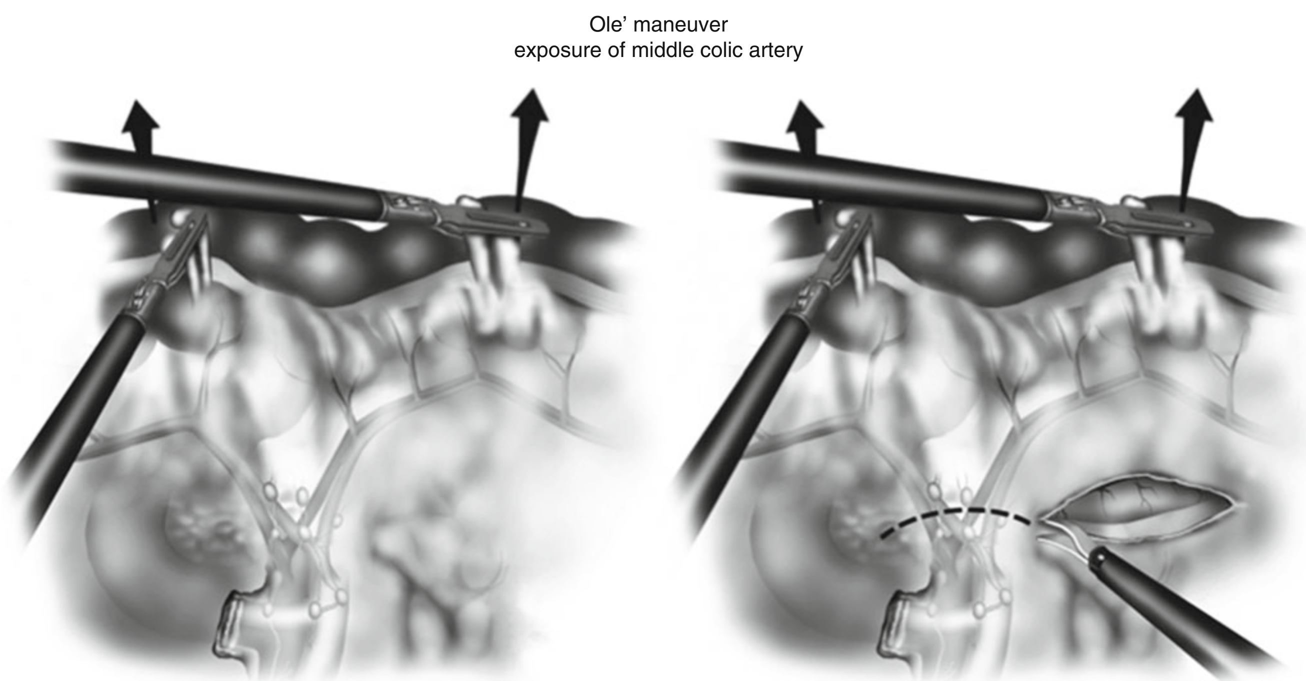

Fig. 12.6 Exposure of middle colic vessels through an Ole maneuver (With permission from Böhm et al. [10])

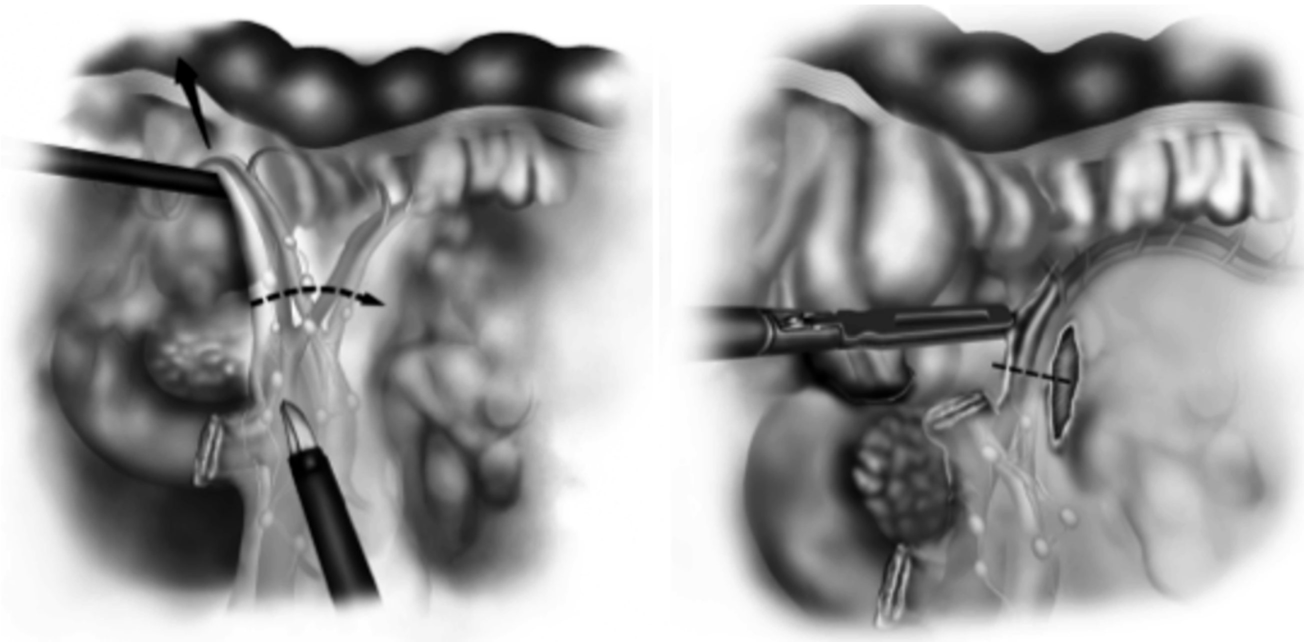

Fig. 12.7 Isolation and division of middle colics (With permission from Böhm et al. [10])

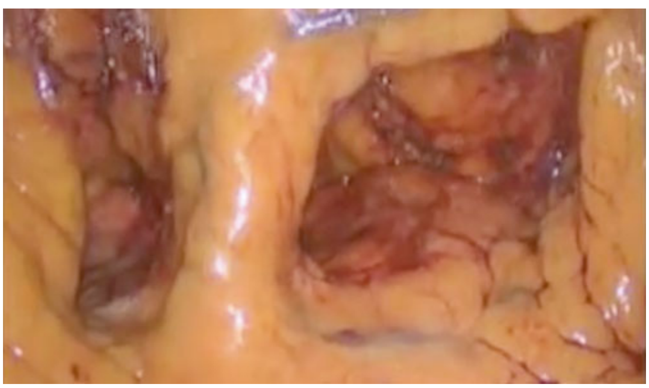

Fig. 12.8 Isolation of the middle colic vessels

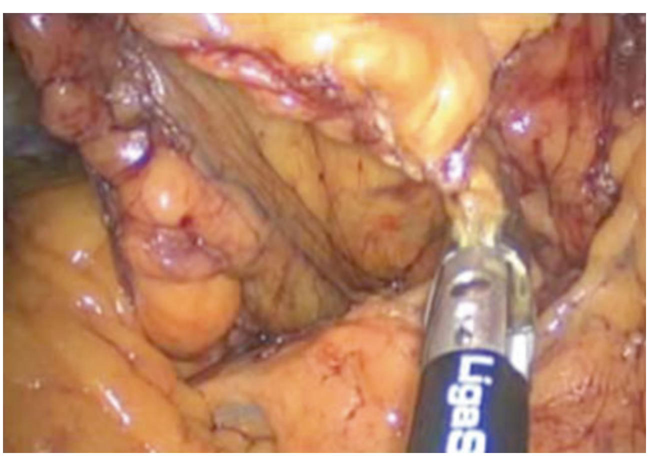

Fig. 12.9 Division of middle colic vessels inferiorly

Alternative to the above-described classic inferior approach, the middle colic vessels can be divided from a superior approach (Box 12.5). Once the hepatic flexure is completely mobilized, a window in the bare area in between the ileocolic pedicle and the right branch of the middle colic artery is created. The hepatic flexure and proximal transverse colon are retracted towards the left lower quadrant, and the previously created window is identified. The window serves as the starting point to divide the transverse colon mesentery. Care should be taken to track this leading edge at all times and to identify the location of the small bowel mesentery.

Box 12.5. Tip
The superior approach is especially easy to perform with a hand-assisted technique and useful in benign disease when a high ligation of the vessels is not necessary.

If the surgeon does not see the vascular anatomy clearly, the laparoscopic approach should be abandoned. Prior mobilization will allow limiting the laparotomy size and the middle colic vessels can be divided by an open approach.

Extracorporeal Anastomosis, Closure, and Re-inspection

Once the appropriate resection has been performed, the anastomosis can be completed. Most commonly used is a periumbilical midline extraction and transection of the proximal and distal colon wall extracorporeally. The use of a wound protector is encouraged, as it can help prevent any tumor implantation into the wound, reduces wound infection rates, and also serves as a wound retractor. For tumors located in the proximal transverse colon, an extended right hemicolectomy with an ileal-distal transverse anastomosis should be performed. For tumors located in the distal transverse colon, an extended left colectomy with a transverse colon (with preserved right branch of the middle colic vessels) to rectal anastomosis or a subtotal colectomy with either an ileal-descending/sigmoid colon (with preserved inferior mesenteric artery) or / ileal-rectal anastomosis is performed. If the patient has a small lesion in the mid-transverse colon and the patient has a redundant colon, it is possible to perform an isolated transverse colectomy with a primary colo-colonic anastomosis. The key is to mobilize both the hepatic and splenic flexures extensively, as this will avoid any undo tension for the anastomosis.

Summary

Laparoscopic transverse colectomy is a challenging procedure for surgeons, especially early in the learning curve, yet offers many potential advantages to patients. It can be performed safely in experienced and expertise hands; however, it is imperative that the surgeon has a thorough understanding of the anatomy, particularly the relationship of the middle colic vessels and the duodenum, pancreas, and superior mesenteric artery. With increasing knowledge and familiarity of the procedure, morbidity can be minimized and a laparoscopic approach will help maximize patient outcomes.

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Part III

Sigmoid and Left Hemicolectomy, Hartmann's Reversal

Sigmoid Colectomy and Left Hemicolectomy: Laparoscopic Approach

13

Charles B. Kim and Ovunc Bardakcioglu

Introduction

The purpose of this chapter is to review the technique of performing a laparoscopic sigmoid resection and left hemicolectomy. The essential steps of the procedure will be discussed in detail, including patient positioning, port placement, identification of key structures (inferior mesenteric artery pedicle, tumor, and ureter), mobilization techniques, extraction sites, and methods of reconstruction. While there are many different approaches to performing a sigmoid resection or Hartmann's reversal, this chapter will describe the pure laparoscopic approach. Additionally, specific considerations and challenges encountered while performing a sigmoid resection will be reviewed.

Background

The laparoscopic approach has become standard for many procedures, including cholecystectomy, appendectomy, nephrectomy, adrenalectomy, and gastric bypass. The conventional treatment for both benign and malignant disease of the colon with laparotomy and curative resection has been well described. In 1985, Erich Muhe performed the first human laparoscopic cholecystectomy [1]. The laparoscopic approach has become the widely accepted for symptomatic cholelithiasis, cholecystitis, and biliary dyskinesia. The first reports of laparoscopic colon resections were published in 1991 [2–4]. The laparoscopic approach for colorectal cancer was initially met with skepticism. There was concern that there may be a compromise in the ability to perform an adequate oncologic resection, negatively impacting overall survival. Port site recurrences were reported, further putting into doubt the capability to perform laparoscopic resection for colorectal malignancy [5]. This prompted numerous randomized controlled trials comparing outcomes in patients with colorectal cancer treated with curative intent. In 2002, Lacy and colleagues published the first single-center prospective randomized control trial comparing the laparoscopic approach to the conventional open approach. In terms of overall survival, for stage II patients, there was no difference in 5-year survival. However, for stage III patients, there was a statistically significant increase in overall survival in patients who underwent laparoscopic resection. Additionally, there was a statistically significant decrease in hospital stay and postoperative complications in the laparoscopic arm [6]. A large multicenter randomized control COST trial comparing the laparoscopic approach to the open approach was performed in 2004. Overall survival was similar in both arms. Additionally, patients undergoing laparoscopic approach, two port site recurrences were reported versus one wound site recurrence in the open group [7]. Similar results were reported in two other prospective randomized trials [8, 9]. These trials indicate that the laparoscopic approach does not compromise the oncologic safety or the overall survival in patients with colorectal cancer treated with curative resection. Numerous advantages of the laparoscopic approach have been identified in patients requiring segmental colon resection. Benefits include decreased postoperative pain, earlier return of bowel function, and earlier return to normal activity [10, 11]. Despite the advantages of a minimally invasive approach, laparoscopic resection has not been widely adopted. In a national database review of academic medical centers, 85,712 patients underwent colon resection between 2008 and 2011. Laparoscopic colon resection was attempted

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_13. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_13, © Springer Science+Business Media New York 2015

in only 42 % of these patients [12]. Numerous factors have been identified as barriers to the laparoscopic approach, including a steep learning curve, need to gain intra-abdominal vascular control, time needed to perform the procedure, need for a larger incision to extract the specimen, and concern about performing an adequate oncologic resection.

Sigmoid resection poses additional and unique challenges when a laparoscopic approach is chosen. In general, left-sided resections are more technically challenging than right-sided resections. Additionally, sigmoid resection in the setting of diverticulitis can significantly increase the difficulty of the procedure. The close proximity of the left ureter to the sigmoid colon mandates successful identification in order to prevent injury to this structure. In order to create a tension-free anastomosis, the splenic flexure may need to be mobilized, further adding to the complexity of performing an adequate reconstruction. A retrospective review was performed comparing 10,603 patients who underwent laparoscopic versus open sigmoid resection for both benign and malignant disease performed at US academic centers between 2003 and 2006 [13, 14]. Interestingly, only 10 % (1,092) of the patients underwent laparoscopic sigmoid resection. In comparing the two groups, the laparoscopic approach was associated with a statistically significant shorter length of stay and lower wound infection rate. Overall morbidity, 30-day readmission rate, mortality, and hospital cost were similar between the two groups. In a prospective study focusing on patients with sigmoid colon cancer, 18 individuals were identified and randomized to laparoscopic versus open resection. The laparoscopic technique resulted in a statistically significant decrease in hospital stay, decreased level of pain 24 h after surgery, as well a quicker recovery to normal daily activities [15].

Diverticular disease of the sigmoid colon can cause significant morbidity in patients who may ultimately require sigmoid resection for definitive management. Definitive indications for elective sigmoid resection include diverticular stricture, fistula, obstruction, intra-abdominal sepsis, and/or presence or inability to rule out malignancy [16]. Deciding when to perform sigmoid resection for patients with recurrent symptoms who do not have the abovementioned conditions remains a matter of debate. Based on the American Society of Colon and Rectal Surgeon (ASCRS) guidelines, patients are recommended to undergo sigmoid resection following two episodes of diverticulitis. However, the absolute number of attacks is not recommended to be the major determining factor in proceeding with sigmoid resection [17]. The ongoing prospective randomized DIRECT trial, comparing expectant nonoperative management versus surgical resection will hopefully elucidate the optimal timing of performing sigmoid resection for recurrent uncomplicated sigmoid diverticulitis [18]. While the ideal timing of proceeding with sigmoid resection for uncomplicated diverticulitis has yet to be clearly defined, multiple studies, including a randomized prospective trial as well as numerous systematic reviews, have been conducted, demonstrating a benefit for a minimally invasive approach. These studies indicate that a laparoscopic sigmoid resection is associated with decreased postoperative morbidity, shorter hospital stay, decreased systemic analgesia requirement, fewer wound infections, decreased ileus rates, and earlier return of bowel function when compared to the open approach [19–23].

Room Setup and Positioning

The laparoscopic cart and monitors should be positioned on either side of the patient with the slave monitor on the opposite side. The surgeon is positioned on the right side and the first assistant on the left side of the patient. A second assistant is standing to the left of the surgeon and is responsible for the laparoscope. A colonoscopy cart should be positioned close to the foot of the table on either side with the colonoscopic monitor next to one of the laparoscopic monitors to allow simultaneous intra- and extraluminal visualization during intraoperative colonoscopy. Some carts allow a picture in picture configuration on one monitor only.

Patient positioning follows the guidelines of safe patient fixation in lithotomy without sliding of the patient during Trendelenburg and left-side-up positioning and avoidance of any pressure points and nerve injuries. This can be accomplished using a simple gel pad without a sheet or a beanbag. The gel pad has an advantage that it allows quick untucking of the arms and fixation of an open retractor system in case of a conversion to an open case.

Port Placement and Extraction Sites

The camera port is placed above or below the umbilicus with the goal to have the port at the apex of the insufflated abdomen. This allows the best visualization of the entire abdominal cavity. In morbidly obese patients with a large pannus, the trocar might need to be therefore well above the umbilicus. The primary working ports of the surgeon L1 and L2 are located in the right lower quadrant (RLQ) and right mid abdomen or right upper quadrant (RUQ); the assistants ports L3 and optional L4 are on the contralateral side in the left lower quadrant (LLQ) and left mid abdomen or left upper quadrant (LUQ). This completes the typical box configuration, which allows access to all quadrants. The working ports are all 5 mm trocars and the RLQ port L1 is upsized if the rectosigmoid transection is performed with an endoscopic stapler, which can also be introduced through a 12 mm camera port instead (see port configuration in Fig. 13.1).

The most common extraction sites utilized for a total laparoscopic sigmoid colectomy are either a limited Pfannenstiel incision or a muscle splitting incision enlarging the LLQ trocar site. These extraction sites have the benefit of decreased incisional hernia rates compared to midline incisions. Rarely, the extraction site needs to be moved to a periumbilical inci-

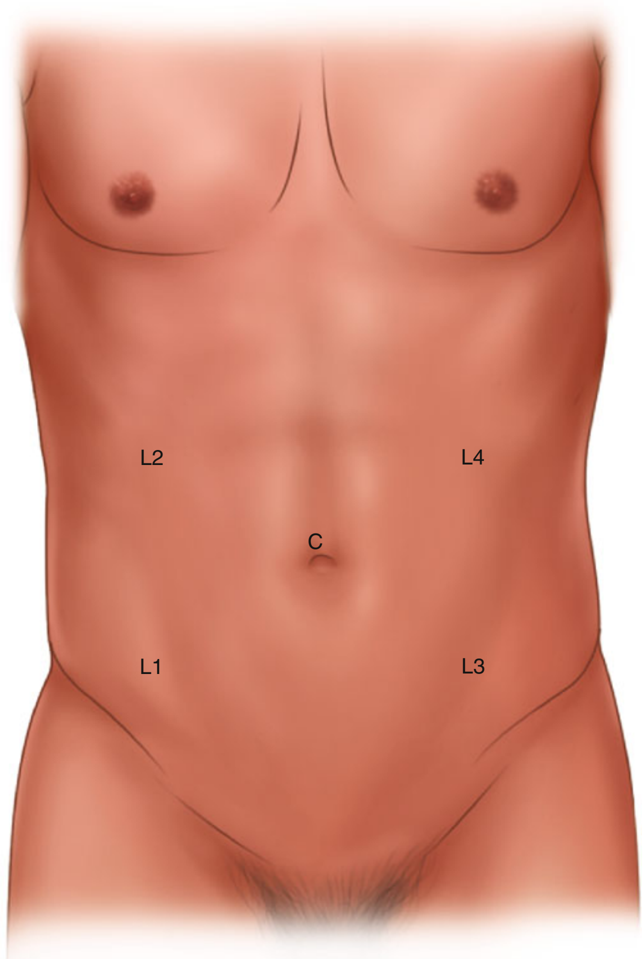

Fig. 13.1 Port configuration. *C*, 5 or 12 mm camera port; *L1*, 5 mm or 12 mm (for stapler) working port right hand; *L2*, 5 mm working port left hand; *L3*, 5 mm assistant port; *L4*, optional 5 mm assistant port

sion in very obese individuals in which the purse string and anvil cannot be placed extracorporeally due to limited reach through a very thick abdominal wall in the Pfannenstiel location. Alternatively, the anvil can be secured intracorporeally using various techniques such as an endoloop placement.

Operative Steps (Table 13.1)

Exploratory Laparoscopy

The abdomen and liver is explored for malignant cases to evaluate for metastases (see Figs. 13.2 and 13.3). For patients with severe diverticular disease, the extent of the inflammatory process, adhesions, and phlegmon formation is assessed to evaluate feasibility of a safe total laparoscopic approach (Box 13.1). Alternatives are early conversion to a hand-assisted approach or laparoscopic mobilization of the splenic flexure only limiting the incision size of an open approach.

Table 13.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy	1
2. Identification of the ureter and ligation of the inferior mesenteric artery	5
3. Mobilization of the sigmoid colon	3
4. Mobilization of the descending colon and splenic flexure with identification and ligation of the inferior mesenteric vein	5
5. Transection of the sigmoid colon	4
6. Anastomosis with leak test	2

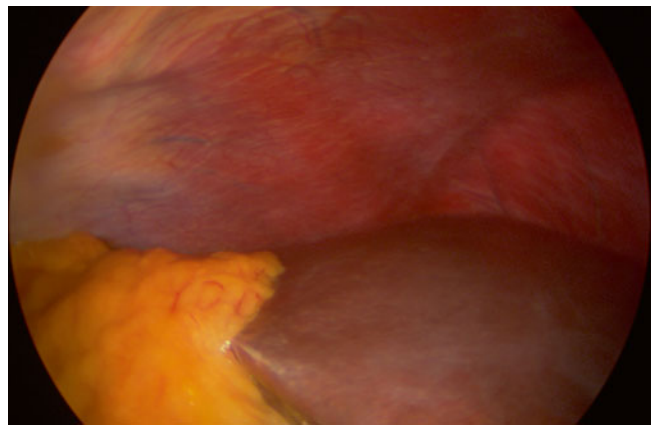

Fig. 13.2 Exploration of right liver lobe

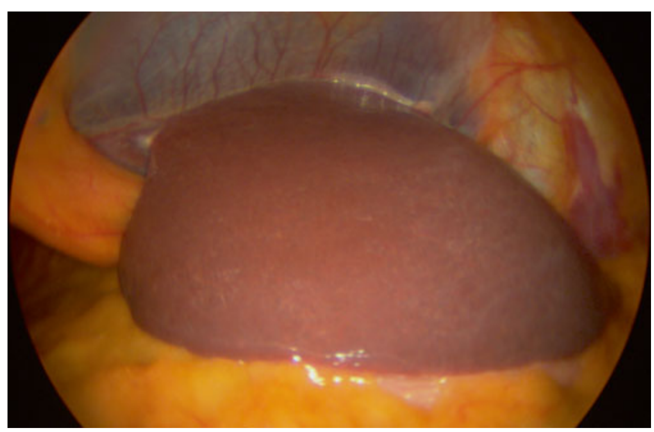

Fig. 13.3 Exploration of left liver lobe

Box 13.1. Tip
Estimate the size of the final specimen, which might be enlarged due to various pathologic processes to see if a larger extraction site is needed and then convert to a hand-assisted technique rather than making the same incision at the end of a total laparoscopic approach.

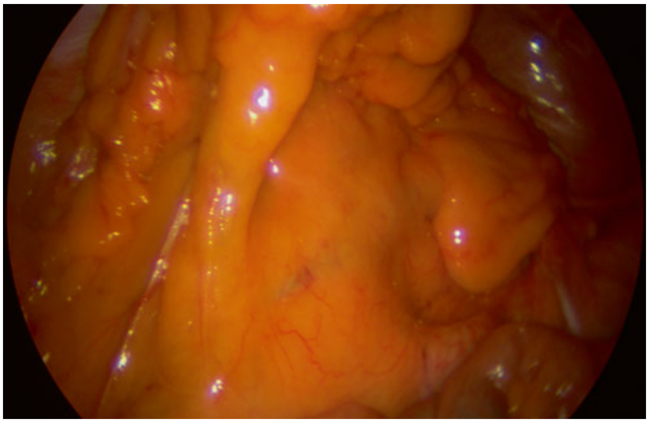

Fig. 13.4 Tension on the sigmoid colon mesentery

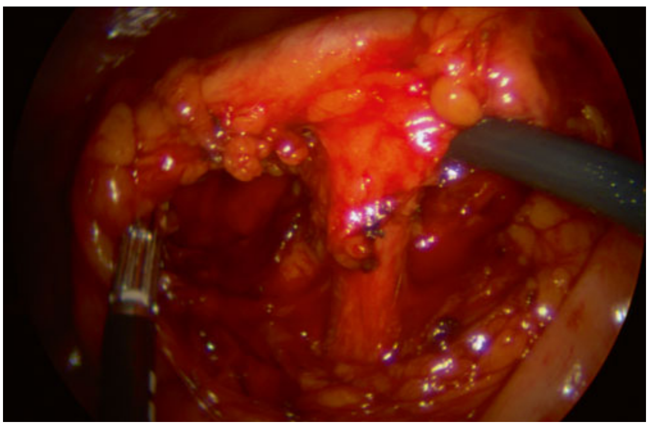

Fig. 13.5 Identification of the IMA (inferior mesenteric artery)

Identification of the Ureter and Ligation of the Inferior Mesenteric Artery

One of the essential steps prior to vascular ligation is the identification of the left ureter (Box 13.2). The assistant through ports L3 and L4 typically tents the sigmoid colon or rectosigmoid colon up to achieve tension on the rectosigmoid mesentery (see Fig. 13.4). The surgeon uses a bowel grasper through L2 and a dissecting instrument in L1. The peritoneum is scored and blunt dissection identifies areolar tissue to enter the upper presacral space. Once this avascular plane is entered, it can be traced superiorly to separate the sigmoid colon mesentery from the retroperitoneum and the left ureter can be identified. The peritoneum proximal to the bulging inferior mesenteric artery (IMA) pedicle is scored and a window created. After identification of the IMA root and the bifurcation of the left colic artery, the IMA is ligated above or below the bifurcation depending on the patient's individual anatomy and surgical indication for resection (see Fig. 13.5). Various bipolar vessel sealers, clips, or an endoscopic stapling device can be used (see Video 13.1).

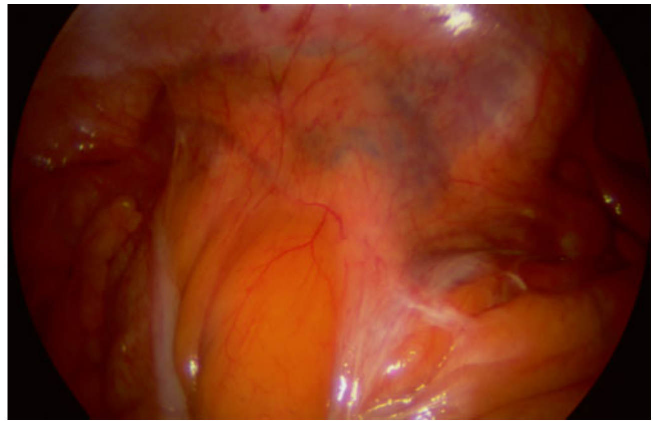

Fig. 13.6 Lateral peritoneal layer after medial dissection

Box 13.2. Tip

If the sigmoid colon is densely adhesed towards the pelvis, it might be difficult to open the window between the superior rectal artery and presacral fascia. The adhesions might need to be divided first or the plane cephalad to the IMA entered first.

Mobilization of the Sigmoid Colon

If the mesocolon of the sigmoid colon was dissected off the retroperitoneum completely through the medial approach, only a thin layer of the peritoneum is left for easy division and this can be seen as a dark hue through the peritoneum (see Fig. 13.6) (Box 13.3). If the medial dissection is difficult and not progressing or the left ureter cannot be identified, the lateral mobilization can be used prior to a complete medial to lateral approach (see Video 13.2). The surgeon and the assistant retract the sigmoid colon medially and the mesocolon is separated off the retroperitoneal structures including the ureter similar to an open approach and the left ureter is seen.

Box 13.3. Tip

Invariably, cases with more difficult anatomy will be encountered, and a switch back and forth between the medial and lateral dissection may be helpful.

Mobilization of the Descending Colon and Splenic Flexure with Identification and Ligation of the Inferior Mesenteric Vein

The inferior mesenteric vein can be ligated high next to the duodenum or more distally parallel to the inferior mesenteric

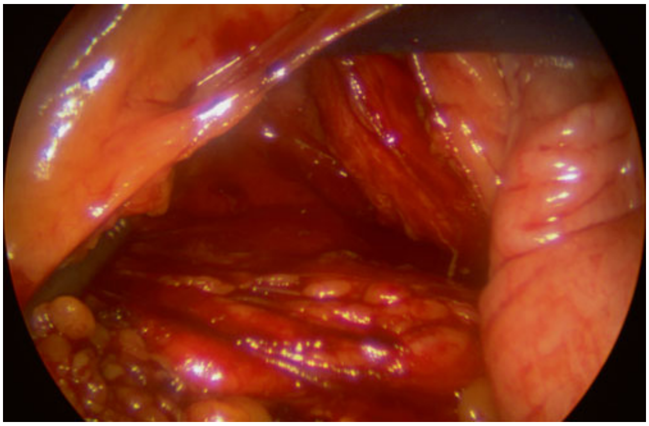

Fig. 13.7 Medial to lateral mobilization

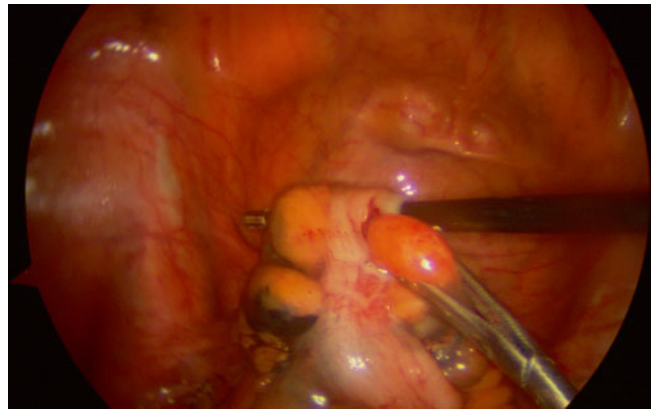

Fig. 13.8 Mesenteric window

artery. The decision is made based on the need to ligate high to ensure a tension-free anastomosis. The high ligation will be therefore described in the proctectomy chapters with coloanal anastomosis. Occasionally the patient's anatomy may mandate high ligation of the IMV during a laparoscopic sigmoid colectomy.

The splenic flexure can be mobilized from a medial, lateral, or superior approach. The patient is placed in the reversed Trendelenburg position.

The medial approach is the continuation of the medal dissection of the descending colon mesentery off the retroperitoneum and Gerota's fascia (see Fig. 13.7). This approach is suitable for isolation and high ligation of the IMV. Continuation of the dissection will identify the inferior border of the pancreas and dissection above the border will break through into the lesser sac. The assistant is again tenting up the descending colon through L3 and L4 and the surgeon is utilizing L1 and L2. The medial approach can be limited in obese patients with small bowel loops falling into the operative field.

The lateral approach is again similar to the open approach. The assistant is on the right side of the patient and retracts the descending colon medially through L2. The surgeon who is standing in between the legs uses L1 to retract the colon and L3 to dissect. The colon is progressively rolled over medially and separated from Gerota's fascia. It is important to turn medially at the junction to the splenic flexure and not dissect along the line of Toldt lateral to the spleen.

The omentum is separated from the distal transverse colon and the lesser sac entered during the superior approach. The assistant is retracting the omentum or stomach superiorly through L4. The surgeon is retracting the colon inferiorly through L1 and using a dissecting instrument through L2. This allows visualization of the splenocolic attachments, which are divided gradually, and the colon is rolled over inferiorly meeting with the previous dissection planes.

Transection of the Sigmoid Colon

After identification of the distal resection margin, the peritoneum overlying the mesorectum is scored bilaterally towards the anterior rectal wall. Using gentle blunt dissection and partial division of the mesorectum, a window is created (see Fig. 13.8). An endoscopic stapler through the RLQ port L1 or the camera port is used for a perpendicular transection of the colon (see Video 13.3).

Anastomosis with Leak Test

The proximal resection margin is identified, pulled towards the pelvis and the rectal stump to test tension-free reach, and marked using monopolar energy (Box 13.4). The colon is then exteriorized using a wound protector through a muscle splitting left lower quadrant or small Pfannenstiel incision, and the proximal colon is transected. After the anvil is secured using a purse string, the wound protector can be twisted 360° and then clamped with a ring clamp to allow re-insufflation. The circular stapler is placed through the rectum under laparoscopic guidance. The spike of the stapler is advanced through or right next to the center of the staple line (see Fig. 13.9), the anvil attached securely, and the anastomosis performed (see Fig. 13.10). If the stapler is not easily reaching the end of the rectal stump, a reversed Baker anastomosis can be performed traversing the spike of the stapler through the anterior rectal wall 5 cm distal to the end.

Box 13.4. Caveat
Do not force the stapler to the end of the rectal stump. Adequate prior partial mobilization of the rectal stump will certainly facilitate this, but a forceful attempt to reach the end can lead to premature separation of the staple line or an anterior rectal tear.

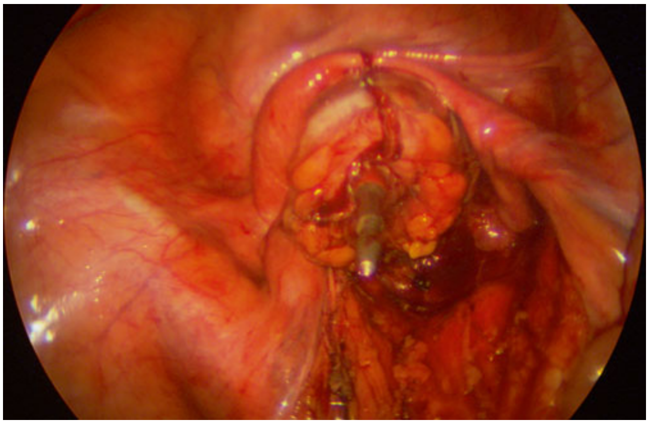

Fig. 13.9 Laparoscopic-guided stapler advancement

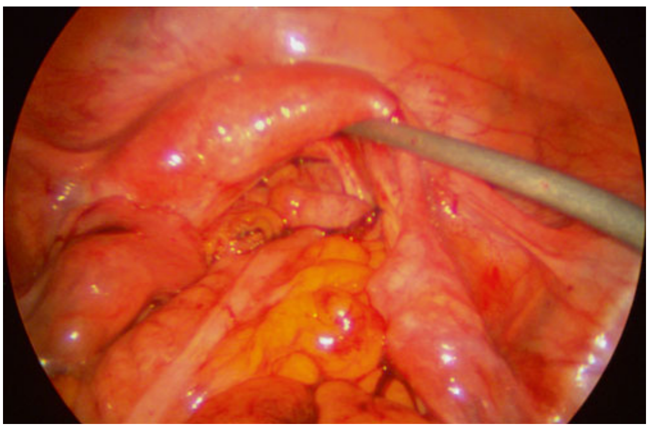

Fig. 13.10 Anastomosis

The doughnuts of the stapled anastomosis should be checked for completeness and sent to pathology for malignant disease. A colonoscope is inserted to observe the anastomosis for bleeding and completeness. The proximal colon is occluded and air insufflated through the colonoscope to identify an air leak of the anastomosis, which is merged in irrigation fluid. In case of an air leak, the anastomosis should be fashioned again given adequate distal length after a sigmoid colectomy. The rectum may have to be further mobilized as described in the proctectomy chapters.

Approaches

Medial to Lateral Approach

The medial to lateral approach follows steps 1 to 6. It has the advantage of precise dissection and identification of the IMA including the bifurcation of the left colic artery and subsequent high ligation. It allows identification of the left ureter through virgin planes when the lateral attachments are densely adhered due to inflammation. Further dissection superiorly ensures access to the proximal IMV for high ligation, which is not possible through a lateral approach.

Lateral to Medial Approach

The approach follows steps 1, 3, 2, 4, 5, and 6. It has the advantage for the novice surgeon to start gaining experience in laparoscopy, as the anatomy of the dissection planes is similar to an open approach. The caveat is that a high ligation of the vessels still needs to be approached from medially and the novice might address this by utilizing an open approach to vessel ligation though a limited lower midline incision prior to advancing to incorporating this necessary step.

The advanced laparoscopic surgeon who mastered the medial approach will still occasionally use a lateral dissection to complement the medial approach. The amount of colon mobilization off the retroperitoneal structures from medial or lateral will vary from case to case with the goal of identification of the ureter and high vessel ligation.

Superior to Inferior Approach

The superior approach is utilized rarely and follows steps 1, 4, 3, 2, 5, and 6. Early mobilization of the splenic flexure ensures that this is accomplished independent of the surgeon's subjective judgment of need for a tension-free anastomosis. It is frequently used as part of a total colectomy and will be described in those chapters more in detail.

Laparoscopic Left Hemicolectomy

A left hemicolectomy is indicated for lesions and malignancies located in the descending colon and splenic flexure or diverticulitis extending into these colonic segments. The left branch of the middle colic artery is divided, and the transverse colon, hepatic flexure, and often ascending colon need to be mobilized. The laparoscopic approach is described in more detail in the transverse colectomy and total colectomy chapters.

The alternative for a splenic flexure lesion is a subtotal colectomy with ileal to descending colon anastomosis preserving the IMA, which is an easier anastomosis to perform avoiding potential issues with the reach of the proximal transverse colon to the rectum.

Laparoscopic Reversal of a Hartmann's Resection

The benefits of a minimally invasive approach have been shown to be beneficial in patients undergoing Hartmann's reversal as well. In 1923, a French surgeon, Henri Albert Hartmann described creating an end colostomy for a patient with proximal rectal cancer, thereby avoiding the potential morbidity and mortality of an anastomotic leak [24]. Currently, a Hartmann's procedure is performed for patients with perforated diverticulitis, ischemic colitis, inflammatory colitis, obstruction, and anastomotic leaks. Initial reports of performing a Hartmann's reversal demonstrated that a laparoscopic approach was both feasible and safe [25–28]. Further investigations, including a systematic review comparing the traditional open approach to the minimally invasive approach have revealed that a laparoscopic reversal is associated with an earlier return of bowel function, shorter hospital stay, decrease in blood loss, and a decrease in overall postoperative complication rate [28–32].

Surgical Technique

Access to the abdominal cavity is typically through Palmer's point in the LUQ. Once the extent of the adhesions in the upper and left abdomen is assessed, trocars are the placed similar to the setup for a laparoscopic sigmoid colectomy: a camera port periumbilically and working ports L1 and L2 in the RLQ and RUQ. Now the patient can be placed in Trendelenburg position to assess if all small bowel adhesions in the pelvis can be lysed laparoscopically to expose the rectal stump. If necessary, a hand port can be placed suprapubic at this point to mobilize the rectum. The colon leading to the colostomy and the splenic flexure is mobilized laparoscopically prior to dissection of the subcutaneous portion and extracorporeal anvil placement. The anastomosis is performed as described above.

Special Considerations and Complications

The Reoperative Abdomen

It is important to recognize that the degree and extent of adhesions is not dependent on number, extent, and type of prior abdominal and pelvic procedures. The surgeon might be surprised to frequently encounter patients who were deemed not suitable for a laparoscopic approach, just to find minimal adhesions during an open approach. A philosophy of approaching all cases with a "peak port" to assess adhesions should be adapted as long as this port can be placed safely as described in various other chapters. At the same time, the surgeon will quickly develop the right judgment based on his or her laparoscopic skill set to proceed or convert early without unnecessary prolongation of the surgical time. It is very important to recognize that the advantages of a laparoscopic approach can be quickly lost by significant lengthening of the procedure time.

Morbid Obesity

Morbid obesity poses many challenges during a total laparoscopic sigmoid colectomy. Meticulous patient positioning is mandatory given the increased risk of pressure injury but also the dependency on gravity for adequate retraction. Trendelenburg positioning might impair pulmonary ventilation, which would exclude a total laparoscopic approach. If the patient's small bowel cannot be positioned out of the pelvis during a straight laparoscopic case due to bulk of the bowel or inability to tolerate Trendelenburg positioning, conversion to a hand-assisted technique might be helpful. The colonic mesentery is thickened, which makes identification of the exact anatomy and isolation of the IMA and IMV difficult. It is still advisable to follow the same principles and avoid "en mass" ligation, which can lead to partial seal/ligation and bleeding. Alternatively, endoscopic staplers are very useful in this scenario.

The increased bulk of the omentum frequently creates adhesions to the descending colon and lateral peritoneum. These need to be separated and the omentum will unfold again to define the anatomy of the splenic flexure. The splenic flexure often times needs to be mobilized combining the medial, lateral, and superior approach.

Diverticulitis

Inflammation and abscesses can lead to significant adhesions and dense chronic scar formations distorting the anatomy of the rectosigmoid colon and pelvis significantly. These can therefore pose the most challenging laparoscopic sigmoid colectomy cases given the limited tactile feedback of a total laparoscopic approach. The surgeon should follow the guidelines to assess the anatomy first to evaluate if a conversion to a hand-assisted or open approach is warranted. If proceeding laparoscopically, the general principles are to reestablish the original anatomy and start with dissection in virgin planes first. Small bowel might need to be freed from the pelvis and the mesocolon first to get access to a medial to lateral approach, which will help in identifying the left ureter early. If the medial access is obscured through folding and dense adhesions of the sigmoid colon to the pelvic sidewall, bladder, or rectum, the medial plane proximal to the IMA may be entered or the left ureter also identified proximally through superior mobilization of the splenic flexure and descending colon. This allows tracing the proximal ureter towards the distorted anatomy. Ureter stents placed preoperatively might be helpful as these can be felt through the tip of a dissecting instrument. If a bladder fistula is found, this can be left alone with Foley catheter drainage, if there is no methylene blue extravasation from the bladder intraoperatively. It can be otherwise closed laparoscopically or through the Pfannenstiel incision.

Locally Advanced Cancer

The goal of the surgery for advanced malignant disease is to achieve an R0 resection. Preoperative imaging using computer tomography or magnetic resonance imaging will clearly identify organ involvement outside the colon. Preoperative identification of hydronephrosis, for example, should prepare the surgeon to be ready to resect and reconstruct the ureter. Therefore, the laparoscopic approach is often times only reserved to accomplish the splenic flexure mobilization. If the abdominal wall, ovaries, and the dome of the bladder are involved, a total laparoscopic approach might be feasible for experienced laparocopists.

Bleeding

Bleeding from the inferior mesenteric artery will rarely occur independent of the tool utilized for transection. If a bipolar vessel sealer is used, the seal and transection should be perpendicular and through the entire width of the vessel. Nevertheless, failure occurs in calcified vessels. Higher-risk patients can be identified and an endoscopic stapler used instead. The most crucial step is to leave a small stump and have a laparoscopic grasper ready to occlude potential bleeding. If bleeding occurs, an endoloop can be safely placed.

Inability to Identify Tumor

The resection of a sigmoid colon lesion has the distinct advantage of quick intraoperative access using the colonoscope and precise determination of the distal resection margin. Ideally, the tumor will be visualized to rule out rectal involvement and distal tattooing by the surgeon preoperatively.

Inadequate Length of Colon for Tension-Free Anastomosis

A tension-free reach of the proximal colon is key for a pelvic anastomosis and various steps during the laparoscopic approach accomplish this. First, a complete mobilization and medial rotation of the distal transverse colon, splenic flexure, and descending colon and mesentery is accomplished. Typically, the Gerota's fascia and the tail of the pancreas will be completely visualized. Next, all omentum needs to be lysed off the descending colon and taken off the distal transverse colon. This can be continued along the transverse colon for heavy and bulky omentum. High ligation of the IMA is not only needled from and oncological viewpoint but also allows mobility of the colon. The decision of ligation above or below the bifurcation of the left colic needs to be individualized. Lastly, high ligation of the IMV next to the duodenum can yield additional length. It is important to emphasize that the proximal transection margin should not be based on length and reach of the proximal colon but based on the location of the malignancy or the extent of diverticulitis.

Summary

Review of the literature indicates that laparoscopic sigmoid resection can be performed for patients with malignancy without compromising the principles of adequate and safe oncologic resection. For patients with benign diverticular disease, a laparoscopic approach can be conducted without negatively impacting morbidity or mortality. The benefits of laparoscopic surgery have also been demonstrated in patients undergoing Hartmann's reversal.

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Sigmoid Colectomy and Left Hemicolectomy: Hand-Assisted Laparoscopic Approach

14

Danielle M. Bertoni and David A. Margolin

Introduction

Sigmoid colectomy and left hemicolectomy are operations that can be done either open, laparoscopic, or utilizing a hand-assist device. Surgeons have found that by using a hand port, these operations can be performed safely and efficiently, achieving the benefits of minimally invasive surgery while maintaining the tactile sensation in open surgery. In this chapter, we will be reviewing the hand-assisted approach to a laparoscopic sigmoid resection, left hemicolectomy, and Hartmann's reversal.

Background

Since its introduction in the early 1990s, laparoscopic colectomy has demonstrated less pain, faster return of bowel function, less blood loss, decreased incidence of wound complications, and postoperative ileus with equivalent oncologic outcomes [1–8]. Despite the benefits to laparoscopic colorectal surgery, less than 10 % of all colectomies are done laparoscopically [9, 10]. This is due to the technical difficulty and steep learning curve of laparoscopic colorectal surgery, which is estimated at about 25–60 cases per year, which may exceed the annual volume for many surgeons [11–13]. In the mid-1990s in response to these perceived difficulties, hand-assisted laparoscopic surgery (HALS) was developed. HALS allows for tactile feedback and the ability to perform blunt dissection, quickly obtain hemostasis in the event of bleeding, atraumatically manipulate the colon, and localize lesions by palpation. Randomized controlled trials have shown that HALS has similar benefits to laparoscopic surgery including the decreased use of narcotics; shorter length of stay; decreased wound complications, ileus, and bleeding; and faster return of bowel function [14–17]. HALS has also been shown to have decreased rates of major complications, a lower conversion rate than straight laparoscopic surgery, and a lower overall cost despite increased cost of the surgery itself [4, 14, 15, 18–22]. Marcello et al. in a randomized controlled trial also demonstrated decreased operating times for HALS compared to laparoscopic surgery [16]. Using HALS may make minimally invasive surgery a realistic option for some surgeons.

Room Setup and Positioning

Prior to doing the procedure, the surgeon must ensure that all of the equipment and facilities necessary to perform the operation are available. For hand-assisted laparoscopic sigmoid colectomy, the surgeon will require at least one atraumatic grasper, an advanced energy device (i.e., LigaSure, EnSeal, Harmonic scalpel), electrocautery, endoscopic scissors, endoscopic staplers, EEA stapler, and a standard laparoscopic instrument tray. Suction irrigator, endo-loops, and reloads for staplers should be in the room and available as well as an open instrument tray in case of conversion. There are several hand port devices; the most commonly used is the Applied Medical GelPort (Rancho Santa Margarita, CA, USA), but this is surgeon-dependent based on comfort and availability.

The patient is placed on a gel pad in the modified lithotomy position using yellow fin stirrups with no more than 10° of flexion at the hip. The legs should be carefully positioned and padded to prevent perineal nerve injury. The knees should be in line with the contralateral shoulder, and both arms padded and tucked in the adducted position. This allows for adequate access to the patient. For larger patients, sleds may be needed to safely tuck the arms. The chest and head of the patient

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_14. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_14, © Springer Science+Business Media New York 2015

should be secured to the operating table to prevent movement with positioning during surgery. An orogastric tube and an indwelling Foley catheter are placed prior to the start of the procedure. Lower extremity sequential compression devices and an upper body forced air warming device are used on all cases. Prior to prepping and draping, the table should be rotated and tilted in all directions to ensure that the patient is secure. Rectal irrigation is performed and the perineum and rectal area are prepped with Betadine scrub and paint. The abdomen is prepped with 2 % chlorhexidine-based solution.

Two monitors are used during the procedure. One will be placed on the patient's left side. The other monitor will be placed at the patient's right shoulder or near the head on the right side for the assistant or scrub nurse. The insufflation tubing, cautery power cord, camera wiring, light cord, and suction tubing are passed off the patient's left leg. A 10 mm or 5 mm laparoscope with both a 30° and 0° lens can be used for most cases.

Port Placement and Extraction Sites

Prior to placing the laparoscopic ports, the surgeon should decide where the hand port will be placed and mark the incision for the hand port on the abdomen (Box 14.1). This assures that once the HALS port is placed, the laparoscopic ports are still useful. The size of the incision for the hand port will depend on the hand size of the operating surgeon and is usually between 6 and 7 cm (Box 14.2). There are three options for location of the hand port: lower midline, Pfannenstiel, or periumbilical. Regardless of location, the hand port is most commonly used as the extraction site. Initially, a camera port can be placed in the supraumbilical position ("peak port") using a Hasson or Veress technique to establish pneumoperitoneum. This allows for a cursory laparoscopic examination of the abdomen and assures that other ports, including the HALS port can be placed in the most advantageous location. Once no contraindication to minimally invasive surgery is found (i.e., metastatic disease, dense adhesions), additional ports are placed. Prior to any port placement, the HALS device is placed externally on the insufflated abdomen and its footprint is outlined.

Box 14.1. Tip
Choosing the location of the hand port site periumbilically for very obese patients allows the proximal colon to be exteriorized more easily for placement of a pursestring suture

Box 14.2. Tip
The initial port should be placed in the LUQ at Palmer's point if the patient had a prior laparotomy and adhesions are expected in the midline.

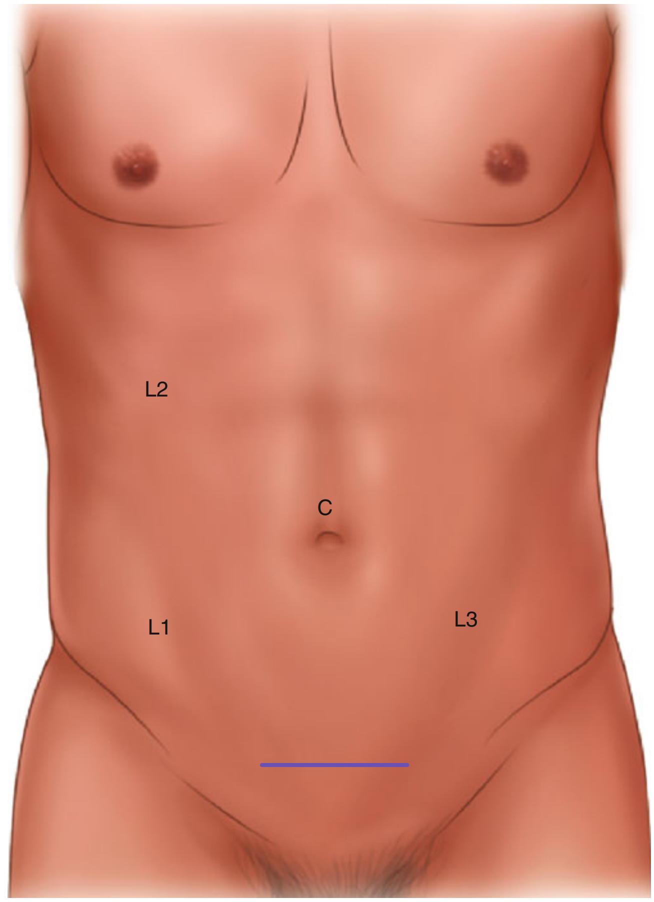

Fig. 14.1 Port configuration. Hand port: right hand, *C*: 5 or 12 mm camera port, *L1*: 5 mm working port left hand, 12 mm if endoscopic stapler is used, *L2*: optional 5 mm port for superior splenic flexure mobilization, *L3*: optional 5 mm port for lateral splenic flexure mobilization

When the HALS device is placed in the Pfannenstiel or lower midline location, the "peak port" will become the camera port (Box 14.3). If the HALS device was inserted first, the camera trocar can then be placed safely under direct guidance of the inserted hand, which lifts up the abdominal wall away from the intra-abdominal contents. The hand is forming a fist and lifting up the abdominal wall. The thumb and index finger are creating a ring in which the trocar can be placed through the abdominal wall safely without visual guidance. Then a port L1 is placed in the right lower quadrant (RLQ) lateral to the HALS footprint. If the bowel is transected through the hand port incision site, this is a 5 mm port; otherwise, this is a 12 mm port to allow the use of a laparoscopic stapler. Additional optional trocars are a 5 mm trocar L2 in the right upper quadrant (RUQ) and rarely a left lower quadrant trocar L3 (see port configuration in Fig. 14.1).

If the HALS device is placed in the periumbilical location, the camera port is moved to a 5 mm trocar in the suprapubic location (see port configuration in Fig. 14.2). The other working trocars are placed similarly as above.

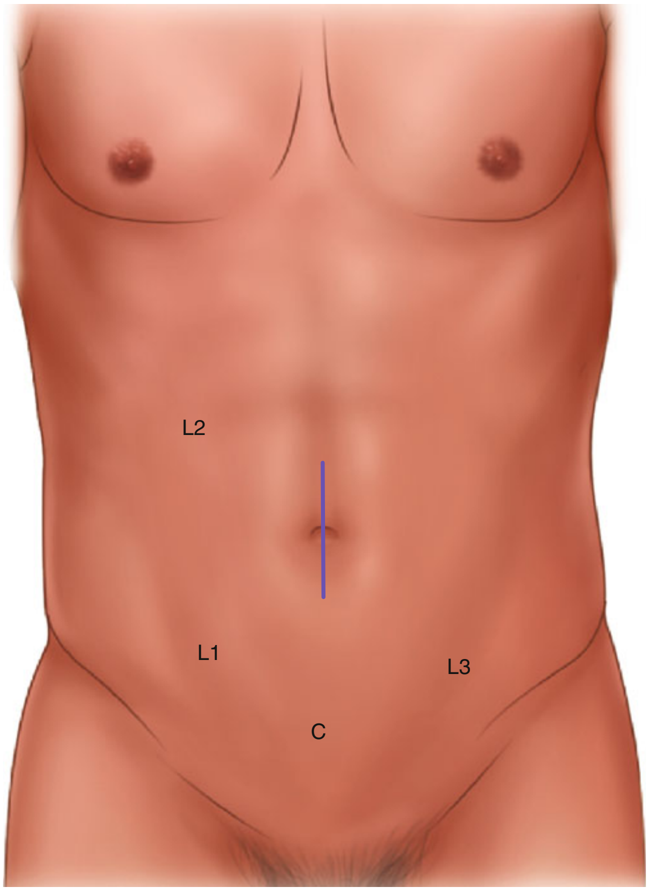

Fig. 14.2 Port configuration. Hand port: left hand, *C*: 5 mm camera port, *L1*: 12 mm working port right hand, *L2*: optional 5 mm port for superior splenic flexure mobilization, *L3*: optional 5 mm port for lateral splenic flexure mobilization

> **Box 14.3. Tip**
> For a virgin abdomen, a hand port can be placed directly through an open incision, thus avoiding potential complications of initial trocar placement.

Operative Steps (Table 14.1)

Exploratory Laparoscopy and Insertion of the Hand Port

With the operating surgeon on the patient's right side, a laparoscope is inserted through the supraumbilical port ("peak port") to inspect the abdomen and pelvis. In cancer cases, the peritoneum and omentum should be checked for peritoneal implants or tumor seeding. The liver should also be closely inspected for metastases. Reverse Trendelenburg positioning can be used to facilitate this if necessary. In female patients, the pelvis should be closely inspected to look for ovarian implants or metastasis. Using the left hand through the HALS port, the sigmoid colon can be palpated either to

Table 14.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy and insertion of the hand port	1
2. Identification of the ureter and ligation of the inferior mesenteric artery	3
3. Mobilization of the sigmoid colon	2
4. Mobilization of the descending colon and splenic flexure with identification and ligation of the inferior mesenteric vein	4
5. Transection of the sigmoid colon	3 (intracorporeally) 2 (extracorporeally)
6. Anastomosis with leak test, closure, and reinspection	2

identify the tumor or the extent of muscular hypertrophy in diverticular disease. Once inspection is complete, the patient should be placed in Trendelenburg position and rotated to the right. The omentum is lifted up over the transverse colon and pushed toward the upper abdomen, and the small bowel is packed to the right side of the abdomen using either a moist lap or blue surgical towel inserted through the hand port.

Identification and Division of Inferior Mesenteric Artery

The patient is still in Trendelenburg position and rotated to the right. The small bowel is packed to the right side of the abdomen, and the base of the mesentery of the left colon is exposed. If necessary, pelvic adhesions are lysed laterally to allow traction of the sigmoid colon to expose the mesocolon medially (see Video 14.1) (Box 14.5). The surgeon's left hand is placed in the periumbilical HALS port, and the sigmoid colon is grasped and elevated anteriorly. This allows the surgeon to visualize the inferior mesenteric artery (IMA). The mesentery distal to the IMA now under tension is scored with either scissors or the alternative energy device through the RLQ port L1 (Box 14.4). This allows air into the retroperitoneum to aid in the dissection. The left ureter is found just lateral and posterior to the IMA. The gonadal vessels are identified just lateral to the ureter. Alternatively, the surgeon's right hand is placed in the lower midline or Pfannenstiel HALS port, the sigmoid colon elevated similarly, and the dissection continued using instruments with the left hand through the RLQ port L1 (see Video 14.2).

> **Box 14.4. Tip**
> Open the peritoneum overlying the mesorectum distal to the IMA widely, and identification and short dissection of the presacral avascular plane allows identification of the correct plane between mesocolon and retroperitoneum

Box 14.5. Tip
If the hand does not create enough tension on the colon mesentery by lifting the colon itself, it can be placed close to the dissection plane lifting the colon mesentery directly.

Occasionally, it will be difficult to identify the left ureter. In these cases, the dissection plane is often too deep and the ureter is displaced anteriorly (Box 14.6). Once the IMA and the ureter are identified, the IMA is mobilized circumferentially. Unless extremely calcific, the vessel is divided with the advanced energy device and divided close to its takeoff (see Video 14.3). Some surgeons divide the IMA with an endoscopic stapler with a white cartridge. It cannot be stressed enough that the left ureter must be identified and preserved prior to dividing the IMA (Box 14.7).

Box 14.6. Tip
If the sigmoid colon is densely adhered and pulled into the deep pelvis, these adhesions should be taken first if possible in a safe manner. Otherwise, the IMA might be pulled into the pelvis, too, and it might be difficult to find the right medial plane.

Box 14.7. Tip
If the left ureter is not identified, do not proceed with ligation of the IMA, identify the ureter from a lateral approach, or convert to an open procedure.

The IMA can also be isolated and ligated in a lateral to medial approach similar to open surgery. This approach tends to be more difficult secondary to a mobilized and redundant colon. Here, the sigmoid colon is grasped with the operating surgeon's left hand and the colon is retracted medially. The lateral attachments are taken down as the colon continues to be mobilized medially until the left ureter comes into view. After identifying the left ureter, the colon is retracted superiorly allowing isolation and safe division of the IMA at its origin. Once the IMA is divided, the remaining mesentery of the sigmoid and descending colon can be dissected using the medial to lateral approach. Here, pneumoperitoneum aids significantly in the dissection. Again using the left hand through the periumbilical hand port, the colon is elevated creating tension in the mesentery.

Mobilization of the Sigmoid Colon

The sigmoid colon is typically mobilized just following the medial dissection plane after division of the IMA. A second option is to mobilize the sigmoid colon from a lateral approach. With the left hand in the periumbilical HALS port, the surgeon retracts the sigmoid and left colon medially. After division of the IMA, sharp dissection with either scissors or an advanced energy device is carried between the colon mesentery along the left sidewall just inside the white line of Toldt up to the level of the spleen. If the hand port is used in the Pfannenstiel location, the surgeon can stand between the legs of the patient and place the left hand through the HALS port for medial and anterior traction and use the LLQ port L3 as the working port. The surgeon can also dissect along the line of Toldt with his/her right hand through the Pfannenstiel location and use an energy device through the RLQ port L1 (see Video 14.4).

Mobilization of the Splenic Flexure

Mobilization of the splenic flexure can be performed from a lateral, medial/inferior, or superior approach (Box 14.8). These approaches do not always need to be followed strictly, and they can be combined (see Video 14.5).

Box 14.8. Tip
Avoid extensive caudad traction of the colon with the hand, and preemptively add additional trocars to avoid injury to the spleen.

Medial mobilization of the splenic flexure is naturally following the progression of the medial mobilization of the descending colon and mesentery (Box 14.9). This can easily be divided up to the splenic flexure by continuing the dissection between the colon mesentery and the retroperitoneum or Gerota's fascia. If the right hand is used through the lower midline or Pfannenstiel incision, the dissection is often times limited through the RLQ port L1. After identification of the inferior border of the pancreas, the dissection stays anterior to the pancreas until the lesser sac is entered.

Box 14.9. Tip
The inferior border of the pancreas should be recognized during continuous medial dissection to avoid pancreatic injury.

Similarly, the lateral approach follows the lateral mobilization of the sigmoid colon. In this case, the surgeon can move in between the legs and use the left hand for retraction and an optional LLQ port L3 for dissection. Occasionally, the working port needs to be moved from a LLQ L3 to an optional LUQ port L4. As the lateral wall attachments are divided, the colon will rotate medially and the Gerota's fascia, the tail of the pancreas, and the tip of the spleen will be exposed. It is important to stay just inside the line of Toldt during this lateral dissection. If the dissection is too lateral, the retroperitoneum is entered causing bleeding and potential injury to the retroperitoneal structures and the spleen. Coming around the splenic flexure, the omentum is released and the lesser sac entered.

The superior approach is often times used as a first step of the entire procedure. This is facilitated by the placement of a periumbilical HALS port. The transverse colon is retracted with the right hand inferiorly, and the lesser omental sac is entered using an instrument through a RLQ port L1 or optional RUQ port L2. Alternatively, the assistant's left hand can be used for downward traction on the transverse colon using the right hand for the camera control through a LM port. The surgeon would then dissect with a right-handed instrument through the RLQ port L1 and create countertraction by lifting the omentum with a left-handed instrument through the RUQ port L2. If the HALS port is in the lower midline or Pfannenstiel location, the HALS port is not used for a superior mobilization of the splenic flexure. The assistant helps with retraction through the RUQ port L4, and the surgeon utilizes ports L1 and L2 again. The dissection is started to the left of the middle colic artery and carried around the splenocolic ligament. If the earlier portion of dissection is adequate, the surgeon should see a purple hue in the tissue on the descending colon side of the splenic flexure.

The high ligation of the inferior mesenteric vein (IMV) is optional. The initial step is to identify the ligament of Treitz. Once identified, the IMV is seen lateral to it. The vein is gently isolated, and dissection is carried out in the plane just anterior to Gerota's fascia. Often times, this portion of the procedure is carried out laparoscopically without the use of the HALS port. However, the assistant, who is on the patient's left side, can use their left hand through the HALS port to retract the sigmoid and left colon anterior and lateral. This allows for mobilization and division of the IMV. Once the IMV is divided, dissection is carried out laterally to the sidewall if this is not already mobilized after a superior, medial, or lateral mobilization of the splenic flexure. Care is taken to stay anterior to Gerota's fascia. The dissection can then proceed cranially to the inferior border of the pancreas.

A high division of the inferior mesenteric vein frequently allows the descending colon to reach the pelvis further for a coloanal anastomosis, and this may again not be needed for a colorectal anastomosis.

Transection of the Sigmoid Colon

The colon can be divided endoscopically with an endoscopic stapler or opened through the HALS port if it is in the lower midline or Pfannenstiel location. If the distal transection is performed first laparoscopically, the pericolonic fat and mesentery are thinned out at the point of intended division, usually at the proximal rectum where the taeniae converge. The endoscopic stapler is inserted through the RLQ port L1. Here, the surgeon's left hand through the periumbilical HALS port is key in positioning the rectosigmoid junction properly in the stapler. An articulating stapler is helpful but not required. The proximal division is performed through the HALS port. The sigmoid colon is brought out through the hand port, and the location of proximal transection is determined. The colon is divided, checked for back bleeding, and the anvil for a circular stapler is placed in the proximal colon and secured by tightening the purse string suture. If the distal transection is done through an open approach, the sigmoid colon loop is delivered first through the HALS port in the Pfannenstiel location and the proximal transection performed using a stapler. After open division of the remaining sigmoid colon mesentery, the descending colon is returned into the abdominal cavity. Retraction of the sigmoid colon stump through the HALS port now allows for open dissection around the distal resection margin and use of a curved GIA stapler through the HALS port.

Anastomosis with Leak Test

For the anastomosis, a circular stapled end-to-end anastomosis is most commonly performed. The anvil and purse string are placed in the proximal colon open through the hand port. At this point, the hand port can be replaced, the abdomen insufflated, and the anastomosis completed laparoscopically or the anastomosis can be performed through the hand port. The assistant will gently dilate the anal sphincters. The stapler needs to be centered on the staple line with the spike set to come through 1–2 mm anterior or posterior to the endoscopic staple line. Prior to firing the stapler, the colon is checked to ensure it is not twisted and that there is no tension on the proximal colon. The anastomosis is placed under water and air is instilled in the colon to assess for a leak, preferably with a colonoscope. Not only does it allow for air insufflation, but also it allows for direct visualization of the anastomosis. Once satisfied with the anastomosis, the abdomen is inspected to confirm again that there is no twisting of the colon and no tension and to ensure adequate hemostasis.

Approaches

Medial to Lateral Approach

This approach is most commonly performed following steps 1–6. It has the advantage of early identification of the left ureter, which is a prerequisite for continuing the laparoscopic technique and allows high ligation of the IMA for oncologic cases. It also allows the surgeon to dissect in virgin territory that is unaffected from inflammation in cases of diverticulitis.

Lateral to Medial Approach

The lateral to medial approach is the most similar to open surgery and follows steps 1, 3, 2, 4, 5, and 6. It therefore might be useful for the novice laparoscopist to follow known tissue planes. Frequently, the medial and lateral approaches are performed simultaneously back and forth.

Superior to Inferior Approach

This approach follows steps 1, 4, 3, 5, and 6 and has the benefit to always have a completely mobilized splenic flexure first. This philosophy maximizes the mobility for a tension-free anastomosis independent of the surgeon's opinion and of the individual anatomy and case. Furthermore, initial mobilization of the splenic flexure can help limit the incision size needed for open surgery if conversion is needed.

Hand-assisted Laparoscopic Left Hemicolectomy

A left hemicolectomy is similar to a sigmoid colectomy. The steps are essentially the same as the sigmoid colectomy with two main differences: the extent of proximal mobilization and the point of transection. The proximal transverse colon and sometimes the hepatic flexure need to be mobilized to allow a tension-free anastomosis to the rectum. This is often done laparoscopically without a hand assist. The avascular plane anterior to the duodenum at the root of the colon mesentery is incised, and dissection is carried up to the gallbladder fossa. Care is taken not to pull on the duodenum. Once the gallbladder fossa is reached, the hepatic flexure is retracted inferior for dissection of the omentum off the colon; the dissection is carried to the left where it merges with the splenic flexure mobilization.

The point of proximal transection is determined by the location of the mass. The mass should be resected with a 5 cm margin. If the tumor is palpable and the surgeon can feel the proximal edge of the tumor, then the point of transection can be determined to be at least 5 cm proximal. For a formal left colectomy, the left branch of the middle colic vessels should be ligated and the proximal colon transected at this level.

Hand-Assisted Laparoscopic Reversal of a Hartmann's Resection

The steps to Hartmann's reversal may be similar to those done in a sigmoid colectomy. The extent will depend on the surgery done previously. If possible, it is best during the initial surgery to mobilize the splenic flexure and place an anti-adhesive membrane (Seprafilm®). This will alleviate the need to mobilize the splenic flexure.

It helps maintain pneumoperitoneum and keeps the proximal bowel out of the way, if the colostomy is not taken down until the rectum is identified and mobilized. Again, it is imperative to identify the left ureter. After identifying the rectal stump and taking down all adhesions from the anterior abdominal wall, a HALS port is placed in the supraumbilical position. This aids in further mobilizing the proximal colon and taking down the colostomy. This can be done as described above.

Next, the colostomy is addressed and dissected circumferentially around the colon intra-abdominally. The surgeon retracts the colon with his/her left hand and uses his/her right hand with either endoscopic shears or an alternate energy source to free as much as possible the intra-abdominal colon. There is frequently a parastomal hernia so it is imperative to go slow at this juncture. Once intra-abdominal dissection is complete, the mucocutaneous junction is incised and dissected down to the fascial attachments. If the dissection was complete from the inside, this will be a thin layer that is easy to divide. The surgeon can aid himself by keeping his left hand in the HALS port and giving traction on the partially dissected stoma. Once free, the colon can be brought out the stoma site and divided and the anvil placed for the circular stapler in the proximal bowel at this time. Once satisfied that the colon will reach the pelvis and that the rectum has been clearly identified and dissected out, the anastomosis is performed as above (Box 14.10).

Box 14.10. Tip

If the EEA stapler does not reach the end of the rectal stump, either continue mobilization of the rectal stump or perform an end-to-side anastomosis 5 cm away from the rectal transection line.

Special Considerations and Complications

The Reoperative Abdomen

While previous abdominal surgery may make a colectomy more difficult, it is not a contraindication to a minimally invasive approach. Whether the hand port or the camera port is placed first is determined by the prior abdominal surgery. If the previous surgery was in the upper abdomen (i.e., a cholecystectomy), a lower midline hand port can be placed first as described above. Once the incision is made and it is confirmed that there are no adhesions in the immediate area, the hand port is placed to feel around for adhesions to the abdominal wall. The first port is then placed in an area that is free from adhesions using the hand to guide the trocar in. The camera is inserted to inspect the abdomen and look for other adhesions. If adhesiolysis is required, a second port is placed under direct visualization in an area free from adhesions to use scissors, hook cautery, or advanced energy device for adhesiolysis. If necessary, the hand port incision is used to take down adhesions. Once adhesiolysis is completed and all ports are placed, the rest of the abdomen is inspected to make sure that the entire area of resection is visualized, that the small bowel is mobile and can be retracted out of the operative field, and that the colon can be mobilized adequately to create a tension-free anastomosis. If adhesions are too thick and any of these may not be possible, then conversion to open procedure may be necessary.

Morbid Obesity

Operating on the morbidly obese patient is more difficult on many different levels from anesthesia to closure of the wound. Positioning of the patient may be more difficult as it may be difficult to place them in lithotomy and to tuck the arms. It is critical to have them in lithotomy to perform the double-stapled anastomosis whether open or laparoscopic. It is ideal to tuck the arms, and sleds can be used to help secure the arms. In addition, placing the patient in Trendelenburg may cause difficulty in ventilating the patient. It is very important that there is good communication between the surgeon and anesthesiologist.

In addition to difficulty with positioning, there are intraoperative challenges. Extra long instruments are sometimes needed if the abdominal wall is very thick. The pannus needs to be taken into consideration while making incisions in terms of location on the abdomen and wound healing. The right-sided port is typically placed closer to the midline to make sure to reach the left colon and splenic flexure. Pneumoperitoneum might have to go to a higher pressure to get adequate visualization. Again, this requires constant dialogue with the anesthesiologist to make sure the patient is tolerating the pneumoperitoneum from a cardiopulmonary standpoint.

The obese patient often has more intra-abdominal fat, an enlarged liver, and thick omentum. These all make the surgery more difficult. The obese patient should always be counselled about the increased risks that come with doing surgery in this population, including increased rate of conversion, increased cardiopulmonary complications, increased DVT and PE risk, and increased wound complications.

Diverticulitis

When sigmoid colectomy is done for diverticulitis, inflammation, phlegmon, abscess, and colovesical fistula might be present. If suspected one or more of these, a ureteral stent can be placed. Due to distorted anatomy, it is critical to identify and preserve the ureter. The approach is adjusted based on where the inflammation is and how stuck the area is. Typically, dissection starts away from the area of inflammation toward it from above and below. With a hand port, blunt dissection with the hand is possible and an advantage compared to straight laparoscopy. This holds true for a colovesical fistula, as well. Once the fistula is taken down, the bladder is inspected to make sure that there is not a defect. Typically, the bladder can be treated with Foley catheter drainage for 5–7 days. A drain is placed adjacent to the bladder and a cystogram performed prior to removing the Foley. In cases where there is a significant defect in the bladder, it can be closed in two layers either laparoscopically or through the hand port.

Despite all best efforts and care to identify and preserve the ureter, injury to the ureter does occur. Placing a ureteral stent at the time of surgery can help the surgeon identify a ureteral injury, but it does not prevent injury. If a ureteral injury is identified intraoperatively, this is an indication to convert to open surgery at the discretion of the urologist.

Locally Advanced Cancer

Bulky tumor that invades adjacent organs can provide additional challenges to the operation but does not preclude hand-assisted laparoscopic approach. If intraoperatively the tumor is invading adjacent organs, it will be necessary to perform an en bloc resection with negative margins. With a hand-assisted approach, the tumor can be felt and the degree of invasion assessed including feasibility of achieving negative margins laparoscopically. For a sigmoid tumor, areas of local invasion most commonly include pelvic sidewall, bladder, and reproductive organs. For pelvic sidewall, it is important to identify the ureter and gonadal vessels. The decision to proceed laparoscopically will largely depend on surgeon experience and comfort.

Bleeding

With a hand-assisted approach, bleeding is more easily and rapidly controlled since the hand can apply pressure directly or pinch a bleeding vessel (Box 14.11). Once temporary control of the bleeding is achieved, the principles are the same as in open or laparoscopic surgery. The source of bleeding is identified and the vessel is dissected out to get proximal and distal control and then ligated. The bleeding can be managed with endoclips, advanced energy device, stapler, endo-loops, suture ligation, or conversion to open surgery.

> **Box 14.11. Tip**
> Laparotomy pads placed through the hand port help rapid visualization and can be used for packing.

Enterotomy

An enterotomy can occur at any point during sigmoid or left colectomy, including during entry and sweeping of the bowel or incidentally during any part of the operation. To avoid enterotomy, entry should be done via an open approach and the peritoneum entered sharply. If the patient has had prior surgery, extreme care should be taken, and initial entry should be done away from the prior site of surgery if possible. The trocars should be placed away from any adhesions and should be placed either directly into the hand of the surgeon or under direct visualization. If adhesions are present and it is not possible to place trocars, adhesiolysis should be performed after the first one or two trocars are placed. In positioning the small bowel, it is best to use sweeping with blunt instruments and or the hand and to avoid grasping the small bowel. Atraumatic graspers should be used throughout the case to avoid accidentally grabbing the bowel with an inappropriate grasper.

If there is an enterotomy, contamination should be controlled immediately. This can be done using a hand, a lap pad, or grasper. If the enterotomy is small, then it can be repaired with intracorporeal suturing. If it is large, it may require an open repair or resection and primary anastomosis. Oftentimes, this can be done open through the hand port by eviscerating the small bowel and replacing it once repaired to complete the surgery. If there is spillage, then the abdomen should be irrigated.

Inability to Identify Tumor

Typically all lesions should be tattooed 1–2 cm distal to the lesion. In a hand-assisted approach, a tumor can often be felt, however occasionally it cannot. If the tumor is not tattooed and the surgeon is unable to palpate the lesion intraoperatively, then intraoperative colonoscopy should be done. While the surgeon is performing endoscopy, the assistant is working in the abdomen and can place a stitch where the mass is located. The specimen is opened on the back table to make sure the tumor is seen with adequate margins.

Inadequate Length of Colon for Tension-Free Anastomosis

Occasionally while preparing the anastomosis and bringing the proximal colon down, there is tension or inadequate length to safely make the anastomosis despite splenic flexure mobilization and high ligation of the IMV next to the duodenum. If either of these scenarios occurs, open surgery should be done to perform either an ileal window or colonic derotation.

Summary

Hand-assisted laparoscopic surgery (HALS) has allowed for more surgeons to safely perform minimally invasive surgery and more patients to reap the benefits of laparoscopic colon surgery. However, it is important for surgeons to know and understand more than one approach and to realize that conversion to open surgery is not a failure but another alternative approach that will provide a safe operation for our patients.

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Sigmoid Colectomy and Left Hemicolectomy: Single-Port Laparoscopic Approach

15

Rodrigo Pedraza, Chadi Faraj, and Eric M. Haas

Introduction

Single-port laparoscopic techniques are utilized for various colorectal procedures. In this chapter, we will be describing the operative steps and differences to the multiport technique of a laparoscopic sigmoid resection and Hartmann's reversal.

Background

Single-incision laparoscopic surgery is an innovative minimally invasive modality in which the camera and instrumentation are placed through a single port. First introduced for gynecological procedures, single-incision laparoscopic surgery has successfully implemented in several general surgery fields including biliary, bariatric, and colorectal surgery [1, 2]. In 2008, the first single-incision laparoscopic colectomy was described [3] and since then has been proven to be safe and feasible for the management of benign and malignant diseases.

This technique consists of the performance of the entirety of the procedure via a mini-incision through which a single port is placed and the utilization of peripheral ports is eliminated. This approach is especially intriguing for colon procedures, since a small incision is already required to extract the specimen.

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_15. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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Single-incision laparoscopic colectomy affords clinical advantages over other minimally invasive techniques, such as reduced postoperative pain, quicker recovery, shorter length of stay, and improved cosmesis [4–8]. In addition, the absence of peripheral ports eliminates the possibility of port site-related complications such as bleeding, infection, hernias, and malignant recurrences.

The single-incision approach is associated with technical challenges, which may delay its ubiquitous adaptation. The close proximity among instruments as well as the collinear instrument configuration results in a functionally narrowed operative field. The tendency for internal and external instrument clashing often leads to awkward surgeon/assistant positioning (see Fig. 15.1). There are, however, some technical modifications that facilitate the completion of laparoscopic colectomy using the single-incision approach.

Room Setup and Positioning

The operating room equipment requirements are identical to those for any other laparoscopic procedure. The surgeon/patient configuration is a "surgeon-disease-screen" setup, which refers to surgeon location contralateral to the diseased segment of the colon, the patient, and the laparoscopic monitor in the ipsilateral side of the diseased colon. For sigmoid/left colectomy, the surgeon and assistant are located on the right side of the patient, while the monitor is on the left.

The patient is secured to the operating room table with both arms tucked in modified lithotomy position and in moderate Trendelenburg with the left side elevated. Anti-slip rubber pads can be used to avoid the patient from sliding off – for adequate patient securing. A "wrapped" technique securing the patient with a three-inch adhesive tape placed at the level of the chest provides tight securing yet allows appropriate chest wall expansion and air flow.

O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_15,

Fig. 15.1 External instrument conflict and clashing resulting in awkward surgeon/assistant positioning during single-incision laparoscopic colectomy

Port Placement and Extraction Sites

There are several single-port devices commercially available, including the SILS® Port (Covidien, Mansfield, MA, USA), GelPOINT® Advanced Access Platform (Applied Medical, Rancho Santa Margarita, CA, USA), and TriPort Access System (Olympus Corporation, Tokyo, Japan), among others (see Fig. 15.2). In addition, sealed hand-assist devices, such as the GelPort® (Applied Medical), may also be utilized for single-incision laparoscopic colectomy. In our institution, the majority of our experience is with the SILS® and GelPOINT® devices.

The SILS® port is a low-profile, one-piece device that allows easy insertion and removal. However, this device has several shortcomings including poor malleability, it is fixed with closely spaced port sites, and it has to be removed upon specimen extraction. The use of a fourth port, although is feasible, demands sacrificing the smoke evacuator. Furthermore, the incision cannot be extended, which restricts its use – especially in those with bulky specimen or thick subcutaneous fat. Another disadvantage is that the SILS® port tends to displace in patients with thick abdominal wall or during instrument torquing, thus releasing the pneumoperitoneum.

The GelPOINT® on the other hand, although more costly, is a more versatile device that allows multiple port placement, sacrificing neither CO_2 insufflation nor smoke evacuator. Moreover, the wound protector is included in the device and affords adjustment based on incision length and abdominal wall thickness.

In comparison with multiport laparoscopy, single-incision laparoscopic port placement is substantially simplified. The single-incision approach affords a straightforward abdominal entry under direct visualization, eliminating the risk for port site bleeding and/or internal organ damage.

For sigmoid and left colectomy, the single-incision device is typically placed through a midline umbilical incision or

Fig. 15.2 Three of the many single-port devices available in the market. (**a**) SILS® Port (Covidien, Mansfield, MA, USA); (**b**) the GelPOINT® Advanced Access Platform (Applied Medical, Rancho Santa Margarita, CA, USA); and (**c**) TriPort Access System (Olympus Corporation, Tokyo, Japan)

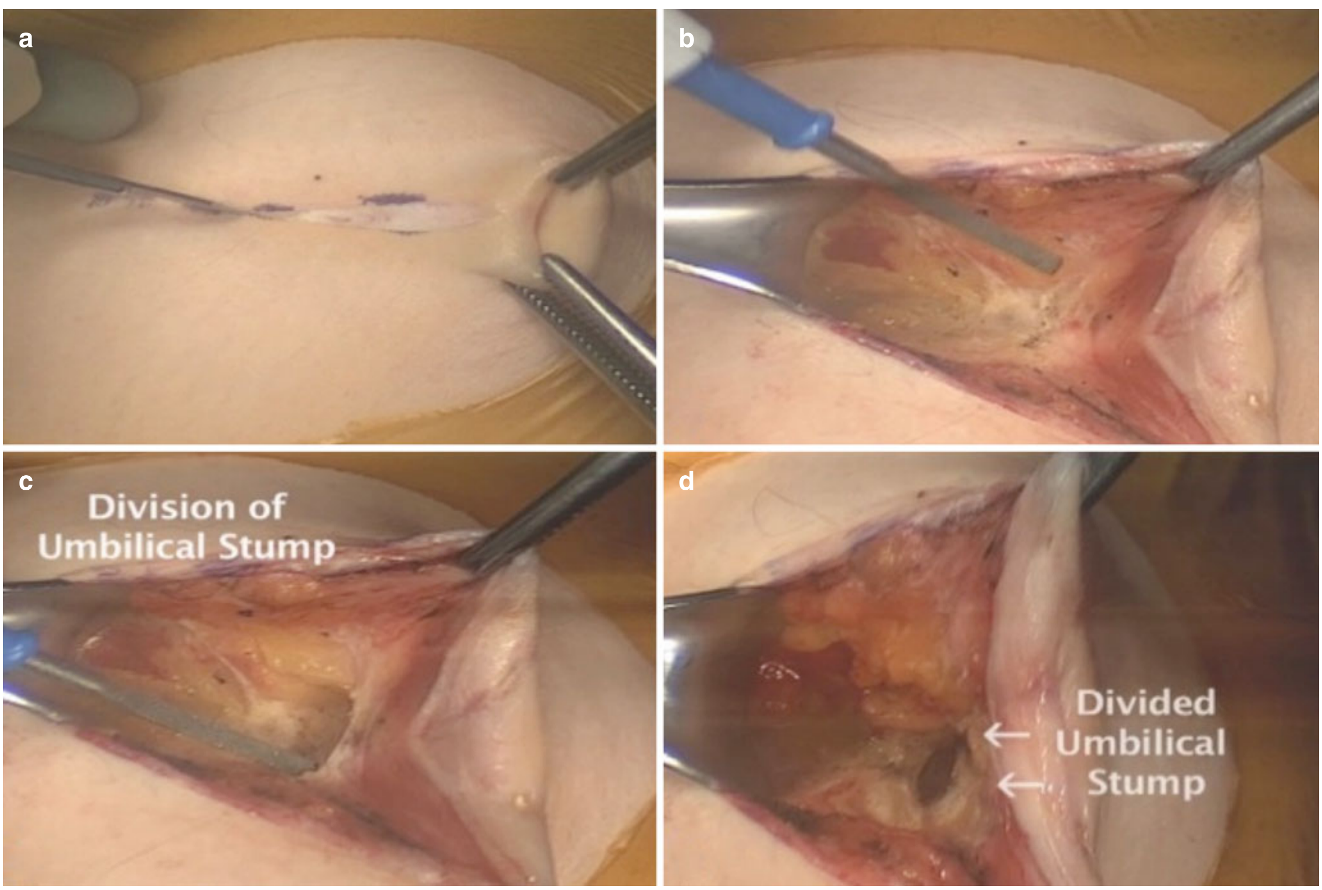

Fig. 15.3 Umbilical access through a 2.5–3.0 cm skin incision. After division of the skin and subcutaneous fat (**a**, **b**), the umbilical stump is identified and divided (**c**, **d**)

via a Pfannenstiel incision. Each of these location sites has benefits and shortcomings as compared with one another. An alternative access is through a Pfannenstiel incision with an additional 5 mm umbilical port for the camera (Single + 1 technique) (see port configuration).

The transumbilical access is performed through a 2.5–3.0 cm skin incision. After division of the subcutaneous fat, the umbilical stump is identified and divided (see Fig. 15.3). Since the umbilical stump is a natural fascial defect, its division allows an extension of the fascial incision to

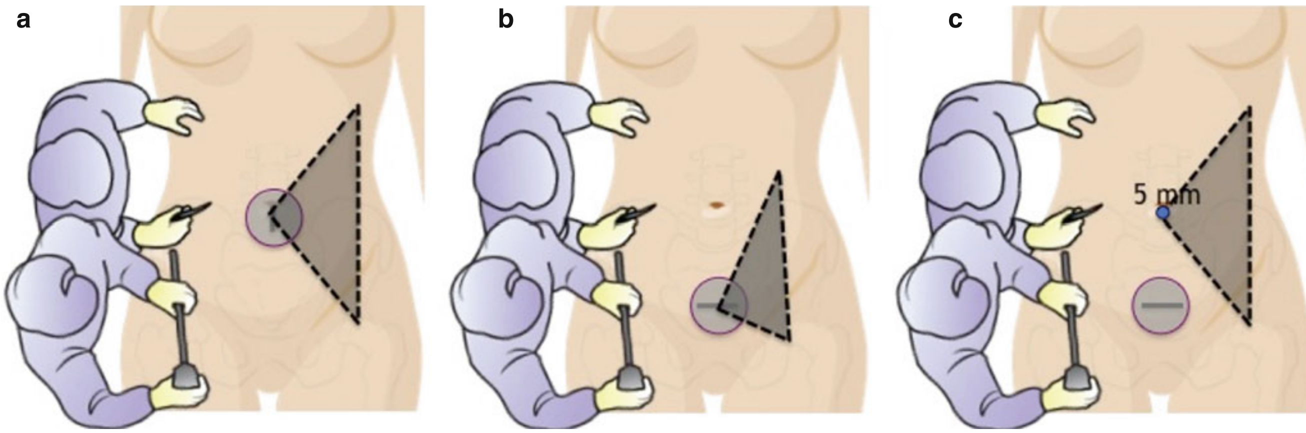

Fig. 15.4 Operative view perspective. The umbilical access (**a**) allows optimal view and reach to the distal transverse colon and splenic flexure and to the sigmoid and upper rectum. The Pfannenstiel access (**b**) has limited reach for splenic flexure takedown and restricts maneuverability due to the instrument close proximity to the target operative field. The "single + 1" technique (**c**) results in enhanced and expanded view, reduces instrument conflict, and facilitates access to the splenic flexure with the use of bariatric length instruments

approximately 5 cm, without requiring extension of the skin incision. This maneuver expands the port site, thus reducing instrument clashing and facilitating removal of bulky disease. The umbilical port location enhances versatility and maneuverability, as the instruments are located in the middle of the target operative fields (see Fig. 15.4a) – resulting in optimal reach to the distal transverse colon and splenic flexure and to the sigmoid and upper rectum. As such, this access location is considered more suitable for those surgeons early in their experience with the single-incision approach. However, as compared to Pfannenstiel incision, the umbilical access is associated with significantly higher hernia rates [9, 10].

For the Pfannenstiel incision access, a 3.5–4.0 cm skin incision is performed, and the peritoneal access is accomplished in a conventional fashion with a muscle splitting technique. This access affords enhanced cosmetic outcomes and lower hernia rates in comparison with the umbilical access. However, the Pfannenstiel incision access demands high laparoscopic technical skills and expertise. When introducing the laparoscopic instruments into the single-port device, they are located in extreme close proximity to the sigmoid and rectosigmoid. Therefore, this access restricts visualization, maneuverability, and range of motion. Additionally, reach to the splenic flexure is also limited due to the distance between the access site and the left upper quadrant (see Fig. 15.4b). Despite these challenges, there are technical modifications that allow the successful completion of the procedure using the Pfannenstiel access. In order to improve the visualization and view perspective of the operative field, an additional umbilical 5 mm port for the laparoscope may be utilized, resulting in the "Single + 1" technique (see Fig. 15.4c). This technique results in enhanced and expanded view, facilitated access to the splenic flexure, and reduction of instrument conflict. During the splenic flexure takedown, however, extra-long instrumentation is often required for retraction and reach.

The port placement itself depends on the specific device. The SILS® port placement is typically facilitated with the use of a curved clamp. The GelPOINT® insertion is achieved by introducing the Alexis® (Applied Medical) wound retractor, followed by the placement of the GelSeal® (Applied Medical) cap. In order to avoid injury, three trocars are inserted in a triangular fashion to the GelSeal® before its attachment to the wound protector component. Regardless of the type of device, once the single-port platform is placed, the instruments are inserted and the pneumoperitoneum is created.

Operative Steps (Table 15.1)

Insertion of the Single Port and Exploratory Laparoscopy

The procedure is initiated with exploration to assess the abdominal cavity and in cases involving malignant pathology, to evaluate the presence of distant metastases. When required, lysis of adhesions may also be performed promptly. In some occasions, adhesions are encountered upon entry to the peritoneal cavity. In such cases, it is often useful to perform adhesiolysis with the aid of laparoscopic visualization even before the placement of the single-port device and creation of pneumoperitoneum (see Fig. 15.5). This affords the release of bowel loops adhered to the abdominal wall and clears the fascial incision in order to safely place the device.

Table 15.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Insertion of the single port and exploratory laparoscopy	1
2. Mobilization of the sigmoid colon, identification of the left ureter, and ligation of the inferior mesenteric artery	6
3. Mobilization of the descending colon and splenic flexure with identification and ligation of the inferior mesenteric vein	6
4. Transection of the sigmoid colon	5
5. Anastomosis with leak test	2

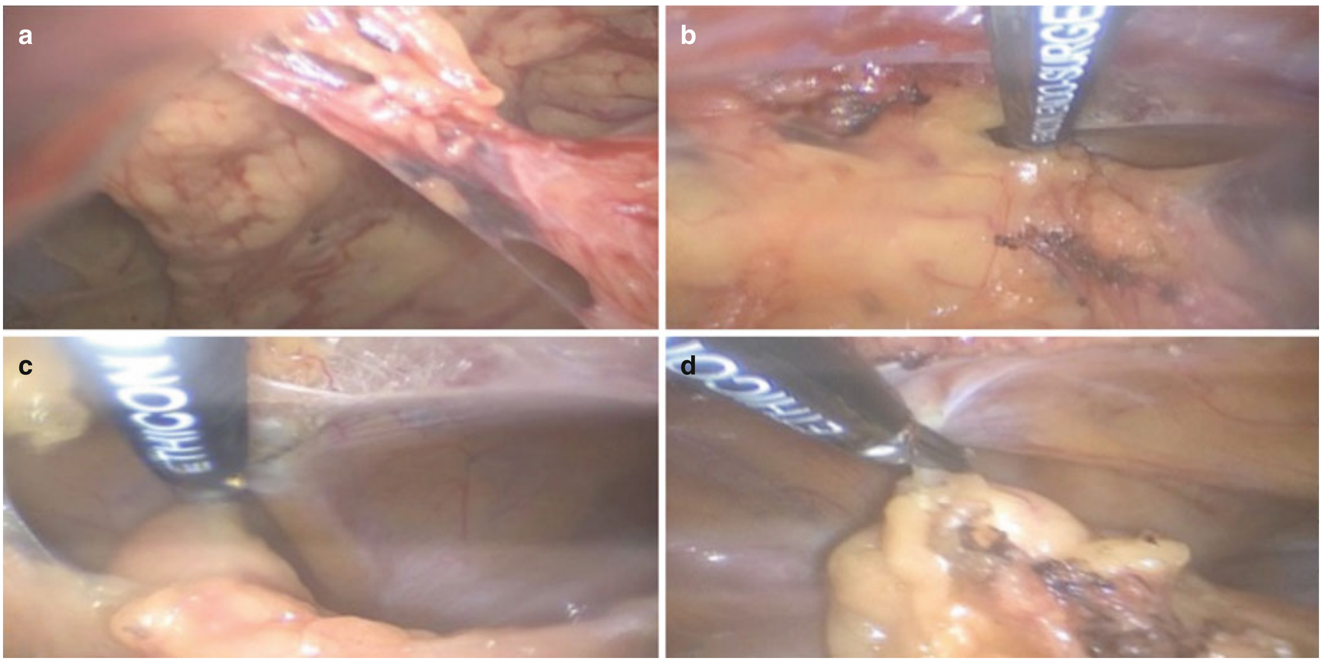

Fig. 15.5 "Pneumoless" lysis of adhesions may be accomplished prior the port placement to ensure safe abdominal cavity entry (**a**–**d**)

Mobilization of the Sigmoid Colon, Identification of the Left Ureter, and Ligation of the Inferior Mesenteric Artery

Following the laparoscopic exploration and taking advantage of the gravity with proper patient positioning – Trendelenburg and left-side elevation – the small bowel is retracted out of the operative field superiorly and to the right (Box 15.1). The rectosigmoid is identified and retracted laterally by countertraction, and a peritoneal incision is made medially at the level of the sacral promontory – with sharp incision or with monopolar energy such as the hook monopolar energy device (see Fig. 15.6a). Precise incision into the correct plane can be confirmed by the appearance of pneumo-dissection, which is characterized by bubble-like configuration expanding into the avascular areolar tissue (see Fig. 15.6b). Such pneumodissection in the avascular plane facilitates a clean precise dissection in a bloodless field. The presacral avascular plane is further developed with a tissue-sealing bipolar or other energy device, utilizing blunt and sharp dissection while maintaining hemostasis. A triangulation technique is utilized to further deepen the plane (see Fig. 15.7b). This technique facilitates exposure and dissection of the retroperitoneal plane with minimal clashing. In this technique, one instrument serves to elevate the tissue, while the other instrument carries out the dissection. It should be noted that triangulation technique is one of the cornerstones for successful completion of a single-incision laparoscopic approach and requires a medial-to-lateral dissection (see Video 15.1).

Box 15.1. Tip
Incising the peritoneum and continuous medial-to-lateral dissection proximal to the IMA (instead of distal at rectosigmoid junction) often times facilitate identifying the ureter due to the camera and instruments reach from a periumbilical single port.

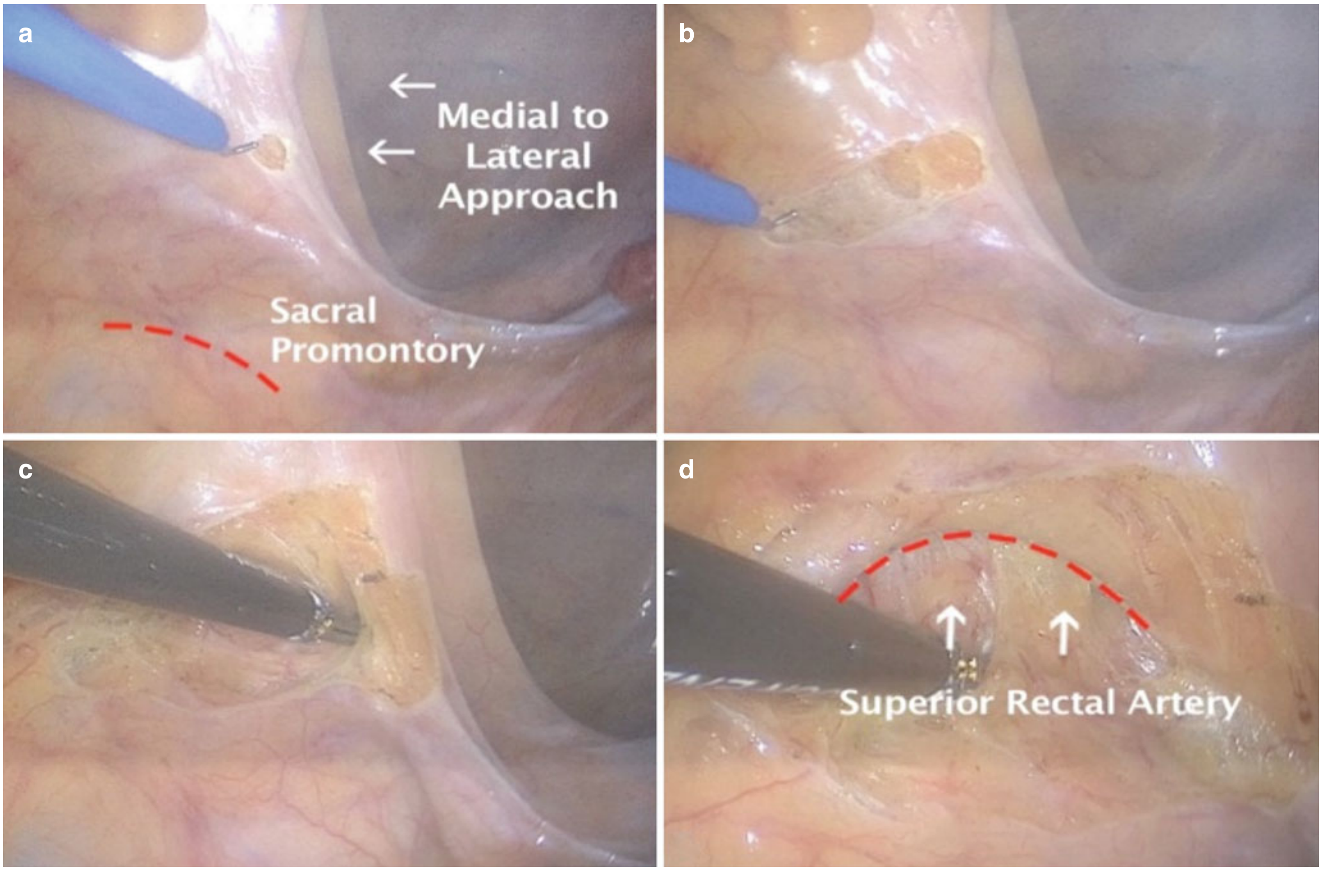

Fig. 15.6 Peritoneal incision to enter the presacral plane. The sacral promontory serves as anatomic landmark for the incision (**a**). The correct plane can be confirmed by the appearance of pneumo-dissection, characterized by bubble-like configuration expanding into the avascular alveolar tissue (**b**, **c**). As the plane is further developed the superior rectal artery is identified (**d**)

At this point of dissection, it is imperative to maintain dissection along the correct planes and avoid deeper planes so as to prevent splanchnic nerve injury. The superior rectal artery is identified, and the dissection is carried out to isolate and ligate the artery (Fig. 15.7d). At this level, it is crucial to identify the left ureter (see Fig. 15.7c and Video 15.2).

In cases of malignant disease in which "high ligation" of the inferior mesenteric artery is required, a superior plane of dissection is required. The left colic artery is identified, grasped, and elevated (see Fig. 15.8a, b). A peritoneal incision immediately superior to the left colic artery is made using the bipolar sealing energy device (see Fig. 15.8c). This creates a window to the retroperitoneal plane. The plane is further developed superiorly to the Gerota's fascia along the inferior border of the pancreatic body and laterally to the white line of Toldt. The concept of single-incision triangulation technique becomes again evident (see Fig. 15.8d). The left ureter is identified and preserved (see Fig. 15.8c and Video 15.3). The dissection is carried out until the retroperitoneal plane is fully developed and the dissection cranial to the inferior mesenteric artery is completed. Attention is then drawn to the inferior mesenteric artery to accomplish complete vascular isolation (see Fig. 15.9a). At this level, the "eagle" sign is identified (see Fig. 15.9b). The "body" of the "eagle" corresponds to the inferior mesenteric artery, the superior "wing" to the left colic artery, and the inferior "wing" to the superior rectal artery (see Fig. 15.9b). The exposure of this sign indicates appropriate vascular isolation and identification. At this point, the base of the inferior mesenteric artery is divided, which is typically accomplished with a linear stapler (see Fig. 15.9c) or an advanced vessel sealer (see Video 15.4).

Mobilization of the Descending Colon and Splenic Flexure with Identification and Ligation of the Inferior Mesenteric Vein

The inferior mesenteric vein is readily identified and high ligated (see Fig. 15.9d). To complete left colon mobilization, the lateral attachments of the descending colon are taken down superiorly to the splenic flexure. This maneuver is

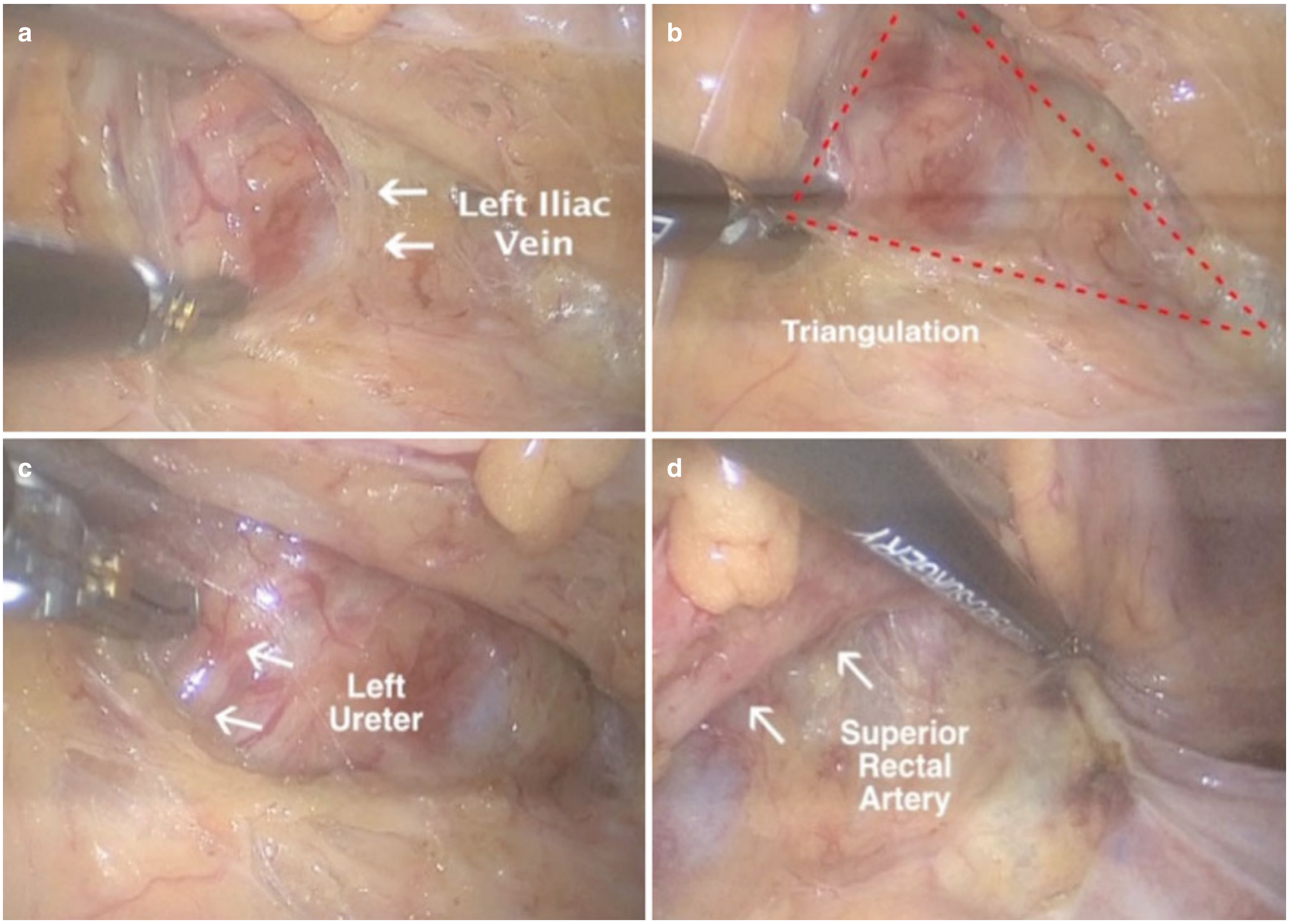

Fig. 15.7 Presacral plane dissection. A triangulation technique is utilized (**a**, **b**), which facilitates exposure and dissection of the retroperitoneal plane with minimal clashing. At this point, it is imperative to identify critical structures such as the left ureter (**c**) and the superior rectal artery (**d**)

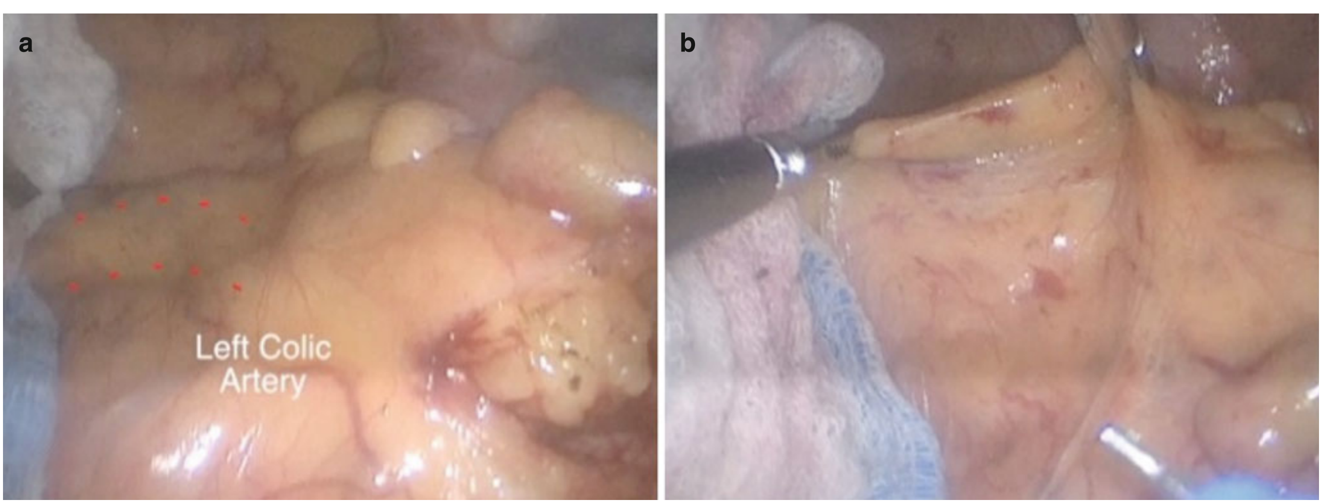

Fig. 15.8 Superior retroperitoneal plane dissection. The peritoneum is incised immediately superior to left colic artery (**a**, **b**). The retroperitoneal plane is developed superiorly to the Gerota's fascia along the inferior border of the pancreatic body and laterally to the white line of Toldt. The concept of single-incision triangulation technique becomes again evident (**d**). The left ureter is identified and preserved (**c**)

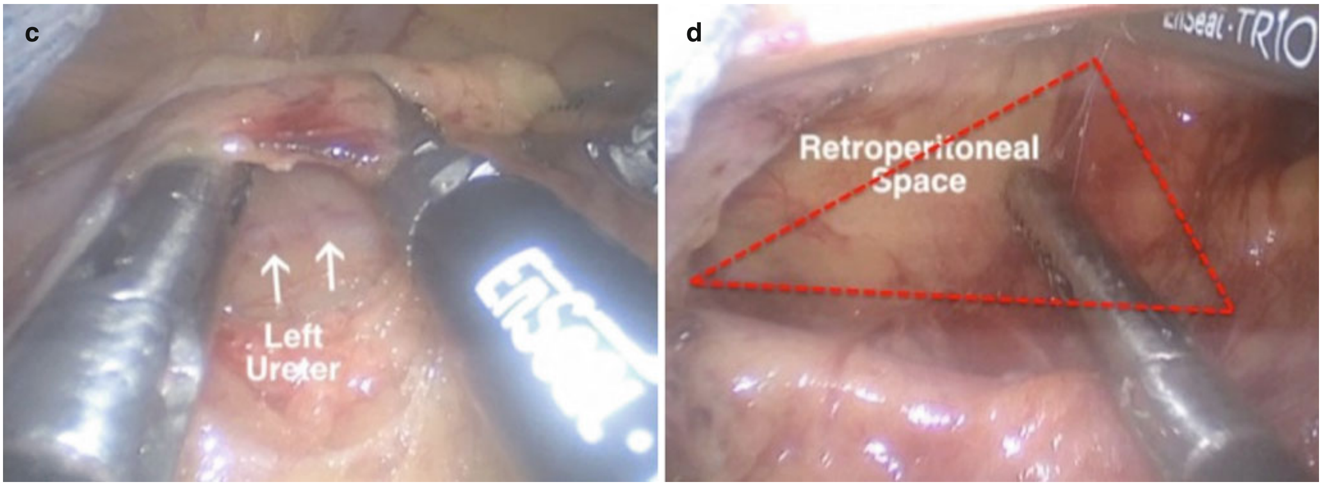

Fig. 15.8 (continued)

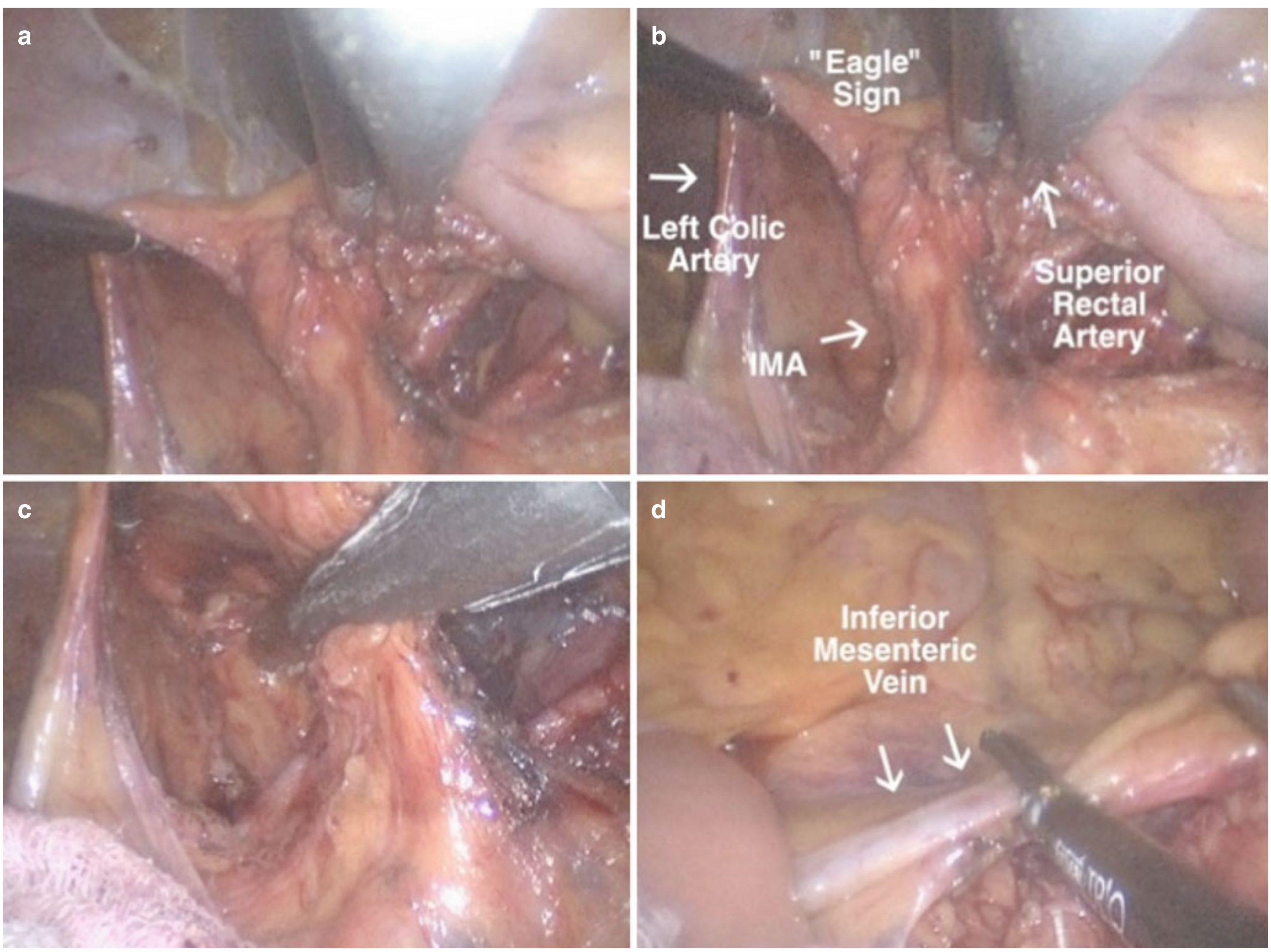

Fig. 15.9 The "eagle" sign and vascular division. The vasculature is isolated (**a**). The "body" of the "eagle" corresponds to the inferior mesenteric artery, the superior "wing" to the left colic artery, and the inferior "wing" to the superior rectal artery (**b**). The base of the inferior mesenteric artery is divided (**c**). The inferior mesenteric vein is readily identified and highly ligated (**d**)

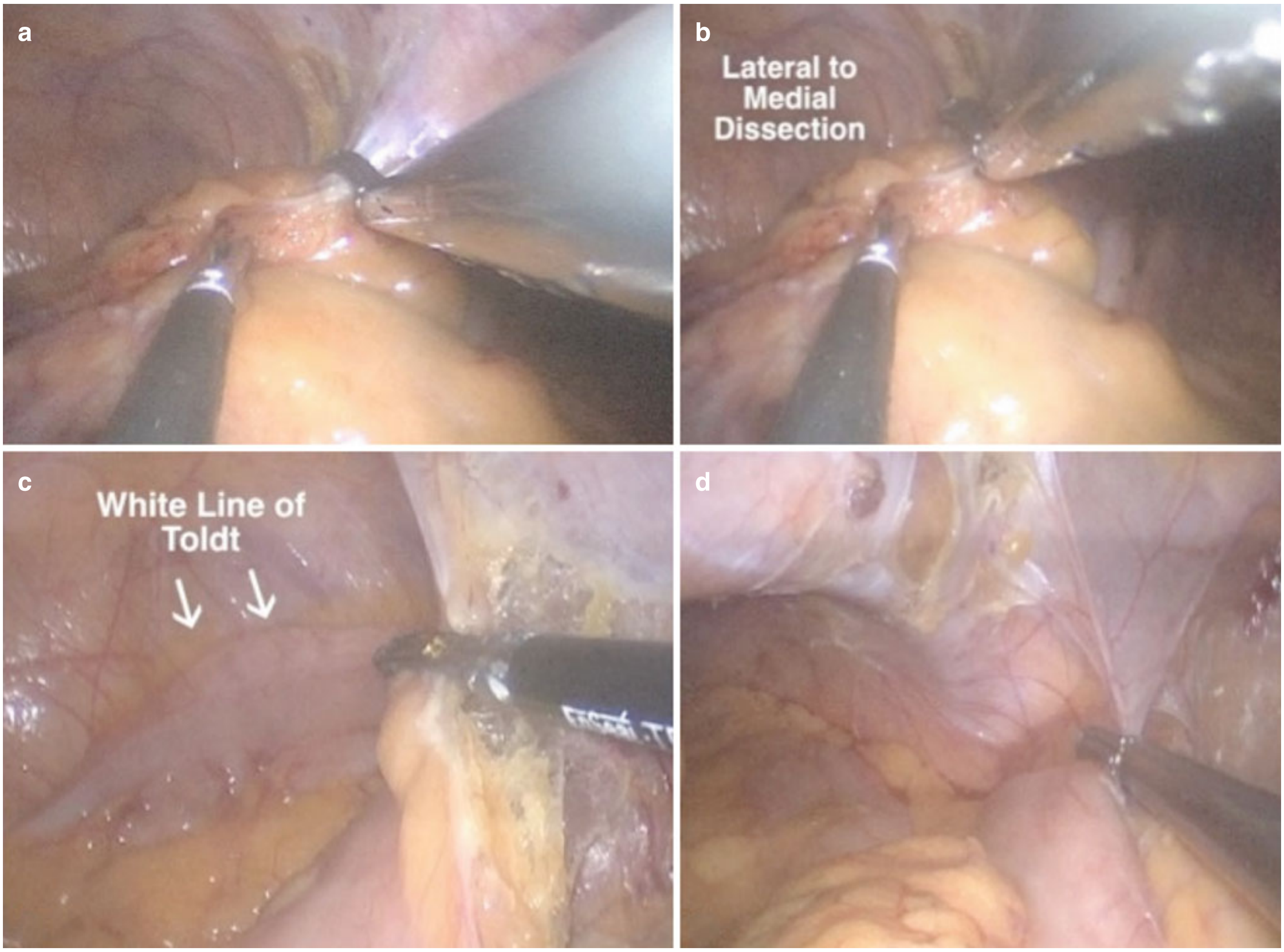

Fig. 15.10 Lateral-to-medial dissection. The lateral attachments of the descending colon are taken down while retracting the descending colon medially (**a**–**d**)

achieved with one instrument retracting the descending colon medially and the bipolar sealing device releasing the lateral attachments (see Fig. 15.10 and Video 15.5).

Transection of the Sigmoid Colon

Attention is drawn to specimen division. Additional rectosigmoid attachments are further released so as to achieve proper mobilization of the proximal rectum (see Fig. 15.11c, d). Often the mobilized bowel can be flipped to facilitate mesentery division. An incision in the mesentery is performed establishing a window (see Fig. 15.12a). The linear stapler is placed through this window and the mesentery is divided or taken down with an energy device (see Fig. 15.12b–d). The bowel is then flipped back to its normal anatomic configuration, and the rectosigmoid is divided with a linear stapler (see Fig. 15.13a, b and Video 15.6). The specimen is extracorporealized, and the division of the proximal bowel is performed (see Fig. 15.13c, d).

Anastomosis with Leak Test

An end-to-end anastomosis is performed with a circular stapler in a conventional fashion. The anastomosis is performed after reestablishing pneumoperitoneum and under direct laparoscopic visualization (see Fig. 15.14). Confirmation of a viable and intact anastomosis can be achieved both with direct endoscopic visualization and the absence of leak on the air insufflation test (see Video 15.7). If a leak is noted, consideration of conversion to a laparoscopic technique for revision of the anastomosis is warranted. In extreme cases, proximal diversion may be required.

Approaches

Left/sigmoid colectomy may be performed in a lateral-to-medial or medial-to-lateral approach. The lateral-to-medial approach is typically utilized for open resections, whereas the latter is typically used for the laparoscopic approach.

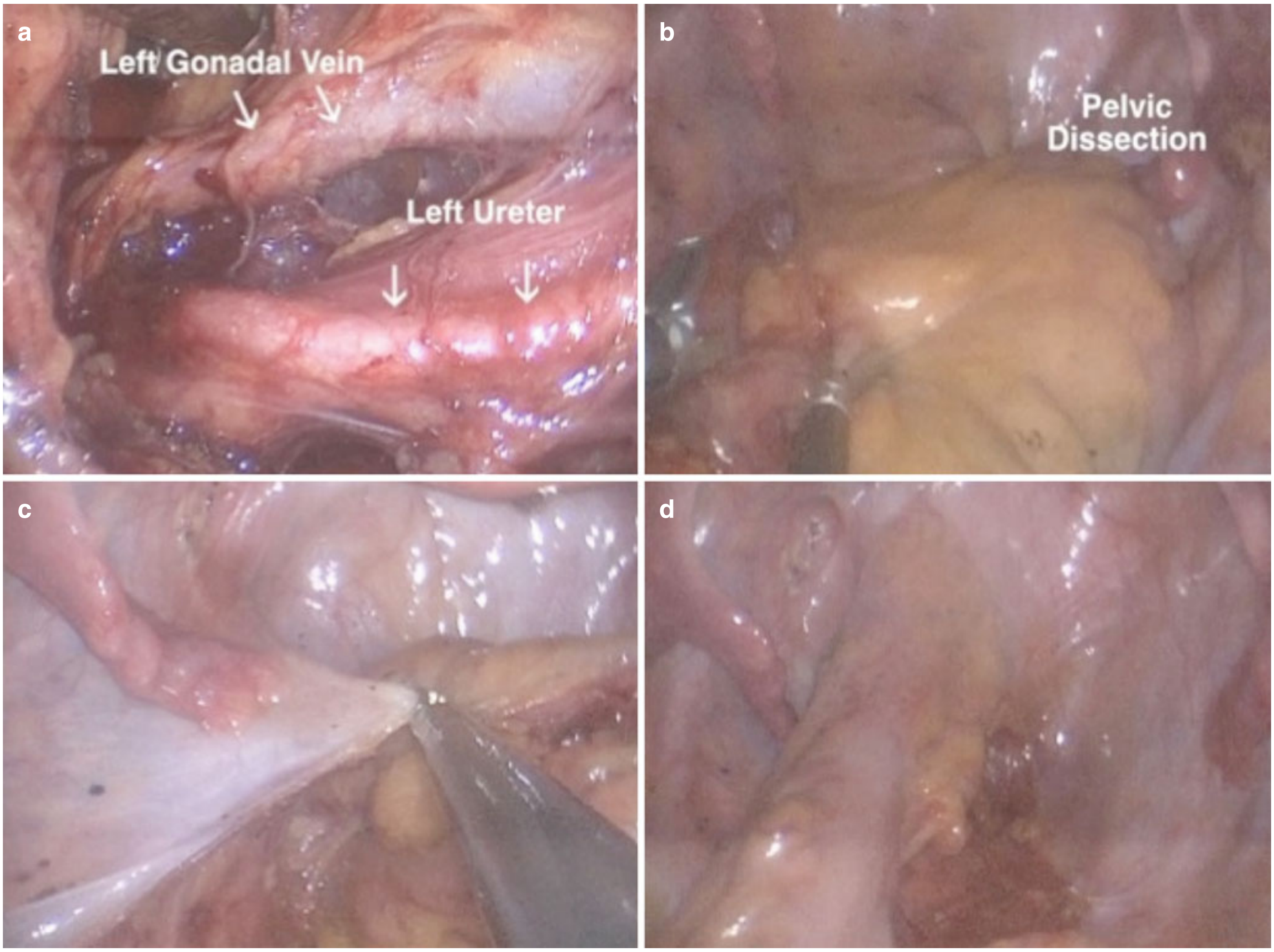

Fig. 15.11 Rectosigmoid attachments release. Additional rectosigmoid pelvic attachments are further released to achieve proper mobilization of the proximal rectum (**a**–**d**)

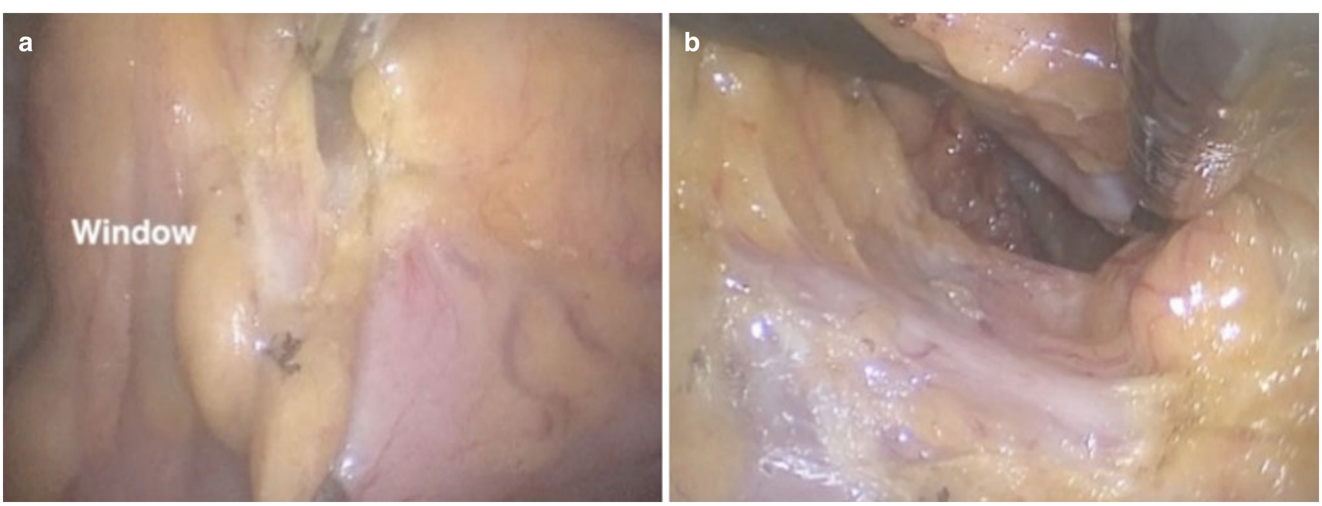

Fig. 15.12 Rectosigmoid mesentery division. The mobilized bowel can be flipped to facilitate mesentery division. An incision in the mesentery is performed establishing a window (**a**) through which a linear stapler (or energy device) is placed. The mesentery is divided (**b**–**d**)

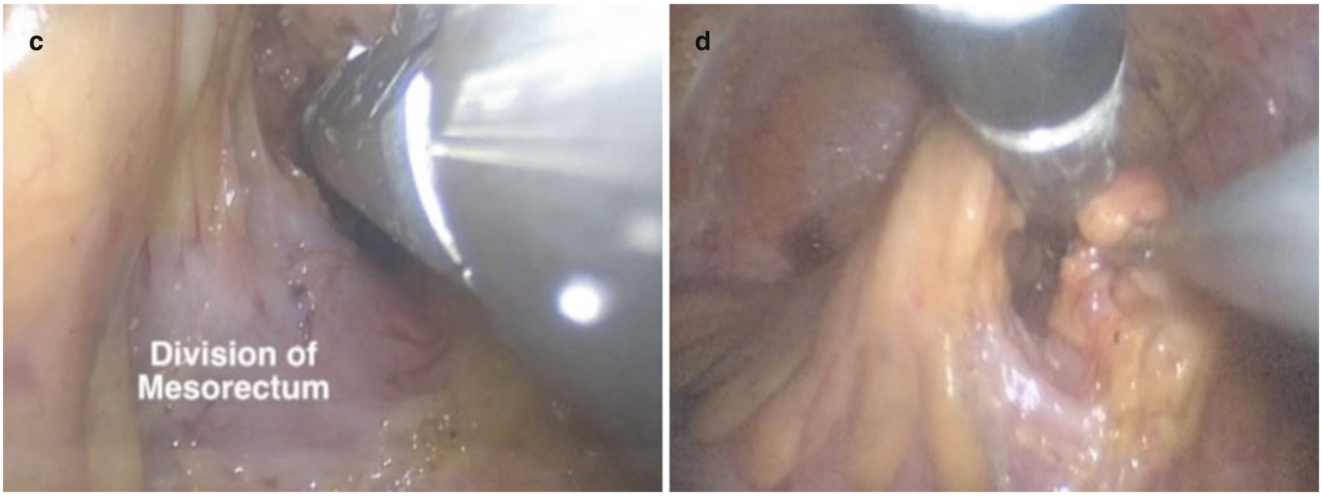

Fig. 15.12 (Continued)

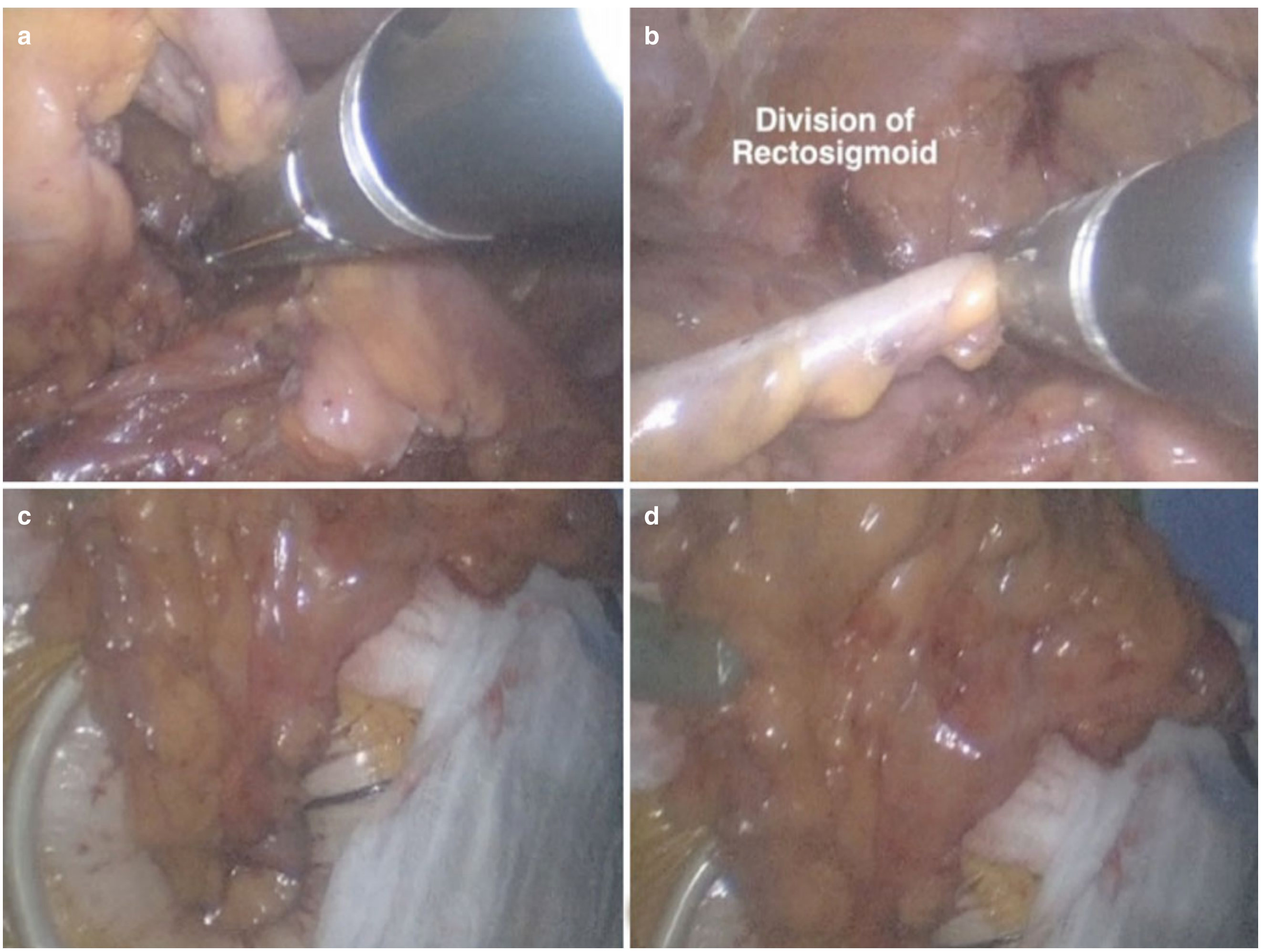

Fig. 15.13 Rectosigmoid division and extracorporealization. The rectosigmoid is divided with a linear stapler (**a**, **b**) and the bowel is extracorporealized to divide it proximally (**c**, **d**)

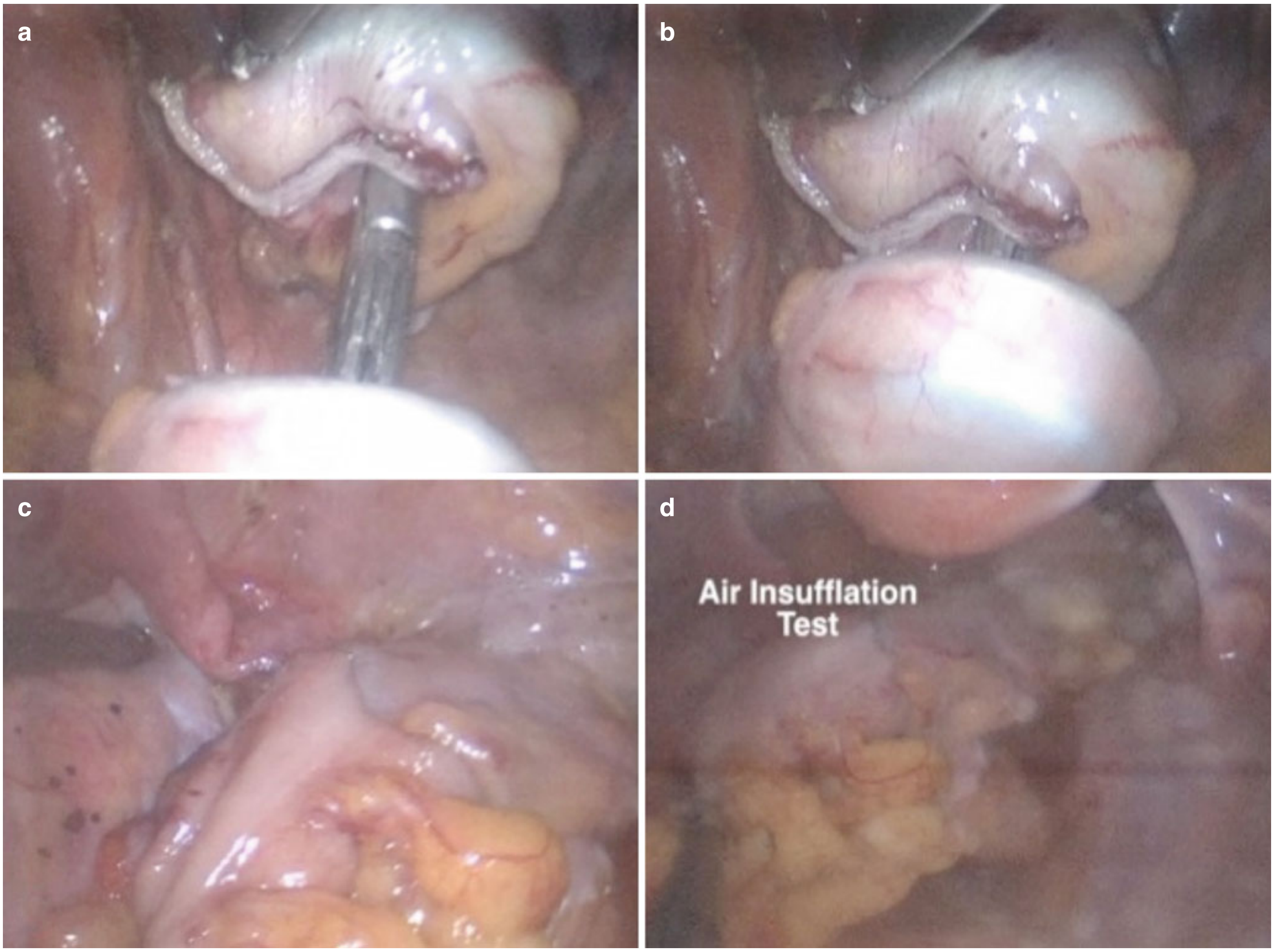

Fig. 15.14 Colorectal anastomosis. An end-to-end anastomosis is performed with a circular stapler in a conventional fashion. The anastomosis is performed after reestablishing pneumoperitoneum and under direct laparoscopic visualization (**a**–**c**). An air insufflation test may be performed to confirm the viability and integrity of the anastomosis (**d**)

For the single-incision laparoscopic technique, the medial-to-lateral approach is more suitable. This approach enables the identification and preservation of critical structures – left ureter, pelvic plexus, and iliac vessels – early in the procedure and facilitates the "triangulation technique," which is crucial for single-incision colectomy (see above). Furthermore, the lateral attachments of the descending colon to the abdominal sidewall serve as fixed point facilitating the medial-to-lateral retroperitoneal dissection. In addition, the instruments are located in the midline; thus, it is more ergonomic to dissect forward laterally rather than backward from lateral to medial.

Single-Port Laparoscopic Reversal of a Hartmann's Resection

Laparoscopic reversal of a Hartmann procedure is a minimally invasive procedure that can afford to the patient many short-term benefits as compared with open surgery [11, 12]. In addition to the avoidance of a large incision, laparoscopic Hartmann's reversal is associated with a reduction of surgical blood loss, postoperative morbidity, and length of stay [11–14]. Consequently, laparoscopic Hartmann's reversal has gradually gained acceptance and widespread adaptation.

More recently, single-incision laparoscopic Hartmann's reversal was introduced [15, 16]. In this technique, the entirety of the procedure is performed via the ostomy site in which the single-incision device is placed. As with conventional laparoscopy, the single-incision approach affords thorough assessment of the abdominal cavity, lysis of adhesions, and bowel resection if required. In contrast to conventional laparoscopic surgery, however, single-incision Hartmann's reversal completely avoids the use of additional ports and incisions, eliminating the associated morbidity. Hence, this procedure may be one of the most beneficial for the single-incision laparoscopic modality.

The reversal of the Hartmann procedure may represent a challenge, especially in cases with history of severe inflammatory reaction. Entering through the ostomy site is often faced with parastomal hernia sac and adhesions. If one cannot release the adhesion safely under direct visualization, the laparoscopic approach can aid in visualization before the pneumoperitoneum is established. In cases in which the abdominal entry through the ostomy site is unsafe or the placement of the single-port cannot be achieved, consideration of multiport is prudent.

It is imperative to perform a comprehensive preoperative assessment. Proctoscopic evaluation in the office setting is typically required to evaluate the rectal stump. As an aid for the identification of the rectal stump during the reversal procedure, it may be tattooed during proctoscopic examination. An abdominal CT scan may be also warranted so as to evaluate the presence of an abscess, in which case, a percutaneous drainage and antibiotic therapy are indicated prior to the reversal. Water-soluble contrast enema is indicated if there is the suspicion of a sigmoid remnant in the rectal stump, which demands its resection during the reversal. The timing for Hartmann's reversal remains controversial. Numerous studies have shown safe Hartmann's reversal following 10–15 weeks of the index procedure. It should be noted, however, that the preoperative clinical judgment in a case-by-case basis is the best indicator for optimal reversal timing. In fact, in some cases of severe diverticulitis, other procedures such as laparoscopic lavage may be warranted prior to considering the reversal procedure.

Surgical Technique

The surgeon/patient configuration during single-incision laparoscopic reversal of Hartmann's operation varies to that of left/sigmoid colectomy. Since the single-incision device is going to be placed at the ostomy site, the surgeon and assistant are located at the patient's left side. Conversely, patient positioning is identical to that described for left/sigmoid colectomy.

The colostomy is freed in a conventional fashion. A circumferential skin incision around the colostomy is performed and further deepened to the underlying fascia and peritoneum. In order to completely release the colostomy, further lysis of adhesions may be required. Once completely mobilized, the exposed colostomy is stapled across in a tangential fashion and the bowel is replaced into the peritoneal cavity.

The single-incision device is placed in the ostomy site and the trocars are introduced through the port. The peritoneal cavity is evaluated, and further lysis of adhesions is performed as required to mobilize the proximal bowel in anticipation of a tension-free anastomosis. This often requires splenic flexure takedown. These steps can be extensive and technically challenging and may comprise a significant portion of the procedure. The rectal stump is then identified. The stump is often adhered to the adjacent tissues and care should be taken to mobilize the portion required to achieve an anastomosis. The utilization of an EEA stapler placed transanally may facilitate retraction. The rectum itself may require partial mobilization to facilitate the placement of the stapling device transanally. The proximal colon is extracorporealized and an end-to-end colorectal anastomosis is performed as previously described.

Summary

Single-incision laparoscopic surgery is a safe and effective minimally invasive alternative for diseases requiring left or sigmoid colectomy. The procedure typically commences with laparoscopic exploration followed by the mobilization of the rectosigmoid entering to the presacral avascular space and with early identification of the ureter and critical vascular structures. The left colon is then mobilized medial-to-lateral and inferior-to-superior to the splenic flexure followed by the IMA division. The descending colon lateral attachments are then taken down from the pelvic brim to the splenic flexure. The bowel is then transected and an end-to-end anastomosis is performed. The utilization of the triangulation technique facilitates tissue dissection and avoids instrument conflict and clashing.

Single-incision laparoscopic Hartmann's reversals, although recently described, have shown to be a safe and feasible approach. This technique avoids the necessity for additional incisions, as the entirety of the procedure is performed through the colostomy site. Once the colostomy is mobilized, the single-port device is placed and abdominal lysis of adhesions as well as rectal stump mobilization is performed in a single-incision laparoscopic fashion. The anastomosis is performed in a conventional fashion utilizing an end-to-end stapling device.

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Sigmoid Colectomy and Left Hemicolectomy: Robotic Approach

16

Rodrigo Pedraza and Eric M. Haas

Introduction

Following the overview of laparoscopic techniques to sigmoid resection and Hartmann's reversal in the previous chapters, we will expand on the utilization of the da Vinci robotic system for this procedure. Certain operative steps described in this chapter are part of a total robotic low anterior resection and proctectomy described in a later chapter for this book.

Background

Robotic-assisted laparoscopic surgery was first introduced to colorectal surgery in 2002 [1] and has since been shown to be safe and feasible for various colorectal procedures including colectomy, rectal resection, and rectopexy [1–4]. Currently, the majority of cases involve rectal resection and total mesorectal excision for rectal cancer. These cases tend to accentuate the benefits of the unique features of the robotic platform, since the majority of the procedure involves confined spaces in the pelvic cavity.

The benefits of robotic-assisted laparoscopic surgery include three-dimensional visualization, stable camera, motion scaling, and wrist-like movements of the tip of the instruments. These features facilitate visualization, maneuverability, and dissection, especially in confined and narrow operative fields such as the pelvis. However, the robotic approach for procedures involving multiple quadrants may be cumbersome and require robot re-docking and patient repositioning, which may add to the complexity of the case. Thus, when utilized for left/sigmoid colectomy, a hybrid approach may be a suitable alternative. In this approach, conventional laparoscopy is utilized for lysis of adhesions and splenic flexure takedown followed by robotic technique for the remaining colon dissection (Box 16.1).

> **Box 16.1 Tip**
> The introduction of the robotic vessel sealer and stapling device expands the use of wristed instruments with increased maneuverability for abdominal procedures.

The most common indications for robotic left/sigmoid colectomy include adenocarcinoma of the colon, complicated diverticulitis, and large polyps not amenable to endoscopic removal [4]. Other less common indications include resection rectopexy for rectal prolapse and inflammatory bowel disease. The utilization of robotic left/sigmoid colectomy for benign pathologies has been advocated as a bridge to attain competency on one learning curve before entering into more complex procedures, such as rectal resection with total mesorectal excision.

Room Setup and Positioning

The operating room configuration varies depending on the operating suite design. The operating room should be large enough to accommodate the three robotic surgical system components (cart, console, and video tower). For left colon/sigmoid procedures, the video tower and robotic cart are typically on the left side of the patient and the assistant is located in the right side (Box 16.2).

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_16. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_16, © Springer Science+Business Media New York 2015

Box 16.2 Tip
When the patient is placed in stirrups, the patient should be positioned in Trendelenburg and left-side up positioning to check that the patient's left knee in the stirrups will not intervene with the docking.

The patient is secured to the operating table with both arms tucked and placed in modified lithotomy position in moderate Trendelenburg with the left side elevated. This positioning will allow for the initial laparoscopic exploration. One must be cognizant that in order to take advantage of the gravitational forces during the robotic segment of the procedure, the patient may be placed in steep Trendelenburg position. Care must be taken so as to ensure that the patient is adequately secured to the operating room table. In our institution, we employ a "wrapped" technique. This entails securing the patient to the operating room table with a 3-in. silk tape at the level of the upper chest in a secure fashion, yet allowing chest expansion. Anti-slip rubber pads may be alternatively utilized so as to prevent the patient from sliding while in a steep Trendelenburg position. It should be noted that improper positioning may result in significant injury. Furthermore, patient positioning cannot be altered once robotic docking is achieved.

Port Placement and Extraction Sites

Port placement varies depending on several factors, including location and type of disease process, body habitus, and preoperative clinical/radiological evaluation (Box 16.3). Additionally, port placement will often vary on surgeon experience and preference. The optimal port configuration must be carefully planned preoperatively so as to avoid the need for additional incisions, unnecessary procedure interruptions, and instrument or robotic arm conflict. Initial entry is achieved typically starting with the 12 mm robotic camera port. This is either at the periumbilical region 2 cm to the right and 2 cm superiorly from the umbilicus or supraumbilical, similar to laparoscopic port placement. Commonly, initial entry is achieved by utilizing optical port entry technique (OptiView®, Ethicon Endo-Surgery, Cincinnati, OH), which allows direct visualization entry in a bladeless fashion. However, abdominal cavity entry may be performed through a Veress needle technique or other techniques in which the surgeon has experience. This can be established in the left upper quadrant (LUQ) at Palmer's point, followed by the optical port entry described above for the robotic camera port.

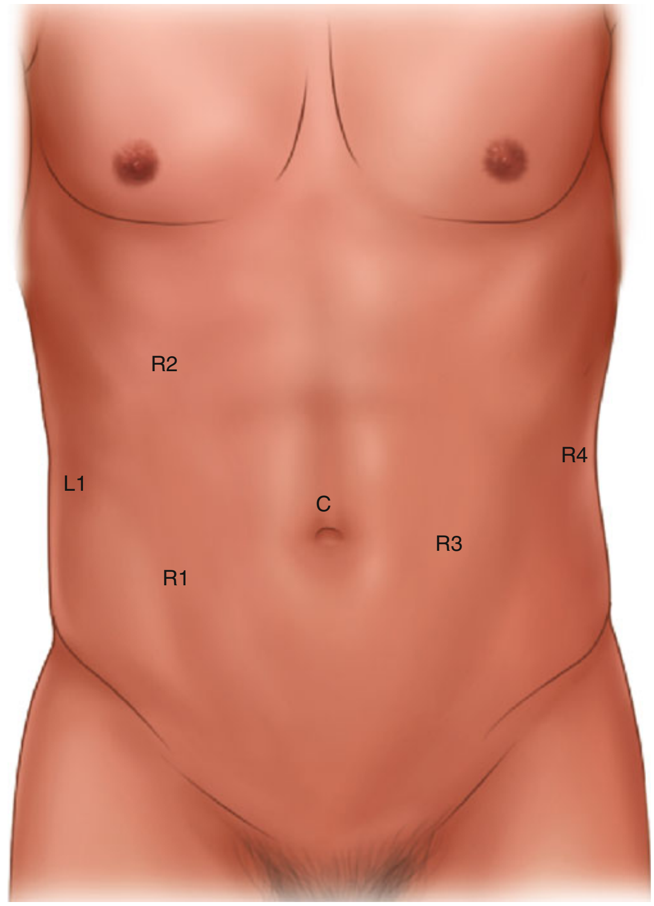

Fig. 16.1 Port configuration. *C* 12 mm camera port. *L1* 5 mm laparoscopic assistant port. *R1* and *R2* 8 mm robotic working ports for arms 1 and 2 during splenic flexure mobilizations. *R1*, *R3*, and *R4* 8 mm robotic working ports for arms 1, 2, and 3 for sigmoid colon and possible pelvic dissection

Box 16.3 Tip
Moving the camera port off midline to the right of the patient might improve the visualization of the base of the IMA.

Once the pneumoperitoneum is created, the remaining trocars are placed under direct visualization. Planned port sites should not be marked before the creation of the pneumoperitoneum, as the location usually alters following the incremental change in the abdominal girth.

Two port configurations are recommended. Figure 16.1 provides two working robotic instruments for the splenic flexure mobilization and three for pelvic dissection and therefore suited for the abdominal part of a total robotic LAR. Figure 16.2 provides three working robotic instruments for the splenic flexure mobilization and two for possible upper pelvic dissection and therefore suited for a robotic sigmoid resection.

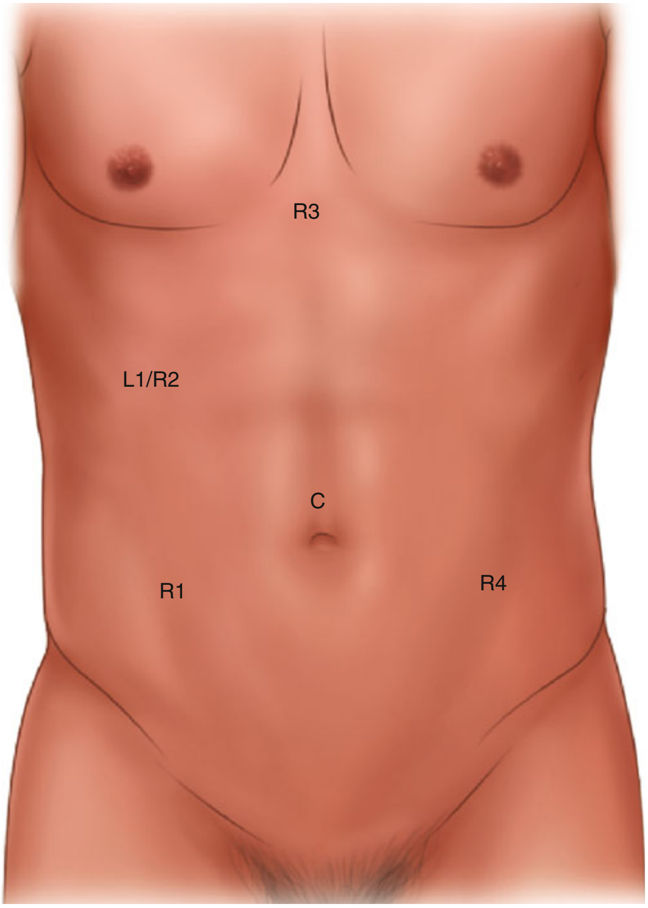

Fig. 16.2 Port configuration. *C* 12 mm camera port. *L1* 12 mm assistant port during sigmoid colon and possible pelvic dissections. *R1*, *R2*, and *R3* 8 mm robotic working ports for arms 1, 2, and 3 during splenic flexure and sigmoid colon mobilizations. *R1* and *R4* 8 mm robotic working ports for arms 1 and 2 during limited pelvic dissection

For port configuration 1, a 5 mm trocar as the assistant port L1 is placed in the right flank to help with the splenic flexure mobilization. A total of four 8 mm trocars are placed: one in the right upper quadrant (RUQ), the right lower quadrant (RLQ), left lower quadrant (LLQ) and left flank (see port configuration 1). It is important to follow an "8 cm rule" for port placement as depicted. This helps to standardize the port location, minimizing port variability and avoiding robotic arm collisions. The RUQ port R2 is placed 2 cm below the rib border at the level of the midclavicular line; this will aid in the mobilization of the proximal transverse colon and splenic flexure takedown. The RLQ port R1 is placed 8 cm lateral to the midline at the point of crossing with an imaginary line from the umbilicus to the anterior superior iliac spine. The ports R3 and R4 are reserved for the second part of the procedure, which involves pelvic dissection. The LUQ port R3 is placed 8 cm away from the camera port in a plane 2 cm inferior to the camera port. The left flank port is generally placed at the level of 2 cm superior to the anterior superior iliac spine. It is critical to avoid placing this port too lateral so as to prevent instrument clashing with the iliac bone during mobilization of the distal sigmoid colon and rectum. R1 and R2 are used for the splenic flexure mobilization.

Table 16.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy and robotic docking	1
2. Mobilization of the descending colon and splenic flexure with identification and ligation of the inferior mesenteric vein	5
3. Identification of the ureter and ligation of the inferior mesenteric artery	4
4. Mobilization of the sigmoid colon	2
5. Transection of the sigmoid colon	2
6. Anastomosis with leak test	2

In Fig. 16.2, the robotic port R2, now inserted through a 12 mm assistant port L1, is moved more inferiorly and the robotic port R3 moved toward the midline and superiorly (see Fig. 16.2). Robotic port R4 is mirrored with R1 and needed only if pelvic dissection is necessary.

The most common extraction site is the Pfannenstiel location as described below, but a muscle-splitting LLQ extraction site can be utilized if the final step of the anastomosis is performed under laparoscopic guidance. In this case, the LLQ port would be enlarged to a size to accommodate the extraction of the sigmoid colon through a wound protector.

Operative Steps (Table 16.1)

Here, we describe the robotic specific approaches to the six common steps of a sigmoid resection. As described in the section about the hybrid approach, the mobilization of the splenic flexure can be more challenging than the laparoscopic approach especially in the obese patient. If it is done in a single-docking technique, the medial-to-lateral approach is typically the only option. The lateral approach may be limited to a more time-consuming double-docking technique coming from the left shoulder.

Exploratory Laparoscopy and Robotic Docking

The procedure commences with laparoscopic exploration. At this point, the peritoneal cavity is thoroughly examined and adhesiolysis is performed, if needed. The robotic cart is typically docked on the left side of the patient's lower extremities in an acute angle. An alternative setup is placing the robotic cart between the legs of the patient. However, this configuration should be avoided if an intracorporeal anastomosis is anticipated, as it would require complete undocking to introduce a circular stapling device. Additionally, one must recognize that with the robotic cart placed between the legs, perineal access is hindered for transrectal or transvaginal specimen extraction. Therefore the left-side cart docking is favored, since it allows enhanced versatility, easier access to the left upper quadrant for full left colon mobilization, and a perineal approach. This configuration affords a safe colorectal anastomosis without undocking the robotic cart with a more reliable robotic-assisted suture repair, if needed.

Mobilization of the Descending Colon and Splenic Flexure with Identification and Ligation of the Inferior Mesenteric Vein

The first segment of the procedure involves mobilization of the descending colon with utilization of the retroperitoneal plane. The first robotic arm is placed in the RLQ port site R1, serves as the surgeon's dominant hand, and employs a monopolar energy device. The second arm is placed in the RUQ port site R2, serves as the surgeon's nondominant hand, and uses a bipolar energy device. The third arm is placed in the UM port site R3 and utilizes grasper forceps. The assistant port if available through the left flank port is employed for suction, irrigation, and retraction. During this portion of the procedure, the LLQ port is not used.

The small bowel loops are mobilized out of the operative field superiorly and toward the right. A medial-to-lateral approach for the left colon mobilization is favored to the lateral one due to often times restricted instrument length of the working instrument from the RLQ port to reach around the splenic flexure. This is further limited due to the robotic positioning coming from the left lower side of the patient. This technique allows direct dissection in the avascular retroperitoneal plane. In addition, traction and dissection of the medial retroperitoneal plane is facilitated with the descending colon partially fixed to the abdominal wall by its lateral attachments. This enhanced maneuverability permits prompt identification of critical structures such as the left ureter and vascular pedicles (see Video 16.1).

With the patient in the appropriate position and the small bowel retracted, the inferior mesenteric vessels are readily identified. At this junction, a peritoneal incision in an avascular plane is performed with the monopolar energy device creating a window proximal to the vascular pedicle into the retroperitoneal plane. The third arm grasper retracts the mesentery in an atraumatic fashion, while the second robotic arm tents up the peritoneum. The retroperitoneal plane is exposed and further developed with the first robotic arm. At this level, the inferior level of the retroperitoneal plane dissection is again completed in a medial-to-lateral fashion. The upper dissection is taken up to the inferior border of the pancreatic body and laterally to the white line of Toldt. It is imperative that during the retroperitoneal dissection, the left ureter is identified and preserved.

With the retroperitoneal dissection fully accomplished, the gastrocolic ligament is divided and detached from the distal transverse colon. Entry to the lesser sac is accomplished, and the splenic flexure is readily taken down and mobilized. The left colon mobilization is fully achieved with the takedown of the lateral attachments of the descending colon. This is accomplished in a superior-to-inferior approach from the splenic flexure to the descending-sigmoid colon junction or laterally (see Video 16.2).

At this level, the first segment of the procedure is completed, and robotic arm repositioning is required for the second portion if port configuration 1 is used.

Identification and Ligation of the Inferior Mesenteric Artery

While the robotic arm 1 remains unmodified, the robotic arm 3 is now placed in the left flank port R4 and the robotic arm 2 is placed in the LLQ port site R3. The robotic arm 1 serves as the dissection instrument, the arm 2 as nondominant surgeon hand, and the arm 3 serves to expose and retract. Note that the arms 2 and 3 may toggle back and forward to be used interchangeably (Box 16.4).

> **Box 16.4 Tip**
> Occasionally, the periumbilical camera port positioning will prevent to see the more cephalad retroperitoneum and identify the left ureter as the IMA pedicle will block the view. In this case, it might be helpful to switch between lateral and medial mobilization back and forth.

With the rectosigmoid retracted by the robotic arm 3, the peritoneum is incised at its base at the level of the sacral promontory, exposing the presacral avascular plane. This plane is entered and the tissues dissected in a medial-to-lateral direction (see Video 16.3). At this point, identification and preservation of the hypogastric nerves, left ureter, and gonadal vessels are accomplished. In cases of complex diverticulitis with effaced anatomy, friable tissues, and/or reactive retroperitoneal fibrosis, early ureterolysis is suggested to identify and release the ureter away from the dissection planes. This is accomplished utilizing the lateral-to-medial technique (see Video 16.4). Care must be taken to avoid injury to the left iliac vein, which typically arises from excessive lateral dissection.

With the retroperitoneal dissection developed up to the inferior border of the inferior mesenteric artery, the vascular "eagle sign" is now fully exposed. The "eagle wings" are represented by the left colic artery superiorly and the superior rectal artery inferiorly, whereas "eagle body" is represented by the inferior mesenteric artery.

The appropriate level of vascular division is decided based on the type and location of the pathology with division either at the level of the inferior mesenteric artery before or after the take off of the left colic artery. The vascular division can be accomplished with a robotic vessel sealer (see Video 16.3).

Mobilization of the Sigmoid Colon

Once divided, the third arm elevates the pedicle and the retroperitoneal plane is further dissected until it is completed (see Video 16.5). The remaining lateral peritoneal attachments are easily divided (see Video 16.6). If the medial-to-lateral dissection was not completed previously, the sigmoid colon is mobilized laterally similar to an open approach and the left ureter identified.

Transection of the Sigmoid Colon

Attention is then drawn to the distal bowel where the proposed level of division is identified. The mesentery corresponding to the distal resection is divided using the bipolar device for hemostasis. Once cleared of its mesentery, the bowel is transected using a robotic or laparoscopic linear stapling device.

Anastomosis with Leak Test

At this point, the arm 1 is undocked and rotated away from the patient to gain access, and a Pfannenstiel incision is then made. A wound protector is placed, and the bowel is extracorporealized. Prior to the anastomosis, the robotic arm 1 is re-docked and pneumoperitoneum is reestablished. An end-to-end anastomosis is performed utilizing a circular stapler under direct robotic visualization. The abdominal cavity is now explored to confirm adequate hemostasis, and the anastomosis integrity is affirmed by the air insufflation test. This consists of water instillation into the pelvic cavity followed by rectal air insufflation. If air leakage is noted, the anastomosis can be reinforced with stitches at the site of air leak and possible diversion performed. If technically possible, the anastomosis should be taken down completely and refashioned. If the robot is not re-docked, the LLQ 8 mm port can be also enlarged to an extraction site and the anastomosis performed under laparoscopic guidance.

Hybrid Approach

During robotic left/sigmoid colectomy, a hybrid laparoscopic/robotic approach can be an alternative approach. In this approach, the initial exploration, splenic flexure takedown, and partial left colon mobilization are performed using laparoscopic technique, and the abdominal/pelvic dissection is performed using the robotic technique. It is important to recognize that the port placement is selected based on the robotic portion of the procedure without requiring substantial modifications as compared to the purely robotic approach. In the hybrid approach, the port placement varies solely by the fact that the right upper quadrant port is not necessitated.

The hybrid approach is particularly beneficial for complicated diverticulitis. Conventional laparoscopy has limitations especially while operating in the pelvic cavity or when severe inflammatory disease is present; robotic surgery offers the merits of fine dissection, enhanced maneuverability, and optimal view. Accordingly, the hybrid approach expedites left colon mobilization and splenic flexure takedown with laparoscopy while dissecting distant from the active disease process; and the robotic portion is reserved for the dissection and tissue manipulation in close proximity with the inflamed sigmoid and adjacent structures.

The laparoscopic portion of the hybrid approach includes the medial-to-lateral dissection, inferior mesenteric vein division, and the creation and completion of the retroperitoneal plane superiorly. It also includes the lesser sac entry, splenic flexure mobilization, and the takedown of the lateral attachments of the descending colon. The superior "wing" of the "eagle sign" (i.e., left colic artery) is also exposed during the laparoscopic approach. The robotic cart is then docked utilizing Fig. 16.1. This portion includes the presacral and perirectal dissection as well as the full exposure of the "eagle sign" and the inferior mesenteric artery division. With the robotic cart docked, the specimen extracorporealization, division, and anastomosis are performed as described above.

Robotic Reversal of a Hartmann's Resection

Robotic-assisted laparoscopic reversal of Hartmann's operation is an uncommon indication for the utilization of the robotic platform for colorectal procedures but emphasizes the superiority of robotic dissection techniques for the pelvis and complex abdominal anatomy (Box 16.5). The procedure is ideal for patients with a short rectal stump or anticipation of a very narrow and deep pelvic anatomy with indistinct tissue planes. Typically, candidates for this approach have undergone a prior emergent or urgent sigmoid or rectosigmoid resection for malignancy or diverticulitis and have a short rectal stump. In this setting, the robotic technique may serve as an enabling modality facilitating meticulous dissection in areas with reactive fibrosis and obliterated tissue planes. Defining and isolating the rectal stump while avoiding injury to the adjacent pelvic structures requires advanced skills and expertise. The robotic instruments can furthermore facilitate minimal invasive dissection around the colostomy.

Box 16.5 Tip
The robotic instruments not only simplify rectal stump mobilization but also small bowel adhesiolysis deep in the pelvis and in a possible parastomal hernia.

Laparoscopic entry is achieved with an optical trocar or Veress needle in the LUQ; additional four ports are placed following the configuration previously described. Careful laparoscopic abdominal lysis of adhesions is performed.

In most cases, the left colon requires completion of mobilization with splenic flexure takedown to afford a tension-free anastomosis. Division of the inferior mesenteric vein at the level of the ligament of Treitz may be required to achieve necessary length. Left ureterolysis is recommended to avoid ureteral injury and to proceed safely with a lateral-to-medial approach. The lateral attachments of the descending colon are taken down in a cranial direction followed by mobilization of the splenic flexure.

The ostomy takedown itself is performed in a conventional fashion. The ostomy is mobilized laparoscopically and stapled tangentially with a linear stapler and is then released from the abdominal wall. The colon is extracorporealized and the anvil of a 29-circular stapler is placed with a purse-string suture and closed. The takedown can also be done after robotic pelvic adhesiolysis and freeing of the rectal stump. Parastomal adhesions can be lysed much easier using the wristed robotic instruments compared to laparoscopic instruments, which are typically more limited in their reach around and above the fascial level.

The patient is then repositioned and placed in steep Trendelenburg with left-side elevation. The robotic cart is then docked following the principles described above. Remaining small bowel is mobilized out of the pelvic cavity if not done previously with the help of better angulation and reach of robotic instruments. Often, small bowel adhesions in the pelvic region can be dense and cumbersome. In such situations, care must be taken to recognize and repair enterotomies or bowel wall injury that is inherent to the procedure. Meticulous robotic pelvic dissection is performed to release the rectal stump. The posterior dissection is carried out to the level of the levator ani and laterally to the lateral stalks. If a short stump is present, anterior mobilization is further accomplished through the Denonvilliers' fascia in men and rectovaginal septum in women.

Once the rectal stump has been mobilized, an end-to-end anastomosis is performed under robotic visualization with a circular stapler as described above. Alternatively, for *ultralow* rectal stumps, a hand-sewn coloanal anastomosis may be performed using a transanal perineal approach.

Summary

A robotic approach to a sigmoid colectomy and Hartmann's reversal is not only feasible, but increased dexterity of instruments and concurrent utilization of three working instruments by the surgeon may have a benefit over a laparoscopic approach for cases with complex pathology and anatomy.

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Part IV

Low Anterior Resection, Abdominoperineal Resection and Rectopexy

Proctectomy and Rectopexy: Laparoscopic Approach

17

Kyle G. Cologne and Anthony J. Senagore

Introduction

Procedures in the lower rectum can be particularly challenging for any surgeon. The bony pelvis constricts the amount of space available, particularly in males. Finding the right plane can be a difficult experience but is of paramount importance as it has oncologic, functional, and anatomic implications. This chapter seeks to explore three rectal procedures in depth: low anterior resection (LAR), abdominoperineal resection (APR), and rectopexy. Our goal is to describe techniques, pitfalls, and pearls that help the pelvic surgeon complete these procedures safely and efficiently.

Background

Low anterior resection allows preservation of the anal sphincters to maintain continence. As the name implies, the connection sits deep in the pelvis and requires removal of a varying amount of rectum, with an anastomosis below the level of the peritoneal reflection. The question becomes, how low can you go? No longer is the previous 5 cm distal margin considered a requirement. In fact, a margin of even 1 cm is considered an acceptable distance for an oncologic resection, although 2 cm is preferred if possible [1]. This is based on evidence that shows; while up to 10 % of rectal cancers may have distal intramural spread past 1.5 cm, only 2 % will have spread beyond 2 cm [2]. Intersphincteric dissection allows the surgeon to complete even a lower anastomosis. The debate among surgeons remains whether a distal margin can be altered by adjuvant therapy. It is unclear from the available literature whether tumor regression allows the safe migration of the distal transection line. Inability to obtain adequate distal margins necessitates an abdominoperineal resection.

After making the decision to operate, the surgeon must decide the approach: open, laparoscopic, or robotic. Each has its perceived advantages and disadvantages. From an oncologic standpoint, the available evidence shows that laparoscopic and open approaches are equivalent [3, 4]. There is less data on long-term robotic oncologic outcomes, but preliminary data show no difference in oncologic quality of specimens or recurrence rates [5, 6]. So it really comes down to the comfort level of the surgeon. The perceived advantages of robotic surgery include improved ergonomics, greater degrees of freedom, surgeon control of the camera, and three-dimensional visualization. These advantages do come at a cost, as robotic surgeries have a higher procedural cost and do not currently provide the surgeon with haptic feedback [6]. In addition, the learning curve for robotic procedures appears to be between 20 and 30 cases, during which time, procedures take significantly longer [7]. There are clear advantages to using a minimally invasive approach over traditional open surgeries. Length of stay, hospital costs, and complications are reduced with a minimally invasive approach [8]. A detailed discussion of these benefits is outside the scope of this chapter. Hand-assisted surgery is a combination of laparoscopic and open approaches. It will not be discussed specifically in this chapter, as the steps are similar to a laparoscopic approach and the technique is not utilized widely for a low anterior resection. Some have advocated its role may be as a bridge in a difficult surgery to prevent conversion to an open approach.

The critical elements of a proper technique are independent of the approach. The "holy plane" of rectal surgery is the key to performing a proper total mesorectal excision (or TME) (Box 17.1). This avascular plane tracks along the presacral fascia and can be opened along the potential retrorectal space.

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_17. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_17, © Springer Science+Business Media New York 2015

This allows preservation of the hypogastric nerves and removal of the rectum, perirectal fat, lymph nodes, and vascular supply as an intact unit. This step should be done sharply, using diathermy, and under direct vision. "Conventional surgery," which was performed bluntly by sweeping the surgeon's finger around the rectum to extract it by brute force, is not an acceptable means of proctectomy. Not surprisingly, adherence to maintaining appropriate planes has decreased local recurrence rates from almost 25 % with conventional surgery to 3–7 % with TME [1]. Some surgeons prefer the robot for this stage of the procedure. Whichever method is chosen, the key to success is good retraction and adequate visualization of the right plane.

Box 17.1 Tip
Overall increasing utilization of the minimal invasive approach to a proctectomy in a correct TME fashion should be the goal of the surgeon, who can then evaluate all available tools, which will help accomplish this goal best.

Room Setup and Positioning

Positioning becomes an incredibly important aspect of colorectal surgery, especially for rectal procedures. The modified lithotomy position allows access to the rectum for placement of a stapler or flexible endoscope. During a laparoscopic procedure, the surgeon relies on gravity to aid in retraction. Thus, a beanbag is a useful adjunct to allow steeper positioning in Trendelenburg, reverse Trendelenburg, and right and left tilt. Many surgeons also tape across the chest to prevent sliding. With patients in the modified lithotomy position, care should be taken to ensure the legs are appropriately positioned to prevent peroneal nerve injury. The lower extremity should point toward the contralateral shoulder, and there should be no pressure on the calf or lateral aspect of the leg. If conversion to an open procedure is possible, one should ensure there is room on the table for placement of a self-retaining retractor, should the need arise. This avoids unnecessary climbing under drapes to add table extensions, etc., during the procedure.

Port Placement and Extraction Sites

Port placement is a key to success to establish adequate reach to the deep pelvis (Box 17.2). In general, ports are placed 2–5 cm medial to the anterior superior iliac spine to allow less crowing of instruments and better triangulation for laparoscopic colectomy procedures. This general rule should be modified with more medial port placement for deep pelvic procedures, especially with the lower quadrant trocars. This is especially important in obese patients, where added length may be required for reach.

Box 17.2 Tip
Adequate port placement is a crucial element to allow reach into a narrow pelvis. Assess the port entry side, sacral promontory, and lateral pelvic inlet to determine how medial the lower quadrant ports need to move to allow reach of a straight instrument.

The camera port is placed in the periumbilical location similar to laparoscopic colectomy procedures. The surgeon's working ports L1 and L2 are placed in the right lower quadrant (RLQ) and right upper (RUQ) or right flank. The assistant's ports L3 and L4 are mirrored in the left lower quadrant (LLQ) and left upper quadrant (LUQ) or left flank. During the procedure the surgeon and assistant can switch sides for part of the rectal dissection. A 12 mm trocar is used for the RLQ port if the rectum in transected with an endoscopic stapler. An extra 12 mm port L5 may be placed in the suprapubic position to allow placement of a stapler or fan retractor to elevate the bladder or uterus (see port configuration in Fig. 17.1).

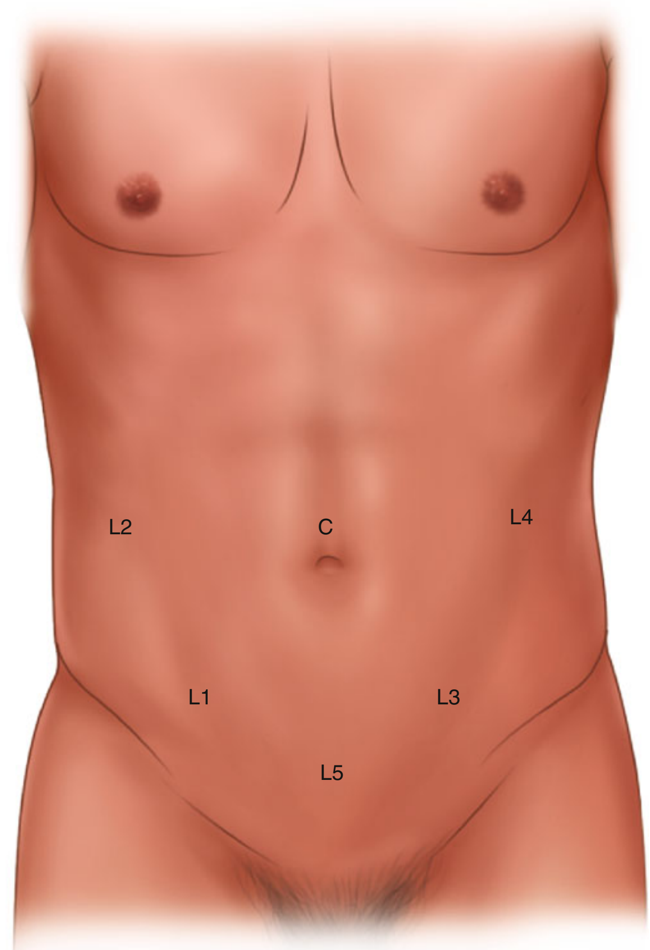

Fig. 17.1 Port configuration. *C* 5 or 12 mm camera port, *L1* 5 mm working port, 12 mm for endoscopic stapler, *L2* 5 mm working port, *L3* and *L4* 5 mm assistant ports, *L5* optional 12 mm port for endoscopic stapler

Various extraction sites can be utilized. A small Pfannenstiel incision has the distinct additional advantage for a low anterior resection to allow placement of an open (TA) stapler for distal transection. A right lower or left lower quadrant muscle-splitting incision can be also utilized offering decreased incisional hernia rates compared to a midline incision.

Operative Steps (Table 17.1)

The initial part of the surgery including vascular pedicle ligation and splenic flexure mobilization is performed similar to a laparoscopic sigmoid resection as described in a previous chapter (Steps 1–4).

Exploratory Laparoscopy

The method for initial access used depends mostly on surgeon preference. A Hasson or Veress needle technique is acceptable. Usually the camera port is placed first at or near the level of the umbilicus, based on the plan for future ports, presence of previous scars, and body habitus. A thorough examination of the abdominal cavity is performed to rule out metastatic disease.

Identification of the Ureter and Ligation of the Inferior Mesenteric Artery

The first step in radical resection for rectal cancer is identification and division of the inferior mesenteric artery or superior hemorrhoidal artery. Preservation of the IMA trunk allows collateral blood flow through the left colic artery and does not result in a decrease in oncologic outcome [9]. It may, however, limit the mobility of the descending colon provided with a high ligation technique (Box 17.3). Placing the sigmoid colon on stretch and incising the peritoneum medially along the right iliac artery from the base of the pedicle toward the pelvis and the peritoneal reflection identifies the IMA pedicle. There is often a subtle change in the color of the fat from yellow mesentery to a dull opaque overlying the area that should be incised (see Fig. 17.2). Careful blunt sweeps directly underneath the superior hemorrhoidal artery allow the retroperitoneal tissues to be swept posteriorly, especially the sympathetic nerves which lie directly below this pedicle. If in the correct avascular plane, these structures can be separated to allow identification of the ureter, which should be done before vascular division. Significant bleeding during this step implies one is too high in the mesentery or too low in the retroperitoneum. From medial to lateral, the structures running in the retroperitoneum include the hypogastric nerve trunks, the iliac artery, the ureter, the gonadal vessels, and the psoas tendon (see Fig. 17.3). Identification of the ureter is paramount before proceeding to the next step. The ureter can easily be swept up with the vascular pedicle and divided unless a deliberate effort is made to identify and preserve it along its course. It should be swept out of harm's way for a distance above and below the level of the vascular pedicle. Failure to identify this structure requires conversion to a lateral to medial or open approach.

Table 17.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy	1
2. Identification of the ureter and ligation of the inferior mesenteric artery	5
3. Mobilization of the sigmoid colon	3
4. Mobilization of the descending colon and splenic flexure with ligation of the inferior mesenteric vein	5
5. Rectal mobilization	8
6. Transection of the rectum	6
7. Anastomosis with leak test	2

Box 17.3 Tip
Entering the upper presacral plane first and tracing it cephalad allows to easily identify the plane between sigmoid colon mesentery and retroperitoneum. The IMA elevates progressively to a perpendicular angle to the aorta.

There is a bare area on the proximal side of the IMA pedicle and between that structure and the inferior mesenteric vein that can be used to create a window to isolate the vessel.

Fig. 17.2 Correct location to begin dissection of retroperitoneum. There is a slight color change from yellow to more gray at the junction of the mesentery with the retroperitoneum. Often, globular yellow fat can be seen in the mesentery. The retroperitoneal fat does not have this quality

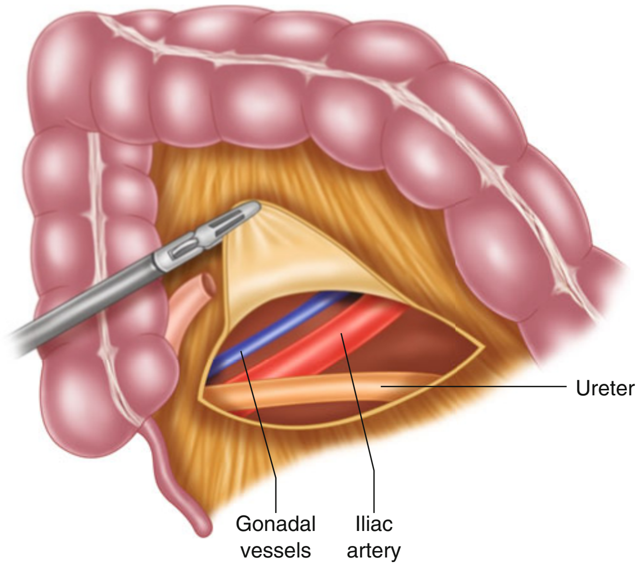

Fig. 17.3 Retroperitoneal structures. At the level of the inferior mesenteric pedicle, the structures identified from lateral to medial are psoas muscle (not shown), gonadal vessels, ureter, and iliac vessels. As one proceeds more inferiorly, the ureter crosses the iliacs and will be seen medial to these structures

Any number of methods can be used for vascular division: surgical stapling, energy device, or suture ligature. The vessel may be stripped of some overlying fat prior to ligation to minimize the risk of device failure [10, 11]. When transecting the vascular pedicle with an instrument in the surgeon's right hand, the left-handed instrument should be used to control stump bleeding should this occur. This allows the surgeon to have complete control of bleeding while additional methods are used to control the pedicle including: clip placement, suture ligature, or endoloop placement.

Mobilization of the Sigmoid Colon

Once the arterial branch is divided, a scissoring motion and blunt sweeps can again be used to lift the sigmoid mesentery off the overlying retroperitoneum. This should be done cephalad and caudad, as it will make subsequent dissection easier.

The white line of Toldt is divided along the sigmoid and descending colon. If the medial to lateral dissection has been carried far enough lateral, there should be only a thin layer of tissue remaining. The previous dissection plane is visualized from above and entered. The ureter can be injured during this step, especially if it was not swept posteriorly at the level of the pelvic brim as it descends into the pelvis. For low pelvic anastomoses, the dissection is carried all the way up the lateral sidewall to the level of the splenic flexure.

Mobilization of the Descending Colon and Splenic Flexure with Identification and Ligation of the Inferior Mesenteric Vein

Release of the splenic flexure is almost always required for sufficient mobilization of the left colon for construction of a tension-free low colorectal or coloanal anastomosis. This is facilitated by complete mobilization of the retroperitoneum at this stage of the operation and high ligation of the IMV near the level of the pancreas. This will also prevent medial mobilization of the kidney when the lateral dissection is performed. Right side down positioning and reversed Trendelenburg can aid in keeping the small bowel out of the way.

Techniques for obtaining additional length include full mobilization of the splenic flexure, division of the inferior mesenteric vein at the inferior border of the pancreas, and successive division of branches of the descending colon mesentery. An important component is preservation of the marginal artery, which allows collateral blood flow to reach the level of the anastomosis. To completely mobilize the splenic flexure, the surgeon must also enter the lesser sac. This can be done either by retracting the colon and omentum caudally and dividing the gastrocolic ligament or by retracting the omentum cephalad and going through the avascular plane at the attachment of the omentum to the transverse mesocolon. This portion of the dissection is connected to the previously completed portion on top of the pancreas. When complete, the entire splenic flexure should be mobile and able to be retracted medially. Overly zealous traction on the colon during this portion of the procedure is the most common reason for splenic flexure injury. Once the colon is completely free of the retroperitoneum, attention can be turned to mobilization of the rectum.

Rectal Mobilization

In open surgery, this rectal mobilization may be aided by cephalad division of the sigmoid colon after progressive ligation of the mesentery along the divided pedicle to allow better visualization of the pelvis. In minimally invasive procedures, keeping the sigmoid intact helps with retraction of the specimen up and out of the pelvis.

A posterior dissection is performed first and should proceed all the way to the pelvic floor or to the level of rectal transection (Box 17.4). Early division of the peritoneal reflection circumferentially around the rectum will aid in appropriate retraction of the rectum out of the pelvis as one proceeds with mesorectal excision. With appropriate anterior retraction on the rectum, the thin areolar layer of tissue

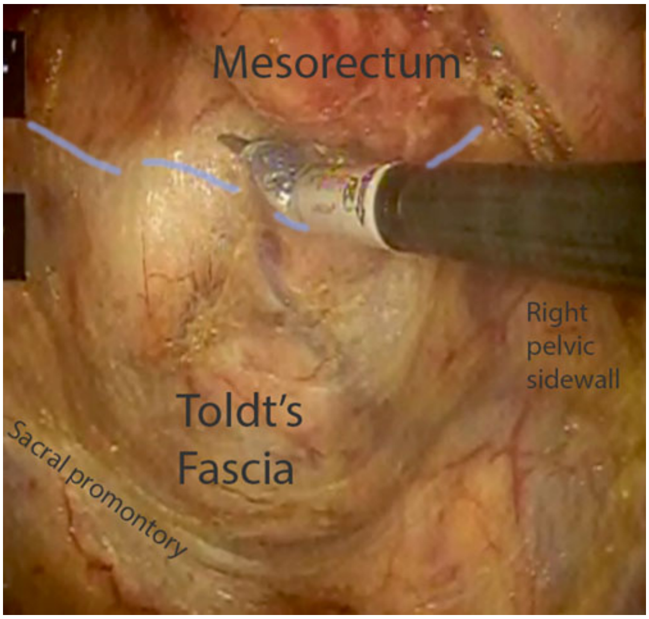

Fig. 17.4 Areolar plane is seen with proper mesorectal dissection. This depicts the posterior mobilization, which should be done along the *dotted line*

dividing the fascia propria of the rectum from the presacral (or Toldt's) fascia is progressively taken sharply or with monopolar energy (see Fig. 17.4 and Video 17.1). The hypogastric nerves should be identified and preserved. This requires continued readjustment of rectal retraction. An additional retractor may need to be placed to assist with this process. Appropriate tension and counter-tension allows clear visualization of the mesorectal envelope, which guides the dissection. Of note, the mesorectum will curve slightly anterior at the level of the coccyx and requires division of Waldeyer's fascia to visualize the pelvic floor musculature.

Box 17.4 Tip
Avoid dissection of the rectum and mesorectum completely on one side only even if it is tempting to just follow the easier posterior plane to the pelvic floor first. Dissect the mesorectal plane circumferentially going from posterior to anterior to lateral in a progressive fashion.

Lateral dissection is perhaps the most difficult and poorly understood component of the operation. The plane between the mesorectum and endopelvic fascia is not as clear here. The ureters may again be injured and must be identified. Again, a recurring theme is that proper dissection in this phase requires minimal diathermy and depends on adequate medial retraction

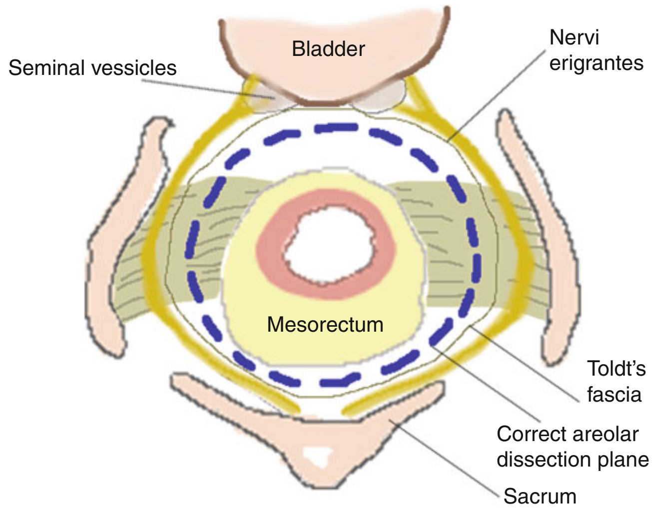

Fig. 17.5 Schematic depicting proper dissection plane along lateral ligaments and anteriorly

of the rectum. The use of both sides of the table and/or a qualified assistant operating from the right of the patient can aid in completing the dissection, especially in a narrow male pelvis. The surgeon can then switch positions with the assistant utilizing the LLQ port for the right dissection plane.

In thinner patients, the surgeon can visualize the nervi erigentes coursing laterally (see Fig. 17.5). These may be swept out of the way. The nerves are again seen running at the back of the lateral edge of the seminal vesicles, bladder neck, and prostate. Bleeding encountered here means one is too medial in the mesorectum or too lateral along the pelvic sidewall, and the plane should be reassessed. The lateral "ligaments" in fact represent only a minimal amount of connective tissue and do not contain the middle rectal artery, which courses much lower and out of reach of most dissections [12].

Japanese surgeons commonly include a lateral lymph node dissection with their LAR specimens. Their experience suggests an 8.6–16.4 % risk of positive lymph nodes within the obturator space, with higher positivity rates in lower tumors [13]. The extended resection significantly increases surgical morbidity, and the approach is not as common in western nations.

Anterior dissection begins at the peritoneal reflection and should proceed along Denonvilliers fascia. This runs along the rectovaginal septum or just posterior to the seminal vesicles. Again, progressive retraction of the rectum out of the rectum is the key to identification of the proper plane, which usually represents a layer of avascular areolar tissue (Box 17.5). A grasper with open jaws placed just below the peritoneal reflection or a fan retractor is helpful to obtain proper counter retraction in laparoscopic surgery. This simulates use of a St. Mark's retractor in open surgery.

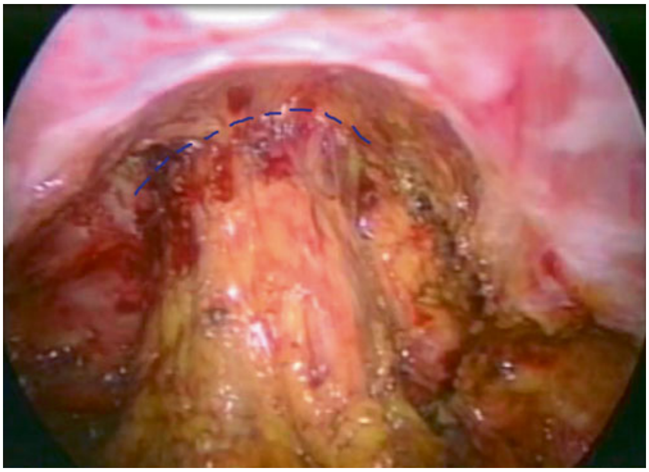

Fig. 17.6 Mesorectal plane along the areolar tissue of the rectovaginal septum. Proper tension and counter tension is essential to identify this plane correctly

Box 17.5 Tip
When the mesorectum curves anteriorly at the level of the coccyx, dissection from anteriorly downwards is easier rather than trying to further lift up the rectum and mesorectum as done with a St. Marks retractor in open surgery.

Depending on the location of tumors, varying amounts of Denonvilliers fascia may be taken. The three layers that have been previously defined are close rectal (peri-muscular), mesorectal, and extramesorectal. The close rectal plane runs within the fascia propria of the rectum directly along the rectal wall. It is not an anatomic layer, so bleeding may be encountered within this layer. Its use is recommended by some in surgery for benign disease, such as inflammatory bowel disease, as it may decrease the risk of nerve injury. The mesorectal plane will leave Denonvilliers fascia intact anteriorly and is the most commonly used approach. The extramesorectal plane includes taking Denonvilliers fascia with the specimen, carrying the dissection more anteriorly. This exposes the prostate and seminal vesicles or includes the posterior wall of the vagina (see Fig. 17.6). The risk of nerve damage is high, but may be necessary for oncologic clearance of an anterior tumor. This plane is not as clearly defined, and meticulous dissection is required to preserve relevant structures [14].

Transection of the Rectum

After completion of the rectal dissection, a rectal stapler may be fired across the distal aspect of the specimen. Maneuvering the stapler deep in the pelvis is often difficult, so a small reticulating stapler through the RLQ port is often used (Box 17.6). Frequently multiple loads are needed, and it is particularly challenging to achieve a perpendicular transection line. Alternatively, the rectum may be stapled through a suprapubic port with downward angulation of the Endo-GIA stapler. After confirmation that the tumor is adequately above the level of division, the staple is fired and the rectum removed. More than two fires of the stapler to complete transection increase the risk of leak [15]. If a significant amount of mesorectum remains at this level, blunt dissection should be used to make a tunnel immediately posterior to the rectal wall. The stapler is fired and the mesorectum is divided subsequently with an energy device or another stapler load. If there is any concern about the integrity of the rectal stump, a stump leak test may be performed, whereby it is insufflated underwater prior to performing any anastomosis.

Box 17.6 Tip
A bulky tumor rarely prevents placement of an endoscopic stapler through an RLQ or suprapubic port. A curved open stapler can be then placed through a Pfannenstiel incision. If this is also not possible, be prepared for a sharp transection and coloanal handsewn anastomosis.

Frozen section is not required to evaluate the distal margin, as it is often unreliable. Gross inspection should be performed at the time of surgery to ensure adequate margins. The mesorectum is subsequently divided to complete specimen removal. The specimen may be exteriorized through any number of methods as described above. A port site in the left lower quadrant or suprapubic location may be enlarged to allow placement of a wound protector. The specimen is then extracted and the proximal portion divided.

Anastomosis with Leak Test

The sigmoid colon is a poor functional substitute for the rectum, as it is the smallest caliber of any part of the colon. In choosing a point for proximal transection, the divided vascular pedicle is followed along the superior hemorrhoidal artery out to the proximal sigmoid. One will come across the marginal artery, which should be pulsatile if divided sharply. This ensures adequate blood supply to the remaining colon, maximum length on the remaining colon, and adequate lymphovascular clearance of the specimen.

For double-stapled anastomosis, a purse string is placed in the proximal colon and the anvil of the stapling device inserted. It is important to ensure enough serosa is elevated onto the anvil, as gaps can cause areas of weakness in the staple line. This will manifest as a defect in the anastomotic doughnut. This may be done using a purse string device, "baseball stitch," or in and out technique. In order to ensure the suture slips down to tighten around the anvil, larger bites with some distance traveled between the bites work better. When passing the stapling device through the anus, the spike is advanced through the midportion of the rectal staple line. Some surgeons prefer to advance the spike through a side anteriorly, to remove an area prone to ischemia. In any case, the ends are joined and the stapler fired. Care should be taken to avoid involvement of any other structures in the staple line. The posterior wall of the vagina can be caught and may result in a fistula. After closing and before firing the device, an examining finger should be placed into the vagina and the stapler twisted to ensure the rectovaginal septum remains free of tethering. After firing, a leak test is performed by insufflating air with a proctoscope or flexible endoscope. The flexible endoscope has the additional advantage in that it can be used to confirm removal of the lesion, may be performed by a relatively inexperienced provider, and the anastomosis can be seen clearly on a video monitor. If the tattoo is not clearly seen, it may be helpful to use the endoscope prior to distal stapling to ensure an adequate margin.

A positive leak test is a feared event among colorectal surgeons. If the anastomosis is high enough, reconstruction with a new anastomosis should be considered, as this will often result in a better anastomosis. Alternatively, repair may be attempted either from above or transrectally if the anastomosis is low enough. This may necessitate prone jackknife positioning to visualize anterior defects. With any positive leak test, fecal diversion should be considered [16].

Alternatively, a coloanal anastomosis may be performed using a handsewn or a double purse string technique. For this, the rectum is not divided, and an intersphincteric dissection is done from a perineal approach to enter the previously dissected retrorectal space. A lone star retractor may be used to aid visualization. After circumferential mobilization of the distal rectum at the level of the dentate line, the specimen is extracted through the open anus. The colon is then sutured to the dentate line using interrupted suture. A coloanal stapled anastomosis may be created by placing a purse string stitch in the proximal colon that is pulled through the anus. An anvil is inserted, the stitch tied, and the colon is returned to the pelvis. Next, a transanal purse string suture is placed at the distal transection margin. This serves to create the distal anastomotic doughnut, and the spike is advanced through this purse string.

Modifications to this method of anastomosis include the use of a colonic J pouch or coloplasty. Both modifications decrease the frequency of bowel movements in the early postoperative period compared to straight coloanal anastomosis by creating a larger rectal reservoir. By 1 year following surgery, all techniques have equivalent outcomes [17]. Coloplasty (longitudinal colostomy closed transversely) results in an increased number of anastomotic leaks in the perioperative period when compared to a J pouch and is often used only in the instance of inadequate length to perform the latter.

Newer techniques such as staple reinforcement provide promise of continuing improvement in technology that may decrease the potential for anastomotic leak or bleeding, which are found in 3–17 % and 5 %, respectively [18], following LAR with double-stapling technique.

Lesions in the upper and middle rectum can often be performed without temporary fecal diversion. Location in the lower rectum (0–5 cm from dentate line) provides a more challenging problem in creating a low anastomosis with an adequate distal margin. Lesions that extend below the coccyx, the mid prostate, or 1 cm above the dentate line should not be excised with a sphincter-preserving approach unless the tumor is confined to the mucosa or submucosa. Deeper lesions at this level should be excised via an abdominoperineal resection, as these have a high risk of a positive circumferential margin.

Accepted indications for fecal diversion following LAR include: coloanal or anastomosis <6 cm from anal verge, severe malnutrition, significant immunosuppression, hemodynamic instability, excessive intraoperative blood loss, purulent peritonitis, pelvic sepsis, neoadjuvant therapy, or a positive leak test.

Special Considerations and Complications

Anastomotic Leak

Anastomotic leak is one of the feared complications after colorectal surgery. Leak rates range from 3 to 17 % following low pelvic anastomosis, with an average of around 10 % [19, 20]. The use of drains in the pelvis has been a highly controversial topic. There is evidence to suggest an increased leak rate (from 9 to 23 %) with drains after neoadjuvant therapy [21]. Some surgeons drain routinely, others selectively. Even when drains are placed, they may not be appropriately positioned to drain a fluid collection from a leak, requiring percutaneous drainage despite the presence of an operative drain.

Bleeding

Bleeding during surgery may occur at several troublesome locations. The pelvic vasculature (including presacral veins), the anastomosis, and the bowel mesentery are common sites. Direct finger pressure will often control the bleeding source initially in open surgery until more definitive methods such as suture ligature or thumbtacks can be applied. This can be only achieved in a limited fashion with a grasper and possible Raytec laparoscopically. Bleeding most often occurs from blunt posterior dissection along the posterior aspect of the mesorectum when presacral veins are torn. This may result in substantial bleeding that is best controlled initially by packing. By contrast, use of scissors or diathermy may prevent entry into the wrong plane or cause bleeding that is easier to control [22]. Bleeding from the lateral sidewalls often indicates the wrong plane. Bleeding anteriorly suggests entry into the posterior wall of the vagina, which is very well vascularized.

Nerve Injury

Nerve injury can be sympathetic, parasympathetic, or both. There are a number of locations where nerve injury is likely to occur, and care should be taken during dissection of these locations. The aortic plexus or subsequent hypogastric nerves contain sympathetic fibers and can be damaged if in the wrong plane at the level of the pelvic brim. After removal of the rectum, the nerves appear as a wishbone, preserved under a thin layer of Toldt's fascia. These nerves may also be damaged at any point during the posterior dissection if the surgeon dissects too far posterior. Injury here results in pure sympathetic injury, causing retrograde ejaculation. Along the lateral sidewalls, parasympathetic injury can occur, resulting in impotence and bladder dysfunction. The nervi erigentes course laterally around the lower part of the rectum from the pelvic plexus. They continue anteriorly near the lateral border of the seminal vesicles (in males) or the cardinal ligaments (in females). Anterior dissection to include Denonvilliers fascia in the extramesorectal plane can also damage these nerves. Injury at any point along this path can result in a mixed sympathetic and parasympathetic injury. Incidence of retrograde ejaculation was 33 %, and impotence rates averaged 12 % in male patients with attention to nerve preservation. This is higher with lateral wall lymphadenectomy and splanchnic nerve resection for locally advanced tumors (nerve dysfunction in 25–75 % of patients, with an average of 50 %) [13, 23].

Abdominoperineal Resection (APR)

When a rectal lesion cannot be removed with an adequate margin above the sphincters, a complete removal of the sphincter complex or abdominoperineal procedure becomes necessary. This was first described by Miles in 1908 [24] and has undergone only slight modifications to become the procedure performed today. In addition to low tumors involving sphincters, the procedure should also be considered in patients with poor neurologic or sphincter tone. Approximately 24–27 % of patients undergoing surgery for curative intent require abdominoperineal resection [25].

Surgical Technique

The technical aspects are similar to a low anterior resection and involve TME until one reaches the level of the levators. At this point, excision of a disk of tissue that includes levator muscle, ischiorectal fat, and sphincters is done to ensure complete tumor excision (Box 17.7). The levator fascia of the pelvis may be divided either during the abdominal portion of the operation or from the perineum. Division from above allows visualization of the ischiorectal fat and decreases the distance required to connect the perineal portion of the surgery with the pelvic cavity.

> **Box 17.7 Tip**
> Proceed with the rectal mobilization only to the level of the coccyx for an extralevator or cylindrical approach to avoid coning of the specimen at this level.

The perineal dissection begins with appropriate lateral retraction of the buttocks. This may be done either with a lone star retractor or by placing of several thick stay sutures. Typically, the rectum is closed off with a purse string suture to prevent tumor spread and contamination of the incision. The incision should encompass an ellipse of tissue from the perineal body anteriorly to the coccyx posteriorly. The lateral extent of the incision is between the ischiorectal spines. Soon after incision, one enters the ischiorectal fossa. This potential space is dissected cephalad to connect with the retrorectal space within the pelvic cavity on top of the coccyx. The tissues should have minimal resistance, but the fatty tissues are prone to bleeding. Electrocautery may be used, or a handheld energy device may facilitate faster dissection. Care should be taken to ensure an adequate lateral margin so that a disk of tissue is excised. A common mistake is to proceed alongside the rectum as this is an easily identifiable landmark. This may resent in positive or threatened circumferential margins. By proceeding first posteriorly, then laterally, one can then flip the specimen into field before performing anterior dissection, which is often the most tedious – where vital structures are prone to injury. This allows improved visualization of this portion of the dissection. Alternatively, one can perform the perineal dissection in the prone position. There is some controversy regarding performing this in the prone or lithotomy position. Some authors suggest that prone positioning decreases perforations and has a lower rate of margin positivity (3.7 vs. 22.8 % and 14.8 % vs. 40 %, respectively). Since 81 % of perforations showed an anterior perforation, some surgeons favor this approach on all patients. However other authors have demonstrated equivalence between the options for patient position [26].

If the perineal dissection is done correctly, it should be virtually impossible to reapproximate the pelvic floor muscles. Instead, the tissues are closed in layers with whatever tissue is available, or a muscle flap may be used. Alternatively, biologic mesh can be used if the defect is too large. The skin edges may be loosely reapproximated. The use of drains here is also controversial. Some authors prefer a drain to evacuate any fluid buildup in the early postoperative period. Others prefer to have this drain out the loosely closed perineum. In any event, perineal wounds have a high rate of poor healing, and no one method has been proven to completely prevent this problem.

An important final part of performing an APR is the creation of a permanent stoma. Because it is permanent, extra attention should be devoted to appropriate placement, with preoperative evaluation by an enterostomal therapist. The stoma aperture should not be made too large, and it should be placed using a muscle splitting technique through the rectus muscle. Scissors, electrocautery, or a combination may be used to make a vertical slit or cruciate incision in the fascia. Some surgeons pexy the stoma to the fascia. It may create additional adhesions and does not appear to affect the incidence of stoma retraction. In obese patients, where abdominal girth limits the ability to reach the abdominal wall, an end-loop stoma is a viable option, as this ensures adequate blood supply to the functional end of the stoma. It typically requires a larger orifice but may solve many reach problems. Consideration should be given to preemptive mesh placement in patients with multiple risk factors for a parastomal hernia. Given the potential contamination during surgery, many authors advocate use of a biologic mesh. Underlay, sublay, and onlay techniques have all been described. No one technique has proven superior in preventing hernia formation.

Rectopexy

Posterior rectopexy with or without prosthetic mesh is the most commonly performed procedure for rectal prolapse. The biggest downside is its association with postoperative constipation, which is present in up to 50 % of patients. This has caused many to consider an anterior rectopexy as a solution. These are the only two procedures that will be discussed in this section. While there are more than 150 described procedures for the treatment of rectal prolapse, many are via a perineal approach. The two procedures described here have the lowest recurrence rates and should be considered the standard for appropriate-risk patients with rectal prolapse.

The debate behind which procedures to perform stems around constipation (Box 17.8). The exact mechanism for this constipation remains unclear, but proposed theories include pelvic floor and nerve dysfunction after denervation, dysmotility caused by scarring and prosthetic material, and redundant sigmoid causing a functional obstruction [27]. An additional consideration in all surgeries for rectal prolapse is the addition of a colon resection. By removing a segment of colon, the surgeon hopes to circumvent constipation much in the same way that colectomy is used for colonic inertia and chronic constipation. This also avoids kinking of the sigmoid over the rectum that may delay transit. The addition of a resection makes most surgeons wary of placing mesh for fear of infectious complications, so only suture rectopexy is performed. The addition of a colon resection in addition to rectopexy results in only a slight increase in operative time and length of stay compared with rectopexy alone, but was associated with less constipation and similar recurrence risk [28].

Box 17.8 Tip
Evaluate the patient for colonic inertia prior to a possible concomitant resection during rectopexy.

Ventral rectopexy is a newer procedure and has only evaluated in several small series. It appears to be associated with lower rates of postoperative constipation (seen in 10–15 % of patients) [17, 29]. Particularly in females it has theoretic advantages of simultaneous correction of anterior rectocele by reinforcing the rectovaginal septum and prevention of associated enterocele or uterine prolapse by elevating the pouch of Douglas by reperitonealizing over the mesh. In the end, the selection of a particular surgical approach should be tailored to each patient based on the surgeon's experience and familiarity with a given procedure and any patient-related factors.

Posterior Rectopexy Technique

The first step is to enter the retrorectal space just anterior to the sacral promontory in the midline. Similar to that performed in an LAR or APR, this is done after reducing the bowel out of the pelvis. With rectal prolapse, all the relevant anatomic structures have a tendency to be pulled caudally, so the IMA pedicle is typically lower than would otherwise be expected. The peritoneum is scored, and careful blunt dissection under the superior rectal artery allows entry into the retrorectal areolar plane where pneumodissection opens the appropriate pathway between the fascia propria of the rectum and the endopelvic (or presacral) fascia. Again the surgeon should proceed on top of Toldt's fascia – the continuation of the retroperitoneal Treitz fascia – performing a posterior mesorectal dissection by lifting the fascia propria of the rectum anteriorly. This should again be done with diathermy, and minimal bleeding should occur. The dissection proceeds

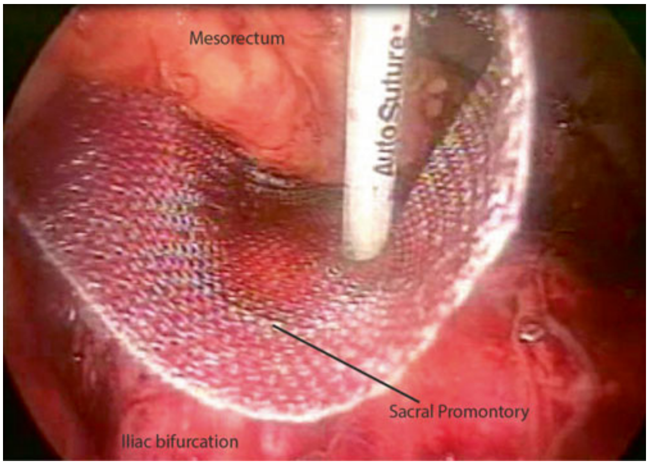

Fig. 17.7 A mesh placement using tacking device in the midline just below the level of the sacral promontory

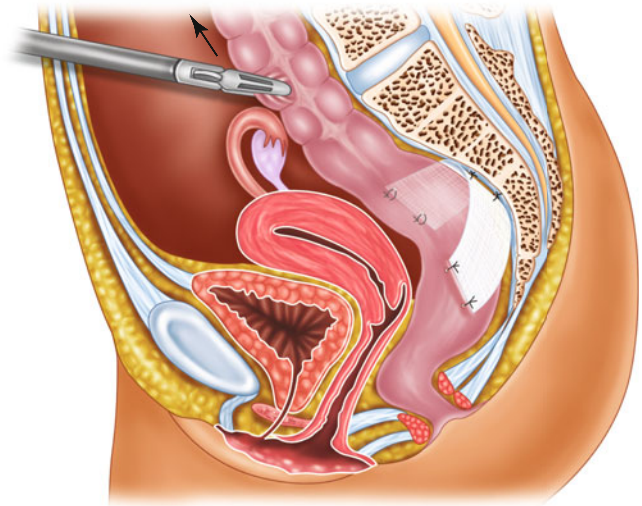

Fig. 17.8 Schematic depicting proper placement of the arms of the mesh alongside the rectum. This is secured to a "wing" of peritoneum mobilized with the rectum. The rectum is pulled forcefully cephalad before placement of these side sutures or tacks

through these avascular planes until reaching Waldeyer's fascia the point of confluence between the fascia propria and presacral fascia. Dividing Waldeyer's fascia allows direct visualization of the pelvic floor, and this is the extent of dissection, which should encompass the posterior 60 % of the mesorectum to leave lateral stalks that contain parasympathetic nerve supply to the rectum intact.

Mesh placement after posterior dissection has been described by Wells [30]. An appropriately sized piece of polypropylene mesh with large apertures is sutured or tacked to the sacrum just below the sacral promontory. This location prevents inadvertent injury to the hypogastric nerves or presacral veins. The large aperture mesh minimizes the risk of infection. Permanent suture or a tacking device is used to fixate this to the bone. The mesh is then wrapped halfway around the rectum and secured to the lateral "wings" of peritoneum alongside the rectum created by previous dissection. The most important part of this tacking is to place the rectum on maximum tension in a cephalad direction, thereby reducing the prolapse as much as possible. In addition, the arms of the mesh should point in a caudal direction to suspend the rectum. The goal is to prevent re-prolapse when the mesh is secured in place. One to two sutures or tacks are required per side (see Figs. 17.7 and 17.8). The Ripstein method of mesh placement, whereby the mesh was placed anterior to the colon and secured posteriorly [31], has largely been supplanted by the Wells rectopexy due to effects of rectal entrapment and constipation.

Anterior Rectopexy Technique

For anterior mobilization and mesh placement, similar principles apply. Dissection begins again at the level of the peritoneum on the patients right side with the rectum retracted to the left. An incision is made in the peritoneal surface at the base of the junction of the mesosigmoid-mesorectal junction

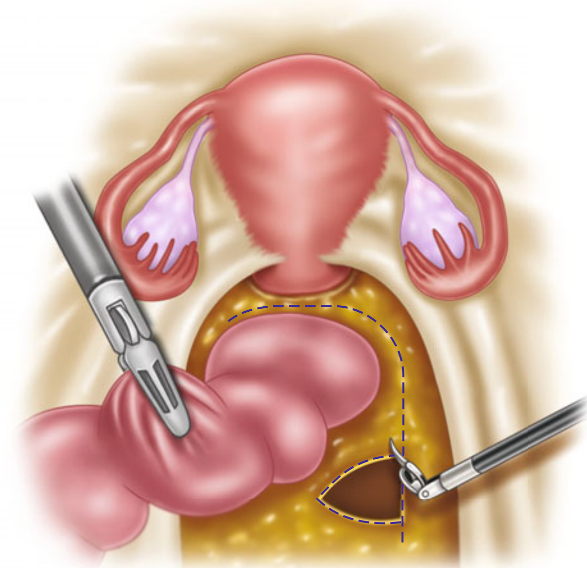

Fig. 17.9 Inverted J incision into peritoneum. The anterior dissection is then carried to the level of the levators

just anterior to the sacral promontory near the midline. Again it is important to reducing the bowel out of the pelvis as much as possible as prolapse causes the relevant anatomic structures to be pulled caudally. An "inverted J" incision is then made in the peritoneal surface by extending dissection caudally toward the rectovaginal septum and around to the patient's left side (see Fig. 17.9). One should be mindful of the right ureter, which crosses the pelvic brim in this location.

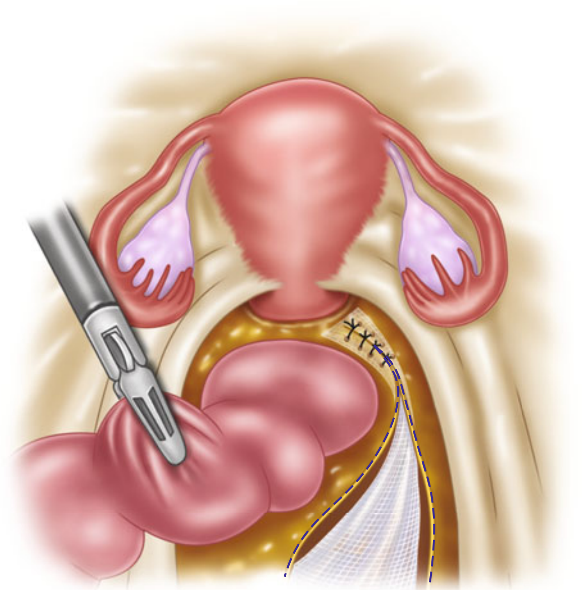

Fig. 17.10 Insertion of mesh along rectovaginal septum. This can be secured to the rectum, posterior wall of the vagina, or both. As in posterior rectopexy, the rectum is placed on traction and secured to the midline just below the sacral promontory. The peritoneum is then reclosed on top of the mesh to prevent inadvertent exposure to the small bowel

The lateral dissection should again identify the avascular plane at the level of the sacral promontory. However, most of the dissection occurs in a true anterior position, and the posterolateral dissection should be minimized. Anteriorly, the rectovaginal septum is dissected along Denonvilliers fascia to the level of the pelvic floor. Alternatively, the pouch of Douglas dissection can be done further posterior in a close rectal (or peri-muscular) plane. This approach leaves the nervi erigentes on the posterior vaginal wall undisturbed but may result in increased bleeding. Most authors proceed in the mesorectal plane, as it is a true anatomic plane. To aid in retraction and visualization, a uterine sound inserted through the vagina or anterior suspension of the uterus assists with this mobilization. One should leave enough peritoneum on the vaginal surface to allow reperitonealization over the mesh at the completion of the dissection. This key step results in elevation of the pouch of Douglas and prevents future enterocele. A thin strip of polypropylene mesh is then sutured to the anterior surface of the rectum and posterior surface of the vagina. It is then elevated on tension and secured to the sacral promontory with sutures or tacks similar to the posterior rectopexy. The mesh can be brought medial to the rectum for sacral fixation (see Fig. 17.10). Some authors split the mesh into an inverted “Y” configuration, which is secured on both the lateral and medial sides of the rectum to the sacrum. Finally the peritoneal surface is reclosed over the mesh to prevent adhesions to the small bowel, which may result in fistulas.

Summary

In summary, a laparoscopic proctectomy can be a challenging endeavor because of the lack of maneuverability. Exposure in a narrow pelvis is often the most difficult obstacle to overcome. Attention to finding the right plane will ensure success. This can be accomplished with appropriate three-dimensional retraction and patience.

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Proctectomy and Rectopexy: Hybrid Robotic Approach

18

Monica T. Young, Joseph C. Carmichael, and Alessio Pigazzi

Introduction

Due to advances in technology and surgical technique, the da Vinci robot has become increasingly relevant in the field of colorectal surgery. This approach is particularly applicable to the technical challenges of pelvic dissection, which require precise movements in a confined space. Improved visualization can lead to lower conversion rate to open surgery, fewer complications, and shorter hospital stay [1]. This chapter will review the operative techniques of a hybrid robotic-assisted low anterior resection, abdominoperineal resection, and rectopexy.

Background

Over the past several decades, laparoscopic surgery has become a widely accepted modality in the treatment of colon and rectal cancer. In contrast, robotic-assisted colorectal surgery is a relatively new minimally invasive approach. Robotic-assisted laparoscopic low anterior resection was first described in 2005 in a small cohort of six consecutive patients [2]. Since this time, robotic-assisted surgeries have become more prevalent but still comprises only a small minority of abdominal procedures overall [3]. Baik et al. [1] published the first prospective randomized trial comparing outcomes of laparoscopic versus robotic-assisted low anterior resection in 2008. He found robotic-assisted mesorectal excision to be safe and effective with comparable short-term outcomes to laparoscopic mesorectal excision. Since this time, several other studies have confirmed the safety and oncologic efficacy or robotic-assisted resection [4–7]. Key advantages of robotic-assisted low anterior resection cited in the literature include a low conversion rate (0.4 %) and a low rate of positive circumferential resection margins, together with an acceptable intraoperative complication rate (0.8 %), operative times, morbidity, and hospital stay [7].

Preoperative Planning

A thorough preoperative history of any symptoms including pain, urinary or bowel incontinence, and sexual dysfunction is obtained. A digital rectal exam and endoscopy verifies the location of the tumor. A colonoscopy needs to be obtained to rule out malignant synchronous lesions. High-resolution rectal MRI can help define the mesorectal fascia and assess resectability.

Room Setup and Positioning

Standard room setup for all robotic colorectal procedures must keep in mind the necessary space requirements for the surgeon, the assistant, and the operating room personnel. The patient is placed on the operating room table in a modified lithotomy position with Allen® stirrups. Various methods have been described to prevent patient sliding during steep Trendelenburg position. A large foam mat to the operating room table underneath the patient works very well. The mat is fixed to the operating room table and is in direct contact with the patient's back. This provides a "friction hold" which prevents sliding. A Velcro belt is strapped over the chest to prevent patient movement during extreme lateral position changes. The patient's buttocks should be aligned just before

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_18. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_18, © Springer Science+Business Media New York 2015

the edge of the table, and the hips are slightly flexed and abducted. The feet and legs must be ergonomically positioned and adequately padded to prevent any pressure injury. The ankle, knee, and contralateral shoulder should be aligned.

The robot can be docked from between the patient's legs or over the left hip in a lateral position. The preferred method is the left hip approach, which allows access to the perineum during surgery. With this approach, the main post of the cart should be aligned with the left anterior iliac spine and the camera port. Appropriate preoperative antibiotics should be administered. The perineum is prepped if a transanal extraction or anastomosis is anticipated. Rectal irrigation with normal saline is performed in rectal cancer cases. The routine use of ureteral stents is not considered necessary. Reassessment of the pathology is accomplished via digital rectal exam or flexible sigmoidoscopy.

Port Setups and Extraction Sites

Generally, triangulation in port placement with a minimal distance of one handbreadth between trocars should be maintained for laparoscopy. For narrower pelvic inlet, more medial robotic ports may be considered.

Pneumoperitoneum is established with a Veress needle placed at Palmer's point, 1–2 cm below the left costal margin at the left midclavicular line (MCL). A 12-mm camera port (C) is placed halfway between the xyphoid process and symphysis pubis. The minimum distance between trocars is typically four fingerbreadths. In cases that require deep pelvic dissection, it is wise not to place the camera port greater than 20 cm above the pubic symphysis after establishment of pneumoperitoneum. Three robotic ports are then inserted under direct visualization: R1 is a 12-mm trocar inserted in the right MCL halfway between C and the right anterior superior iliac spine (ASIS) in the right lower quadrant (RLQ). R2 is an 8-mm trocar placed in a mirror image of R1 on the left side in the left lower quadrant (LLQ). R3 is an 8-mm trocar inserted 8–10 cm lateral to R2, usually directly above the left ASIS in the left flank. It may be necessary to mobilize the sigmoid colon prior to placement of this port. Two laparoscopic-assisted ports are inserted: L1 is a 5-mm port located along the right MCL about 12 cm superior to R1 in the right upper quadrant (RUQ). L2 is a 5-mm port inserted halfway between the right MCL and the midline about 12 cm superior to L1 (see port configuration in Fig. 18.1).

Some variations in port setup will be required depending on the case and patient. The narrower the pelvic inlet, the more medial the robotic ports will need to be placed.

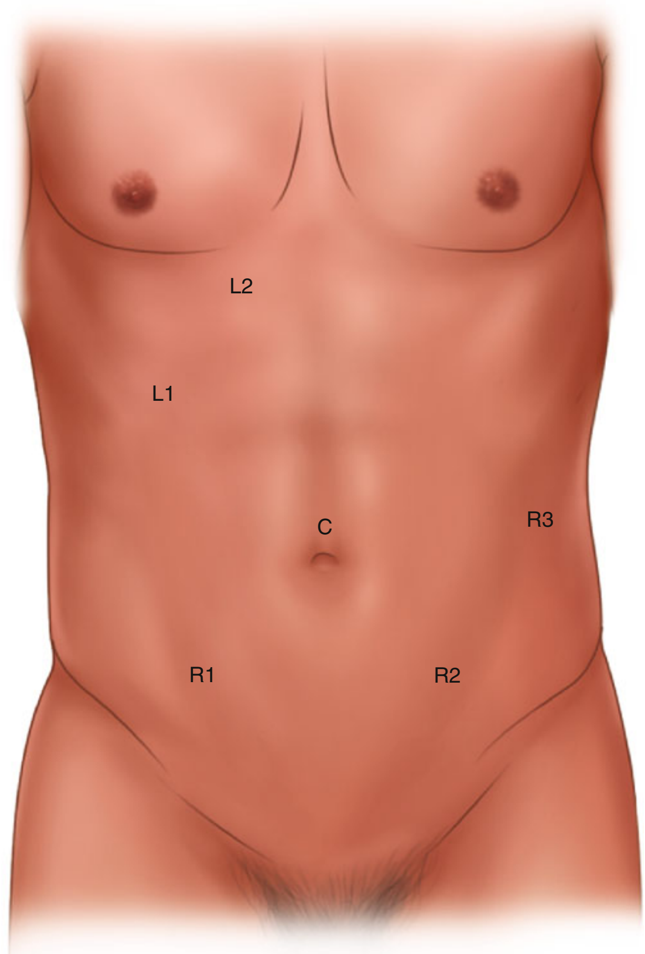

Fig. 18.1 Port configuration. *C* 12-mm camera port, *L1* and *L2* 5-mm assistant ports, L1 is 12 mm if endoscopic stapler is used, *R1*, *R2*, and *R3* 8-mm working ports for arm 1, 2, and 3

The most commonly used extraction site is a small transverse Pfannenstiel incision. Alternatively the specimen can be removed with an off midline left lower quadrant or ileostomy site incision if there is adequate reach to the right to place an extracorporeal purse string. A transanal extraction can be used for most distal malignancies when a handsewn coloanal anastomosis is planned and the mesocolon and/or tumor are not too bulky to fit through the anal canal.

Operative Steps (Table 18.1)

During a hybrid approach to a robotic-assisted low anterior resection, steps 1–4 are performed in a laparoscopic fashion and are essentially the same as in a laparoscopic sigmoid resection. The various approaches to these steps have been

Table 18.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy	1
2. Identification of the ureter and ligation of the inferior mesenteric artery and vein	5
3. Mobilization of the sigmoid colon	3
4. Mobilization of the descending colon and splenic flexure	5
5. Rectal mobilization	5
6. Transection of the rectum	3
7. Anastomosis with leak test	2

described in a previous chapter, and we will briefly review the steps again.

Exploratory Laparoscopy

Both surgeon and assistant stand on the right side of the patient. It may be necessary to have the anesthesia team move away from the patient's head or move the patient table caudally to allow for two people to work side by side on the patient's right. The peritoneum is first examined for any evidence of metastatic disease. The patient is placed in Trendelenburg position with the left side elevated to promote displacement of small bowel out of the pelvis. Atraumatic bowel graspers are used to avoid bowel injury during mobilization.

Identification of the Ureter and Ligation of the Inferior Mesenteric Vessels

The R1, L1, and L2 ports are used during this portion of the operation. A medial to lateral mobilization of the sigmoid colon starts lateral to the ligament of Treitz. The inferior mesenteric vein (IMV) is identified and gently retracted anteriorly. The peritoneum posterior to the IMV is opened using monopolar cautery or scissors, and blunt dissection is used to elevate the IMV and mesocolon off of the retroperitoneum. After the IMV is dissected from its attachments to the left mesocolon, the vessel is clipped and divided with a vessel sealer device or vascular stapler (see Fig. 18.2).

The sigmoid colon is then retracted anteriorly, and the parietal peritoneum is incised medial to the right common iliac artery at the sacral promontory. A combination of sharp and blunt dissection is used to enter this avascular plane and isolate the superior hemorrhoidal artery and the pedicle of the inferior mesenteric artery (IMA). Care is taken to avoid injury to the hypogastric nerve plexus and the left ureter

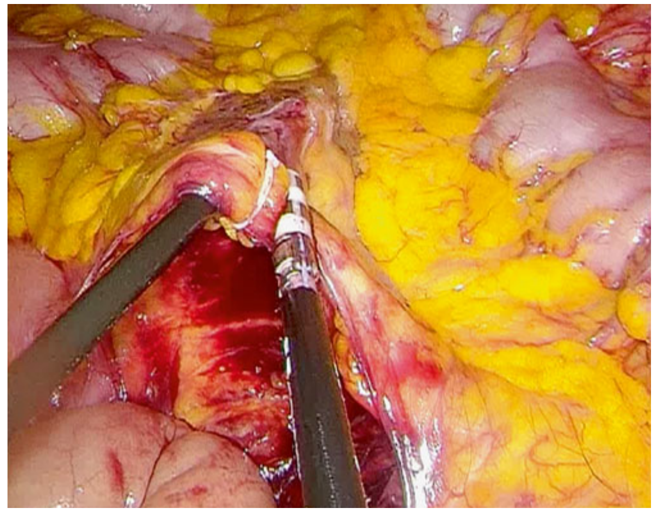

Fig. 18.2 Inferior mesenteric vein clipped and divided

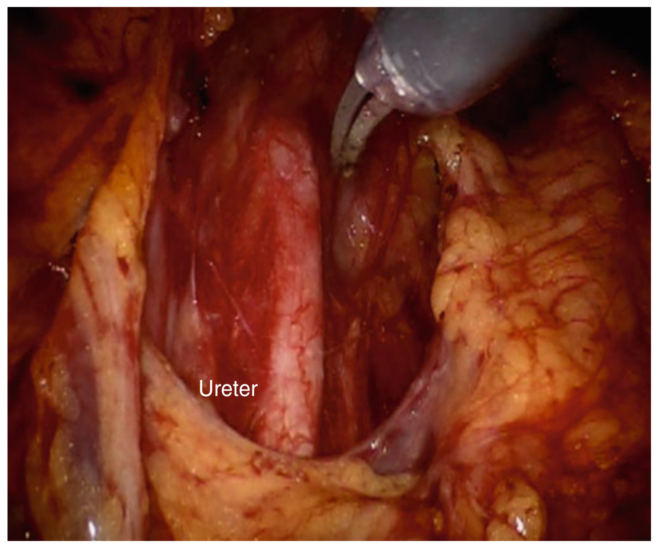

Fig. 18.3 Care should be taken to avoid injury to the ureter

(see Fig. 18.3). These structures are swept posteriorly. The IMA is dissected out until the junction of the left colic artery and superior hemorrhoidal artery can be visualized in a "T"-shaped configuration (see Fig. 18.4). The IMA is then divided at its origin with a vessel sealer device or vascular stapler. The left ureter should be reidentified just prior to transection of the vessel. In most patients, the left colic artery is also divided in this location to allow for greater left colon mobilization into the pelvis. The medial to lateral mobilization of the left colon mesentery is completed to the left abdominal wall.

There are some instances when access to the base of the mesentery can be difficult, such as an obese patient or a

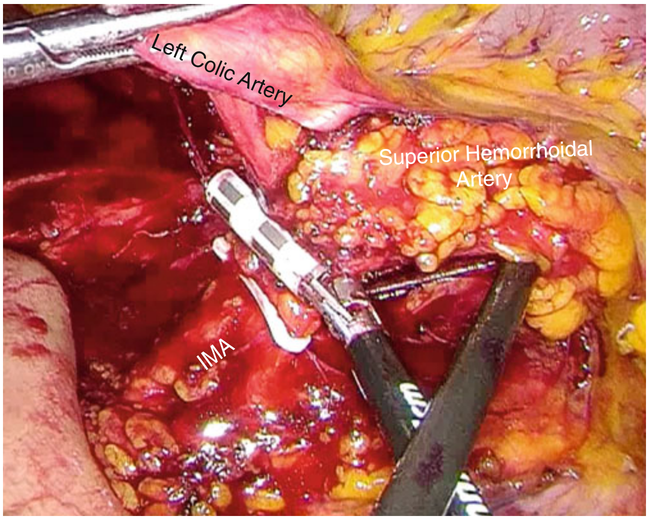

Fig. 18.4 View of the "T formation" created by the inferior mesenteric artery, left colic artery, and superior hemorrhoidal artery

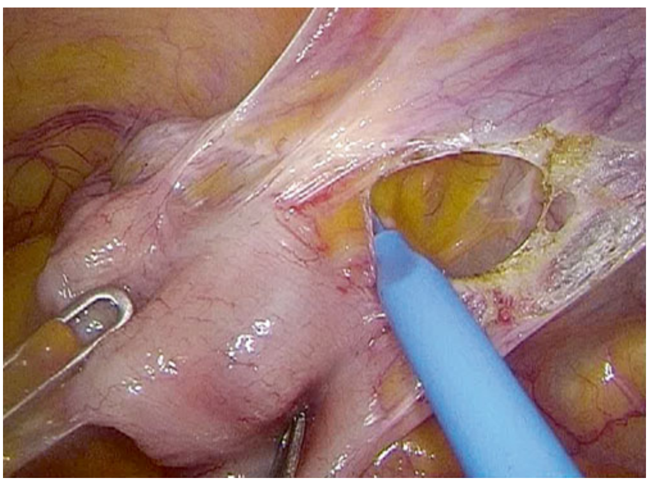

Fig. 18.5 Dissection beginning at the line of Toldt

small patient with minimal intra-abdominal domain or distended small bowel. This can limit the medial-to-lateral approach or make it impossible to safely accomplish. In these cases, a lateral-to-medial approach should be considered.

Mobilization of the Sigmoid Colon

After the medial dissection is complete, lateral dissection is begun at the sacral promontory. The assistant surgeon retracts the colon medially, and the lateral peritoneal reflection is dissected at the line of Toldt (see Fig. 18.5).

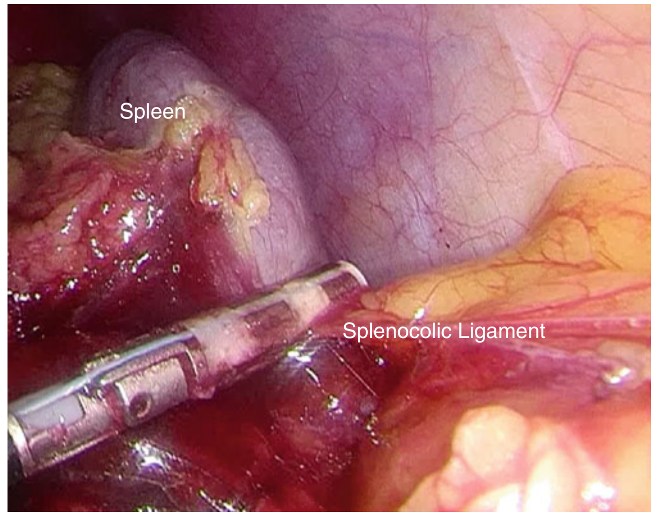

Fig. 18.6 Takedown of the splenocolic ligament at the splenic flexure

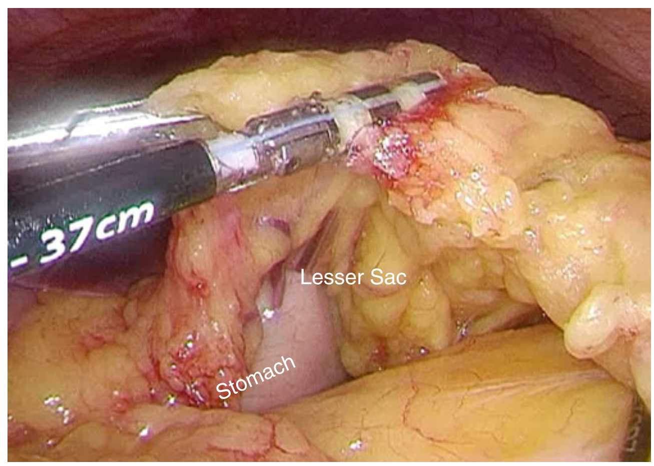

Fig. 18.7 Entry into the lesser sac

Mobilization of the Descending Colon and Splenic Flexure

The plane between the colonic mesentery and the retroperitoneum is entered medially. The dissection should run along the inferior border of the pancreas, toward the left upper quadrant in the direction of the splenic hilum. Lateral dissection is continued cephalad by division of the phrenocolic and splenocolic ligaments (see Fig. 18.6). The lesser sac is entered (see Fig. 18.7), and the dissection is carried to the base of the mesentery. Care is taken to avoid injury to the tail of the pancreas.

Rectal Mobilization

A four-arm da Vinci robot is docked at the patient's left hip. This setup allows access to the anus to perform intraoperative digital or endoscopic examinations as well as transanal extraction of the specimen. A 0-degree robotic camera is placed in C. Arm 1 is docked in R1 using a "trocar-in-trocar" technique and will carry a hook cautery or monopolar scissors. Arm 2 is docked in R2 with a bipolar fenestrated grasper. Arm 3 is docked in R3 with a Prograsp™, Cadiere™ forceps, or robotic suction irrigator. The assistant surgeon continues standing on the right side of the patient, while the surgeon moves to the console. The assistant will use L1 and L2 to assist in retraction as well as suction/irrigation. An extended-length (rather than standard length) suction irrigator is usually necessary.

The robotic total mesorectal excision (TME) is begun at the sacral promontory below the superior hemorrhoidal artery. Arms 1 (right hand of the surgeon) and 2 (left hand of the surgeon) are used to develop a plane of dissection within the avascular presacral space, while Arm 3 provides retraction (see Video 18.1). It is important to be careful grasping the mesorectum with Arm 2, as the strong robotic arm may tear the tissue and cause bleeding (Box 18.1). Monopolar scissors are preferred to advance the plane of dissection with minimal use of electrocautery (see Fig. 18.8). The hypogastric nerves and both ureters are identified. It is important to perform the dissection in the posterior mesorectal space and not the presacral space. Entering the presacral space will result in injury to the hypogastric nerves and presacral venous bleeding. After entering the plane between the presacral fascia and mesorectum, the dissection is started posteriorly. The sigmoid is retracted anteriorly, and Waldeyer's fascia (rectosacral fascia) is entered distally at approximately the level of S3. The dissection is advanced caudally to the level of the levator muscles. It is then carried circumferentially within the lateral and anterior planes (see Video 18.2). The hypogastric nerves are identified laterally and preserved along the pelvic sidewall, performing complete autonomic nerve preservation (see Fig. 18.9). Anteriorly, dissection is achieved by incising the peritoneum between the rectum and vagina in women or the seminal vesicles and prostate in men (Box 18.2). In the case of large anterior tumors, the Denonvilliers' (rectovesical) fascia is resected en bloc with the rectum (see Video 18.3). Arm 3 is the ideal anterior retractor during this part of the operation. The lateral stalks are divided close to the rectum to avoid nerve injury (see Video 18.4).

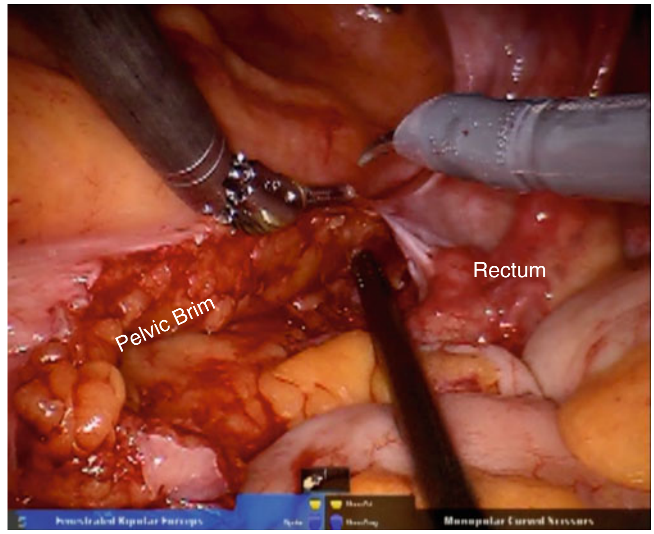

Fig. 18.8 The sharp dissection should be performed using endoshears

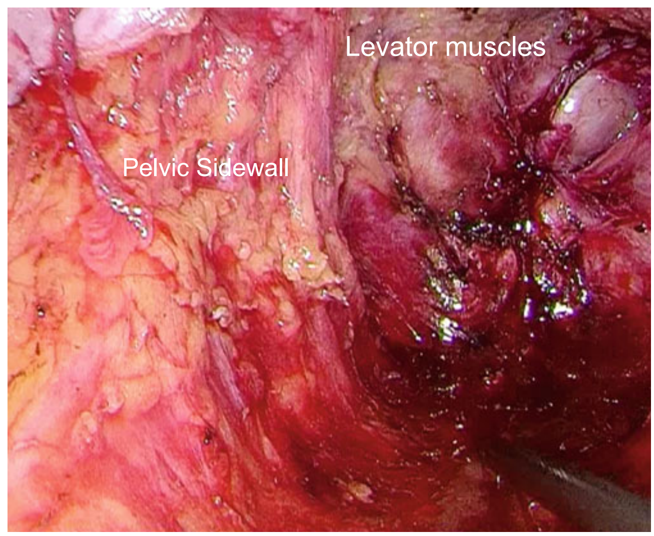

Fig. 18.9 A view of the pelvic sidewall and levator muscles after total mesorectal excision

Transection of the Rectum

Once an adequate circumferential margin is obtained, digital rectal exam or flexible sigmoidoscopy is performed to assess the proper level of rectal division. The rectum is divided using an articulating linear stapler (see Fig. 18.10). The R1 8-mm port is removed together with the entire robotic arm, and the 12-mm port is used laparoscopically to accommodate the articulating stapler. This can also be done from the

Box 18.1 Tip
Avoid grasping the mesorectum and/or mesentery to prevent bleeding and subsequently obscuring the surgical field and the exact TME plane of dissection. Grasp the rectal wall, appendages, or peritoneum instead, and meticulously control any miniscule bleeding immediately.

Box 18.2 Tip
Avoid dissection of the rectum and mesorectum completely on one side only even if it is tempting to just follow the easier posterior plane to the pelvic floor first. Dissect in the mesorectal plane circumferentially from proximal to distal, and "peel" the rectum out of the pelvis (Video 18.5).

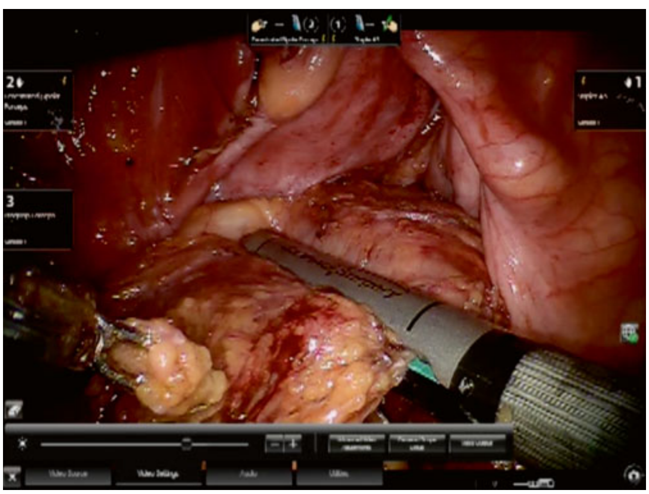

Fig. 18.10 A laparoscopic or robotic stapler can be used to divide the rectum

L1 assistant port without undocking. A 45-mm green stapler load or the purple tristaple cartridge is recommended, especially in cases with preoperative radiation. Rectal transection should ideally be achieved with a single stapler firing as studies indicate that multiple firings lead to increased anastomotic leak rates [8]. If this is not technically possible, however, the stapler is fired sequentially, and care is taken not to cross previous staple lines (see Fig. 18.11). An average of 2.5 staple loads are needed.

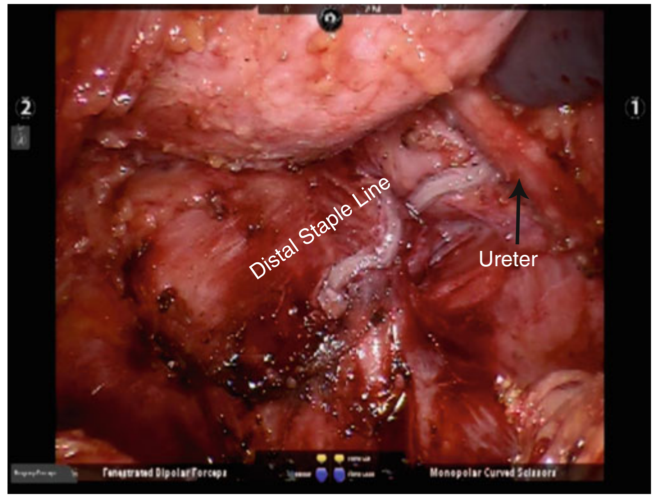

Fig. 18.11 Care should be taken not to cross previous staple lines

Anastomosis with Leak Test

After the distal specimen has been divided, the robot is undocked. The specimen is brought out through a mini suprapubic Pfannenstiel incision covered with a wound protector. A transanal or off midline extraction is also feasible in selected cases. The mesocolon is then ligated at the proximal edge of the resection, and the colon is divided. The specimen is removed. An anvil is inserted into the end of the remaining proximal colon and secured with a purse string suture. A colonic J pouch can be created at this point if preferred. The colon is placed back in the abdomen, and a laparoscopic end-to-end stapled anastomosis is constructed using a circular EEA stapler (see Fig. 18.12). A flexible sigmoidoscopy is performed to assess perfusion and air seal. If any integrity appears compromised, the decision must be made to reinforce versus reconstruct the anastomosis. A round Blake drain can be placed within the pelvis. A loop ileostomy can also be constructed in high-risk patients or for a low anastomosis (<5 cm).

Abdominoperineal Resection

Very low rectal tumors invading the sphincter complex that cannot undergo a sphincter-preserving operation are best treated with an abdominoperineal resection (APR). However, with advances in neoadjuvant therapy and total mesorectal excision, indications for APR have decreased over time [9]. After studies showed a higher rate of local recurrence and lower survival after APR compared to anterior resection and TME [10], a wider perineal and pelvic floor resection has

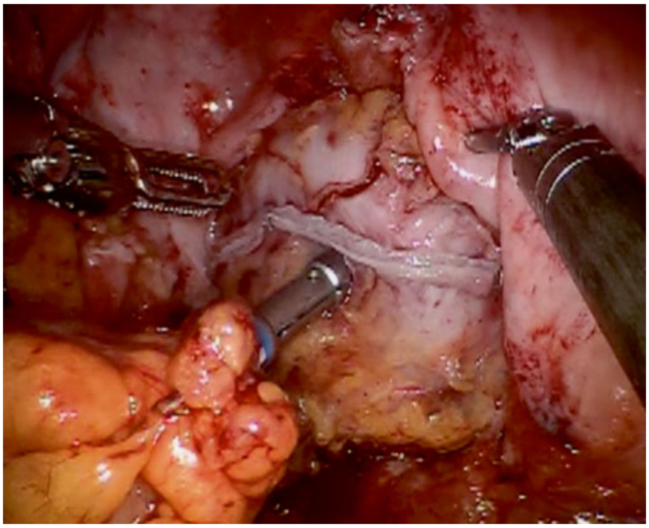

Fig. 18.12 Construction of an end-to-end stapled anastomosis

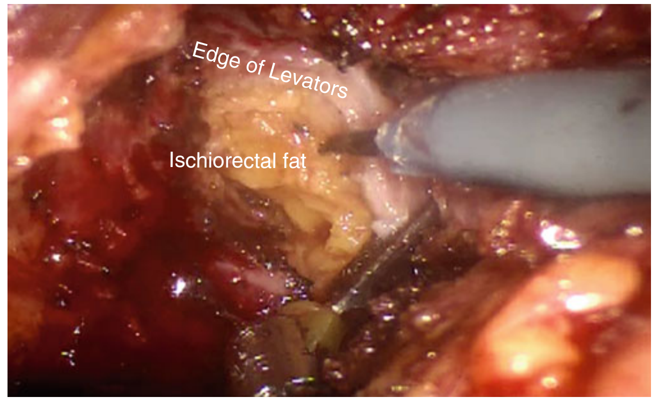

Fig. 18.13 Ischiorectal fat as encountered during abdominoperineal resection

been proposed. Extralevator APR (E-APR) modifies the traditional approach in an effort to decrease the rate of positive resection margins and local recurrence rates [11].

After laparoscopic mobilization of the left colon, a robotic total mesorectal dissection is performed as described above. In contrast with the robotic low anterior resection, takedown of the splenic flexure is not typically necessary in this procedure. A shorter length of colon is required for creation of a colostomy, and there is usually adequate length without further mobilization. However, in certain patients such as those with a high BMI or with previous surgeries, this step may be necessary.

Unlike a conventional low anterior resection, care is taken not to lift the rectum off the levators (Box 18.3). Rather, a wide resection is performed using robotic scissors. Circumferential transection of the muscles at their origin is carried out posteriorly and anteriorly until the ischiorectal fat is visualized on both sides (see Fig. 18.13). The dissection is then continued through the ischiorectal fossa until just before the perianal skin. A digital perineal exam performed by the assistant can help identify the posterior limit of the rectal dissection relative to the top of the coccyx. The transection of the levators meets posteriorly in the midline where the anococcygeal ligament is transected. The lateral limit of the dissection is the medial edge of the obturator fascia. Autonomic nervi and branches of the iliac vessels can be found laterally and preserved. Denonvilliers fascia in men and the pouch of Douglas in women form the anterior border. Care must be taken to identify and avoid urethral injury, especially in male patients.

Box 18.3 Tip
It is easier during an extralevator APR to identify and divide the levator muscles at their origin using the robotic approach compared to the perineal division in an open E-APR, which frequently requires prone positioning.

There are four key zones where autonomic nerve injuries are most likely to occur during rectal resection: the superior hypogastric plexus during dissection of the IMA, the hypogastric nerves during posterior mobilization, the pelvic plexus during lateral mobilization of the rectum, and the anterior *nervi erigenti* during anterior dissection. The use of robotic assistance can promote a more controlled pelvic resection and therefore minimize the risk of accidental injury to vascular, neurologic, or urologic structures. This approach also eliminates the need to turn the patient prone for perineal resection and thus potentially improves perineal wound healing rate [12].

After the rectal portion is complete, the robot is undocked. The patient is placed in steep Trendelenburg position, and a circumferential incision is made in the skin around the anus from the perineal body to the coccyx. The inferior hemorrhoidal vessels are encountered anteriorly and posteriorly in the ischiorectal fat. Dividing the rectococcygeus muscle enters the presacral space. In male patients, the remaining attachments of the rectourethralis muscle and fascia are divided. Anteriorly the transverse perineal and rectourethralis muscles are divided. In female patients, unless the tumor is small or localized to the posterior rectum, an en bloc posterior vaginectomy may be required. The specimen is then delivered through the perineum, and the wound is copiously irrigated.

The skin is closed in a three-layered fashion. The abdomen is re-insufflated, and a drain is placed in the pelvis. A laparoscopic end colostomy is brought out through a premarked stoma site.

In cases of locally advanced anal or low rectal cancer, a perineal reconstruction may be required. Neoadjuvant radiation therapy can result in complications such as an abscess or unhealed surgical wounds. Closing skin defects with a pedicle flap can sometimes prevent these adverse outcomes. Among the variety of flaps, the vertical rectus abdominismyocutaneous (VRAM) flap is a popular surgical option, but the use is limited in a laparoscopic or robotic approach. The width of the skin paddle is determined based on the size of the perineal defect to be filled. The anterior rectus sheath is incised and a flap is raised. The skin paddle, subcutaneous fat, and rectus abdominis muscle are then mobilized and rotated to reach the pelvic floor. The flap is sutured into place. Alternatively a gracilis muscle flap is used in minimally invasive abdominal approaches to an APR.

Rectopexy

Many surgeries have been described for the treatment of rectal prolapse. Patients frequently present with both prolapse and incontinence [13]. In these patients with mixed pelvic floor complaints, the rectal prolapse should be addressed first, as most patients will have improved continence after the reduction or excision of the rectal procidentia [14]. A chronically prolapsing rectum can result in decreased sphincter function and is also at risk for incarceration.

The surgery can be performed via a perineal or a transabdominal approach. The perineal approach has traditionally been reserved for high-risk patients, although recent studies indicate that morbidity and mortality may be comparable for both approaches [15]. The transabdominal approach can be performed as an anterior or posterior rectopexy. Posterior is currently the most common technique in the United States; however, anterior rectopexy is increasing in popularity [16]. The choice of procedure remains based on surgeon experience and preference. The use of minimally invasive or robotic techniques for abdominal rectopexy has been shown to result in decreased postoperative pain, shortened hospital stay, early recovery, and return to work [17]. Several reports have evaluated robotic surgery for rectal prolapse and demonstrated the safety and feasibility of this technique. For the purpose of this chapter, we will describe a robotic resection and posterior rectopexy without mesh.

Rectal prolapse surgery includes three general steps: rectal mobilization, sigmoid resection if indicated, and fixation of the rectum to the sacrum. Controversy remains over which step contributes the most to minimizing recurrence rates. The decision to perform a sigmoid resection with or without mesh placement is based on patient symptoms and anatomy. Constipation usually indicates a need for resection, whereas normal bowel function may allow rectopexy alone [18].

If the rectum is prolapsed, it should be reduced prior to starting the abdominal procedure. After pneumoperitoneum is obtained, a camera port, three robotic ports, and two laparoscopic-assisted ports are inserted in the same location as described above. The patient is placed in Trendelenburg position, and a sigmoid resection is begun laparoscopically as previously described in a medial to lateral fashion. A robotic mobilization of the rectum is similarly carried out from the sacral promontory and continued to the level of the coccyx (see Videos 18.5 and 18.6). The peritoneum is opened over the lateral mesorectum and the peritoneal reflection, but the lateral mesorectal stalks are not divided. Division of these stalks has been associated with a decreased risk of recurrent rectal prolapse, but an increased risk of pelvic floor dysfunction and constipation.

If indicated, a sigmoid resection is performed at this point. The left colon is not mobilized, and only the redundant sigmoid colon is resected. The mesorectum (just below the level of the rectosigmoid junction) is divided with a vessel-sealing device, and the rectosigmoid is divided with a laparoscopic stapler. The amount of colon removed should be limited to the redundant portion of the sigmoid. The superior rectal artery can be spared to preserve blood supply to the colorectal anastomosis. A suprapubic 3–4 cm Pfannenstiel incision is used to extract the redundant sigmoid colon. The proximal colon is transected, and a purse string suture is placed around the anvil of the EEA stapler. The proximal colon is placed back in the abdomen and the fascia is closed. An EEA stapler is then used to perform a laparoscopic end-to-end stapled anastomosis under robotic vision. The anastomosis is inspected for integrity and perfusion.

The rectopexy may be performed with or without mesh. A robotic needle driver is passed through the R1 port site. If performed without mesh, the mesorectum is sutured to the sacrum on the right side with two or three permanent sutures (see Fig. 18.14 and Video 18.7). They are used to maintain the rectum in its new position until scar tissue forms for more permanent fixation. The sutures are placed 1–2 cm below the sacral promontory and just lateral to the midline. Care is taken to avoid injury to the ureters, presacral veins, or hypogastric nerves. If the sigmoid is not resected, a posterior mesh rectopexy may be performed. Mesh selection is surgeon dependent, and there is no established consensus on the appropriate mesh for this surgery at this time. The mesh is fixed to the sacrum in a similar manner to the rectopexy suture placement. The mesh is wrapped around the rectum anteriorly and secured to the lateral mesorectum on both sides with suture. Care is taken not to kink the rectal lumen during suture rectopexy or mesh rectopexy. If a sigmoid resection has been performed, tension cannot be applied to the newly formed anastomosis during subsequent rectopexy maneuvers.

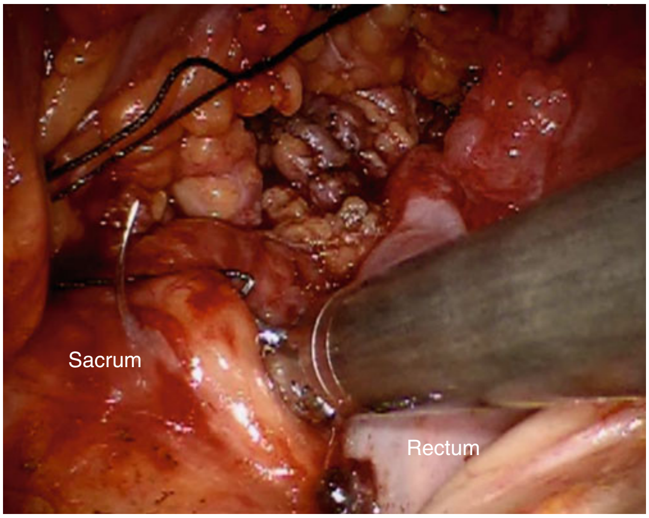

Fig. 18.14 Suturing to the sacral promontory

Summary

Robotic-assisted proctectomy has been found to be safe with equivalent oncologic and perioperative outcomes compared to laparoscopic proctectomy. The use of robotic assistance in the pelvic dissection allows excellent visualization of key structures such as the hypogastric nerves and ureters. Care must be taken to maintain gentle retraction with the robotic arm, so as not to distort the dissection plane or tear the mesorectal tissue. With experience, robotic assistance can facilitate a meticulous oncologic mesorectal resection.

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19 Proctectomy: Total Robotic Approach

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Introduction

This chapter will review the operative technique and advanced approaches to a total robotic low anterior resection (LAR) and abdominoperineal resection (APR). The hybrid approach has been described in detail in the previous chapter. Specifically, this chapter will address the technique of single or dual docking for the mobilization of splenic flexure during rectal and left colonic surgery. We will also describe the end-to-end anastomosis utilizing the double purse-string technique described by Prasad et al. and the transabdominal transanal (TATA) robotic-assisted, coloanal pull-through for sphincter-sparing ultralow rectal cancers.

Background

The explosion of robotic technology has reached all surgical specialties, and colorectal surgery has not been immune to the applications and possibilities. Total mesorectal excision can be performed safely in experienced hands with excellent oncologic and clinical outcomes, with potential advantages over conventional laparoscopic techniques [1–7]. Several reports have indicated improved sexual function with the use of robotic technology due to the theoretical advantage of visualization and precise dissection. Currently studies are underway to elucidate this objectively in a clinical setting. After a relatively shorter learning curve, robotic technology has become a mainstay of rectal cancer surgery for many [8].

An important surrogate for rectal cancer surgery is the circumferential rectal margin. Current literature ranges from 0 to 7.5 % [2, 9–12]; however, a recently published report of a single experienced robotic surgeon achieved a circumferential resection margin positivity in a very acceptable 3.5 % and local pelvic control rate of 93 %. In this series, the author had personally performed well over 200 robotic proctectomies mitigating the learning curve effect from most of the early reports [13].

Preoperative Planning

Preoperative assessment with digital rectal examination, endorectal ultrasonography, and rigid proctoscopy is a must. Additional information can be obtained from high-resolution MRI for the relationship of the tumor to the mesorectal and deep pelvic planes. Full colonoscopy must have been completed prior to the surgery. Awareness of preoperative colonic stents placed due to near obstruction is important, as the retraction in the pelvis may be severely impaired. Endoscopic extraction should be considered intraoperatively although it may be significantly difficult if embedded in the mucosa. Preoperative assessment of urinary or sexual dysfunction is important to quantify and discuss with the patient possible postoperative changes. Ureteral stents are not routinely placed, unless complex preoperative surgery is expected or complex intestinal genitourinary fistulas are diagnosed preoperatively.

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_19. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_19, © Springer Science+Business Media New York 2015

Room Setup and Positioning

In robotic-assisted surgery, repetition and standardization of the steps are very important to become more efficient. An assistant at the bedside well versed in robotic technology is strongly recommended even in academic institutions in order to help the less-experienced trainee. The anesthesia team may require to have more room away from the patient; the use of a face shield or Mayo stand table on top of the head of the patient may minimize collision of the heavy robotic arms with the patient's face which should be protected with foam. The patient is placed in Trendelenburg positioning with constant attention to respiratory pressures and cardiac rhythm. Constant communication between the anesthesia team and the surgeon is fundamental, especially in morbidly obese or cardiac patients.

Proper positioning and set up in robotic pelvic surgery is the mainstay to success of the robotic approach. Placing the patient, the robotic cart, and arms in the right place from the beginning will dictate how the procedure will progress, as most of the ergonomics of the port placement, if not done properly will potentially result in multiple collisions and intraoperative events that will frustrate the surgeon and unnecessarily prolong the surgery.

The patient is routinely positioned in modified lithotomy position with Allen® stirrups. Our method is to use the Allen® Hug-U-Vac® Steep Trend Positioner (Allen Medical Systems, Acton, MA). With this system there is none or minimal sliding even when the steepest Trendelenburg position is taken in morbidly obese patients as this device straps to the table and "hugs" the patient. The buttocks should be approximately 8–10 cm over the lower end of the table to provide access to perform any perineal procedures. In morbidly obese patients (see Fig. 19.1), at times, tape will be needed and wrapped around the chest and the operative table. The hips of the patient are in flexed and partially abducted position, with the feet and legs properly padded to avoid any excessive pressure points. They are also placed in-line to the contralateral shoulder. Rotation of the patient 10–15° to the right will displace the small intestine out of the dissection zone. In obese patients, who are unable to tolerate significant amounts of Trendelenburg, small intestine can obscure exposure to the pelvis. The placement of the Alexis Laparoscopic System with Kii Fios First Entry® (Applied Medical, Rancho Santa Margarita, CA) over the extraction site and abdominal pads at the base of the small bowel mesentery will hold the viscera out of the field of surgery (see Fig. 19.2).

The assistant uses atraumatic laparoscopic bowel graspers through the laparoscopic port. A zero-degree camera is used for the entire procedure unless there is difficulty during the

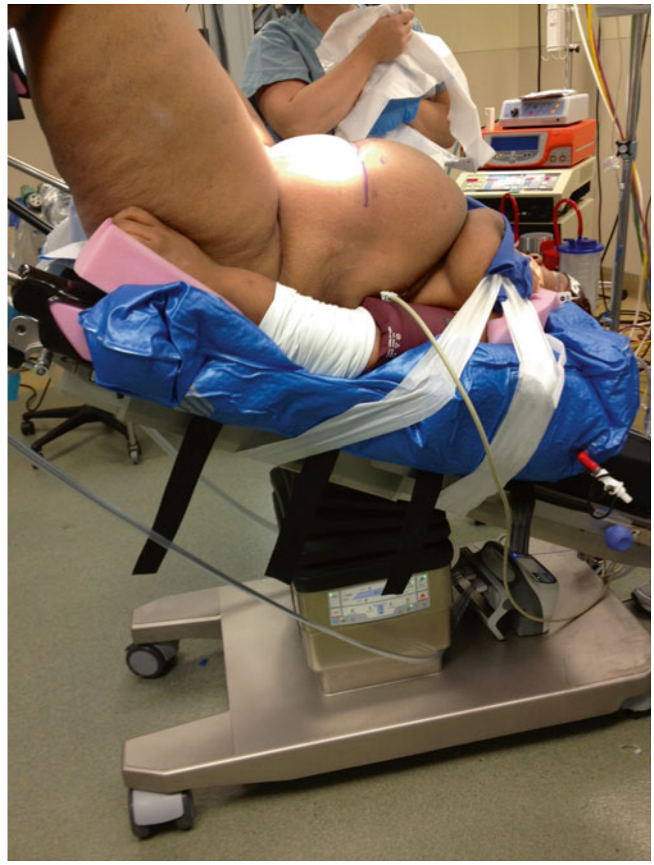

Fig. 19.1 Patient placement and Trendelenburg testing

Fig. 19.2 Alexis laparoscopic system

Fig. 19.3 Left hip robotic placement, docking assistant side view

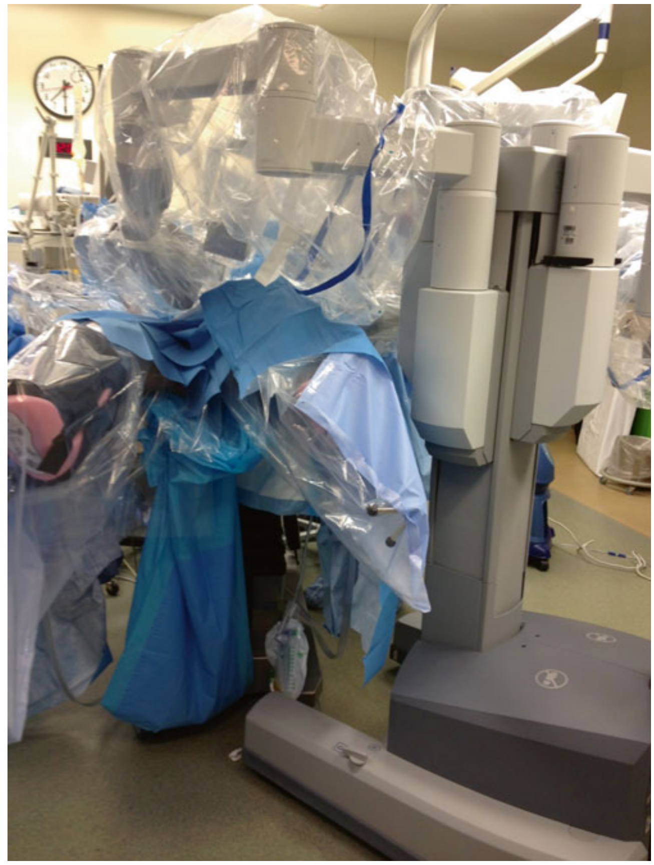

Fig. 19.4 Left hip robotic placement, side view

splenic flexure mobilization. At that time, the 30-degree camera with the angle down may be of help. The robotic cart is docked over the left hip, aligning the camera port with the left hip and the contralateral right shoulder (see Figs. 19.3 and 19.4). Adequate room should be left in the space between the legs to properly perform transanal surgery especially for an intersphincteric proctectomy, the TATA approach, or an abdominoperineal resection. The abdomen and the perineum are prepped separately.

Port Setups and Extraction Sites

Port placement is dictated by the location of the pathology. For all pelvic pathology, the 12 mm camera port is routinely placed in the periumbilical area with the optiview technique. Veress needle or Hasson technique are optional. The placement of the camera port varies depending on the body habitus of the patient though. Taller patients will require the port placement at or below the umbilicus; shorter patients will have it placed somewhere between the xiphoid and the umbilicus. Smaller patients will also require the ports placed more widespread to avoid collisions. Routinely about 10–15 cm of distance between the ports is required.

Three robotic ports (R) are then inserted under direct visualization (see port configuration in previous chapter):

R1 is a robotic stapler trocar inserted approximately midway between the anterior superior iliac spine and the umbilicus in the right lower quadrant (RLQ). If an ileostomy is expected, all attempts should be made to place the port through the lateral aspect of the marked area to avoid any further incisions.

R2 is an 8 mm trocar located about 2–3 cm below the level of camera port in the left midclavicular line over the left lower quadrant (LLQ).

R3 is an 8 mm trocar located about 5 cm above the umbilical camera port in the anterior axillary line over the left flank. Proper placement of this port is crucial in order to perform cranial retraction and exposure during the deep portion of the pelvis.

Fig. 19.5 Robotic LAR port placement

One 8 mm laparoscopic port is placed (L) in the right midclavicular line above the level of camera port in the right upper quadrant (RUQ) (see Fig. 19.5). Care should be taken that this port is not placed too far towards the lower quadrant or “in-line” with the camera towards the splenic flexure, so it is possible to perform the splenic flexure mobilization avoiding the collisions internally or externally. A 12 mm port is utilized here if a laparoscopic stapler is needed for the colonic transection.

The preferred extraction site is the planned ileostomy site. Despite adequate mobilization of the proximal colon, it might not reach the right side of the abdomen sometimes. The benefit of a total robotic approach is that it allows the proximal transection and placement of a purse string intracorporeally. Alternatively, the specimen can be pulled through the anus for a coloanal hand-sewn anastomosis or utilizing a robotic distal purse string as described below.

Operative Steps (Table 19.1)

Exploratory Laparoscopy

Appropriate pneumoperitoneum is established, and evaluation of the abdominal cavity and solid viscera is done for metastatic disease. After initial laparoscopic exploration, ports are placed and the patient positioned as described above.

Table 19.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy	1
2. Identification of the ureter and ligation of the inferior mesenteric artery	5
3. Mobilization of the sigmoid colon	3
4. Mobilization of the descending colon and splenic flexure with identification and ligation of the inferior mesenteric vein	6
5. Rectal mobilization	5
6. Transection of the rectum	3
7. Anastomosis with leak test	2

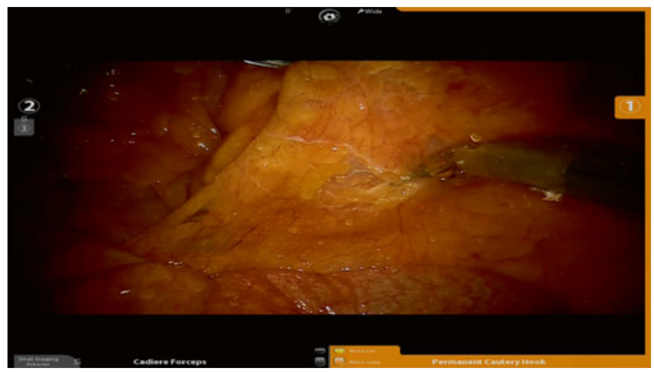

Fig. 19.6 Medial to lateral entry

Identification of the Ureter and Ligation of the Inferior Mesenteric Artery

All robotic ports and the assistant port are used during this operation. Medial to lateral identification of the pedicle is performed with the monopolar hook through R1 and a fenestrated grasper through R3 (see Fig. 19.6 and Video 19.1). R2 and the assistant port are used to tent up the sigmoid colon. Identification of the ureter is done medially below the pedicle (see Fig. 19.7). In some cases a second window can be opened above the pedicle to identify the ureter as well. Care is taken to identify hypogastric plexus, which is made possible with the three-dimensional visualization. The nerve plexuses are preserved prior to the transection of the vessels. The inferior mesenteric artery pedicle is taken with the robotic bipolar energy device (see Fig. 19.8).

Mobilization of the Sigmoid Colon

After the medial to lateral mobilization of the sigmoid colon and division of the IMA, the lateral attachments can be easily taken again using a monopolar hook through R1. The graspers through R2 and R3 retract the sigmoid colon then medially. Although the medial to lateral approach is routinely

Fig. 19.7 Medial to lateral ureteral exposure

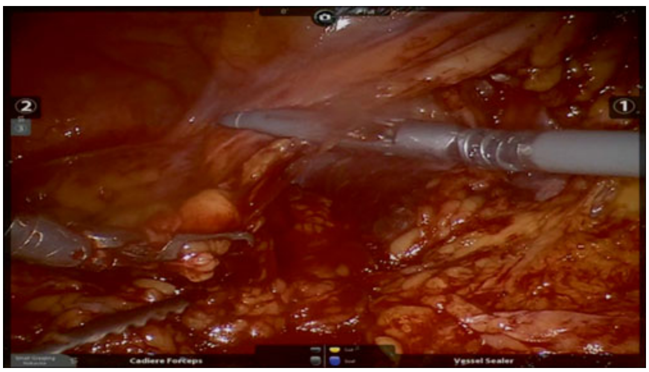

Fig. 19.8 IMA division

employed, the surgeon must be well versed in the lateral to medial approach as in obese patients it may be very helpful to identify the ureter.

Mobilization of the Descending Colon and Splenic Flexure with Identification and Ligation of the Inferior Mesenteric Vein

The robotic vessel sealer is used again to complete a retroperitoneal dissection bluntly above the Gerota's fascia cranially until the splenic flexure is reached, avoiding the tail of the pancreas. The inferior mesenteric vein (IMV) is taken also with the robotic vessel sealer device.

There are two recommended techniques to perform the splenic flexure take down robot assisted. Surgeon's preference dictates whether this is performed in the beginning or at the end of the procedure.

The first technique involves the continuation of the medial dissection after ligation of the IMA and medial to lateral mobilization of the sigmoid colon. R1 is used for the right-handed instrument; typically the robotic sealer and R3 will be used for the left-handed instrument, typically a fenestrated grasper. For this, R3 needs to be repositioned described as the "flip technique" (see Fig. 19.9). R3 is undocked from the left

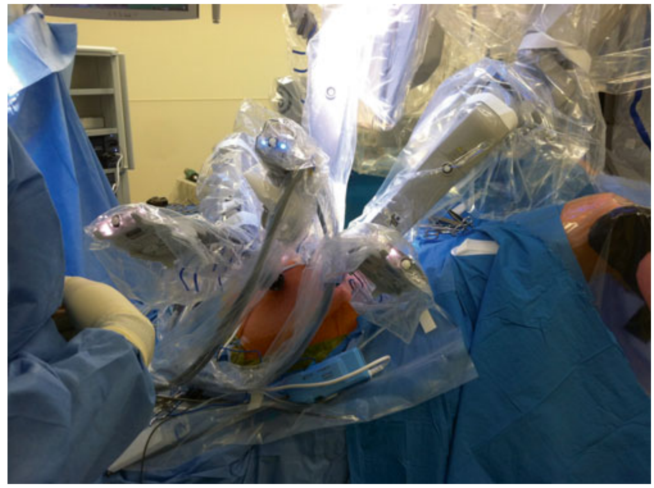

Fig. 19.9 Flip technique for splenic flexure take down

flank port and docked through the 12 mm laparoscopic port in the RUQ. That port may be changed to a robotic port or a robotic port may be telescoped through the 12 mm port. If the commercially approved dual robotic 8/12 mm trocar kit is not available, care must be taken when performing this maneuver, as the manufacturer does not recommend it. The assistant can use R2 after the robotic arm has been undocked.

The second technique involves undocking and redocking of the robotic cart from the left shoulder in-line to the right superior iliac crest. The port configuration would be similar to above. This double-docking technique can be done prior to the pelvic dissection as per surgeon's preference.

Rectal Mobilization

The grasper in port R3 is now passed underneath the recto-sigmoid junction and used to "hook" the colon laterally and cranially for retraction. This helpful maneuver will routinely produce excellent exposure to the pelvic inlet. Using R2 and R3 will expose the posterior planes perfectly. Anteriorly, R3 becomes the main retracting arm.

Full mobilization of the posterior plane anterior to the presacral Waldeyer's fascia down to levator muscles or even to the anal cuff/perineal skin is performed posteriorly using close retraction with a fenestrated bipolar in R2 and a monopolar hook in R1, while R3 is constantly retracting the rectum cranially out of the field of vision. Depth of the dissection can be gauged asking nursing staff to perform DRE during the procedure. The lateral rectal stalks are then taken similarly. Anterior dissection is performed just anterior to the Denonvilliers' fascia or rectovaginal septum and extended down to connect with the posterior dissection at the level of the levator muscles or lower. It is very important to stay within the confined "holy plane" of mesorectum. During this portion of the procedure, the assistant retracts the rectum

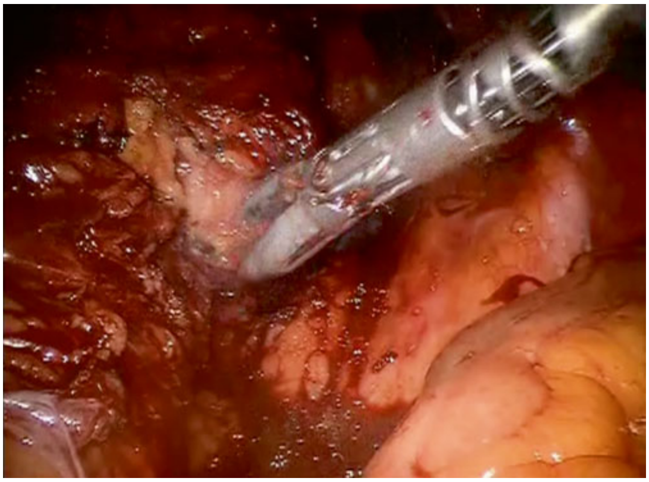

Fig. 19.10 Partial TME

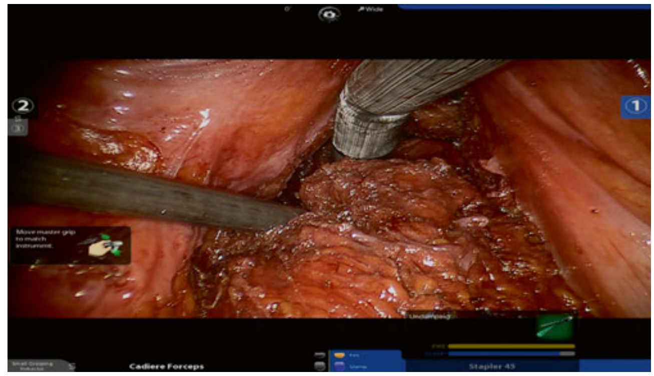

Fig. 19.11 Robotic stapling

Fig. 19.12 Firefly

with a laparoscopic atraumatic grasper cranially and lateral or medial as needed. The grasper through R3 is now placed anteriorly and opened in a V-shape fashion to retract vagina or prostate and seminal vesicles. As the dissection progresses it is important to constantly reassess the retraction and triangulation. This skill of continuous clutching R2 and R3, once mastered, speeds up the surgery deep in the pelvis and decreases the total console time. Nervi erigenti are identified precisely and spared. In certain clinical scenarios, if the pathology warrants posterior vaginal resection, care must be taken to avoid losing the pneumoperitoneum. A moist pad may be placed in the vagina for identification once the wall has been resected.

Transection of the Rectum

After the rectal dissection is completed, attention is placed to perform the rectal transection. In patients with upper rectal cancers, a tumor-specific partial TME is performed (see Fig. 19.10), using the R1 with the robotic vessel sealer to transect the mesorectum and skeletonize the rectal wall. After that maneuver is performed, routine use of the robotic stapler 45 mm on a green load allows the surgeon to obtain instant feedback of the staple height and proper compression of the bowel wall (see Fig. 19.11 and Video 19.2). Usually one or two staple firings are required. If robotic stapling technology is not available, standard laparoscopic stapler with a 45 or 60 mm length is utilized through the laparoscopic assistant port. It is often times easier to perform the transection vertically especially in the deep tumors, instead of coming from laterally within the confines of the pelvis as the stapler collides with bony structures.

Prior to extracorporealization of the specimen, near infrared imaging of the colon is used to assess perfusion of the proximal and distal ends. This is achieved with intravenous administration of indocyanine green (see Fig. 19.12). The robotic vessel sealer is used to dissect the feeding pedicle to the proximal sigmoid colon, and the proximal transection margin is marked with hook cautery. Visualization of the vascular flow to the colon and rectal stump is documented. Recently published data has indicated a change of the proximal transection margin up to 40 % of cases [14].

In order to minimize incisions, the ileostomy site is used for extracorporealization, transection, and reinsertion of the 29 mm anvil to perform the robotic-assisted intracorporeal anastomosis. The R1 arm is removed, and the surgeon and the assistant will perform the extraction from the right side of the patient. The use of the Alexis Laparoscopic System with Kii Fios First Entry® (Applied Medical, Rancho Santa Margarita, CA) helps maintain pneumoperitoneum once the intestine has been returned to the abdominal cavity.

Once the wound retractor has been placed, the colon is extracorporealized, transected where the prior marking was performed, and the 29 mm anvil is routinely inserted and secured using a reusable purse-string device and a 2/0 Prolene suture. Attention is placed to avoid any possible diverticula. The colon is returned to the abdominal cavity, and the cover of the wound retractor is placed to reestablish pneumoperitoneum.

Anastomosis with Leak Test

The assistant will serially dilate the rectum to a 31 mm sizer under direct vision, introducing at that point the 29 mm EEA stapler which is connected to the proximal anvil using the R1 robotic port in the center opening of the wound retractor cover and a robotic grasper.

Double Purse-String Robotic Stapled Anastomosis Technique

Once the colon has been returned into the abdominal cavity and pneumoperitoneum has been reestablished, in patients with a long enough rectal stump, the distal rectal stump staple line may be resected and a second purse string is performed utilizing instruments through R1 and R2. Under direct vision the EEA stapler is introduced, the purse string is tightened, and the anvil connected to the staple gun under direct vision closed and fired. Two complete donuts are observed, and the integrity of the anastomosis is checked irrigating the pelvis, proximal clamping of the colon using the Graptor™ (Intuitive Surgical, Sunnyvale, CA) retractor through R3, and air insufflation.

As an alternative, if no ileostomy is required, transanal extraction (see Fig. 19.13) and resection of the specimen can be done after the removal of the staple line through a small wound protector placed in the anus. The anvil is then placed in the proximal colon and returned to the abdominal cavity. Completion of the anastomosis is done using the double purse-string technique.

Intersphincteric Resection, Distal Mucosectomy, and Hand-Sewn Coloanal Anastomosis

Robot-assisted TATA, intersphincteric resection, and hand-sewn anastomosis are used for the most distal tumors within 2 cm from the dentate line. This technique is very similar to a Soave procedure performed in Hirschsprung's disease in children [15, 16]. After the transabdominal portion of the procedure, the clinical decision is made upon evaluation of the residual tumor to perform and intersphincteric resection or mucosectomy (see Fig. 19.14). The use of a Lone Star Retractor System™ (Cooper Surgical Inc., Trumbull, CT) effaces the anal canal. At that point, mucosectomy is performed starting approximately 1 cm above the dentate line. The depth of the dissection is in the submucosal plane for a mucosectomy or resecting part of the internal anal sphincter

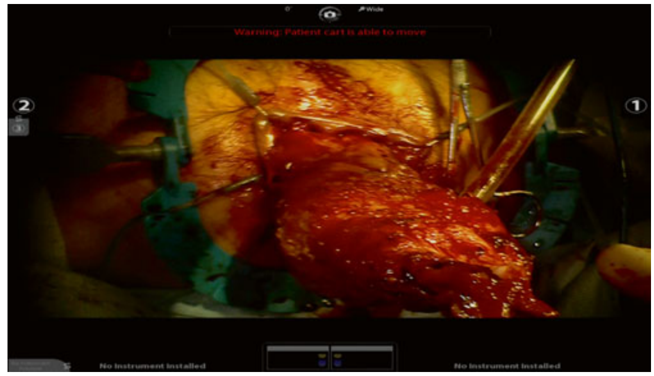

Fig. 19.13 Transanal extraction

Fig. 19.14 Intersphincteric proctectomy incision

for an intersphincteric dissection. Dissection progresses first posteriorly and through the lateral aspect of the anal canal and distal rectum and then anteriorly (see Video 19.3). Care is to be taken to avoid a full thickness perforation of the vaginal wall. Entering into the seminal vesicles may cause bleeding which is difficult to control. After the distal portion is mobilized (Video 19.4), the rectum and colon is extracorporealized transanally, transected proximally, and finally coloanal hand-sewn anastomosis performed (Video 19.5).

Abdominoperineal Resection

The standard dissection can be accomplished transabdominally with the use of robotic technology, followed by a perineal dissection to remove the anorectum. The planes past the levators may be entered and continued to the ischiorectal fossa and perianal skin. The assistance of digital rectal exam improves the dissection.

APR has been associated with a higher incidence of positive circumferential margins, and the concept of cylindrical resection with transabdominal levator dissection has evolved in order to achieve better local surgical control. Marecik et al. described the technique in five patients, achieving intact mesorectum and radial margins. The dissection is started posteriorly and circumferentially around the rectum; the iliococcygeus and pubococcygeus muscles are transected until the lobular fat of the ischiorectal fossa is seen bilaterally [17].

Summary

In conclusion, a safe and time-efficient approach to a completely robotic proctectomy is feasible by following the abovementioned principles. The procedure itself is very systematic. Docking and port placement in the midaxillary line bilaterally and anterior axillary line on the left side are basic for retraction and dissection. R3 is the mainstay arm for the retraction and triangulation. As the surgeon gains in experience, it becomes a second nature to "clutch" and use that arm multiple times. Distal transection should be carefully tailored to the patient trying to avoid positive circumferential margins and, when in doubt, perform an extralevator APR. Overall, there is a relatively short learning curve that needs to be surpassed to offer patients significant benefits of minimally invasive colorectal surgery.

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Part V

Total Colectomy with Ileorectal Anastomosis and Proctocolectomy with Ileoanal Pouch

Total Colectomy and Proctocolectomy: Laparoscopic Approach

20

Jean A. Knapps and Anthony J. Senagore

Introduction

"Fast-track" or "enhanced recovery" programs have become paramount in the treatment and care of patients undergoing colorectal surgery. This strategy is divided in three important elements: preoperative, intraoperative, and postoperative care. Of these, the use of laparoscopy has become essential in the reduction of postoperative physiologic stress, morbidity, and reduced hospital length of stay.

Surgery remains the only definite treatment in our armamentarium against ulcerative colitis (UC) and laparoscopic restorative proctocolectomy with ileoanal pouch anastomosis (RPC-IPAA) its most attractive alternative. Total colectomy with ileorectal anastomosis also referred to as subtotal colectomy with primary anastomosis may be performed on patients with the attenuated form of familial adenomatous polyposis (FAP) or MUTYH-associated polyposis (MAP) and patients with colon cancer associated with hereditary nonpolyposis colorectal cancer (HNPCC), synchronous colon cancer, or an obstructing mass causing severe dilation of the proximal colon. Other cases include colonic inertia as well as lower gastrointestinal (LGI) bleeding.

This chapter will focus on the aforementioned procedures and will review some of the literature supporting their use.

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_20. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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Background

Laparoscopic surgery has increasingly gained popularity since its inception and has, for the past decade, experimented a dramatic growth in its use. It is recognized as a factor associated with shorter intensive care unit and total hospital stays, fewer complications, lower mortality, fewer readmissions, and less use of skilled nursing facilities after discharge [1–4]. As such, the complexity of surgical procedures performed using a minimally invasive approach has also increased making it a desirable experience for the patient [5]. Unfortunately, the steep learning curve seen with minimally invasive colorectal surgery has caused a slow adoption trend nationwide [6].

RPC-IPAA, which was first described by Parks and Nichols [7] in 1978 and later by Peters [8] in 1992 for the laparoscopic approach, remains today the "gold standard" of treatment for UC and FAP. Initial reports comparing the open and the laparoscopic approach found no difference in short-term outcome [9]. In 2000, Marcello et al. [10] conducted a case-control study where they included 40 patients (20 laparoscopic and 20 open). They were matched by disease type and severity and found a more rapid return of bowel function (2, 1–8 days vs. 4, 1–13 days), $P=0.03$, and a shorter hospital length of stay (7, 4–14 days vs. 8, 6–17 days), $P=0.02$ when comparing laparoscopic and open cases. They reported complications in four of their laparoscopic cases and five of their open cases. Important to note however is that they did perform a diverting loop ileostomy in the laparoscopic arm in 12 of the 13 patients operated for UC and in all of them with the open approach (13 patients).

A more recent study published in 2013 by Schiessling et al. [11] was designed as a prospective randomized controlled trial. Patients and assessors were blinded to either a laparoscopic (LAP) or conventional (CON) arm group. They had a total of 42 patients with 21 in each arm and found no discrepancies in length of hospital stay, postoperative pain, bowel function, and quality of life between both approaches. The LAP approach was superior regarding the length of skin

O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_20, © Springer Science+Business Media New York 2015

incision, whereas the CON approach was superior in length of operation. A conversion rate of 23.8 % was reported. They concluded that the LAP approach was at least as safe as the open approach with improved cosmetic results. Unfortunately, the study was stopped early due to insufficient recruitment.

Beyer-Berjot et al. [12] in 2013 evaluated fertility in 63 patients who underwent laparoscopic RPC-IPAA between 2000 and 2011 and compared it with a cohort undergoing laparoscopic appendectomy in the same period. They collected data prospectively and had the patients answer a telephone questionnaire about fertility. The mean age at time of surgery was 31 ± 9. The surgery was performed for UC in 73 % of cases and for FAP in 17 %, with a mean follow-up of 68 ± 33 months. Eighty-nine percent (56 patients) responded to the questionnaire. They found that 11 (73 %) of 15 patients trying to conceive were successful, with 1 miscarriage. No significant difference in fertility was seen between the two groups, and they concluded that there appeared to be a lower infertility rate in the laparoscopic RPC-IPAA approach than after open surgery.

Unfortunately there are a limited number of papers comparing the open to the laparoscopic RPC-IPAA approach and even less so of randomized studies. This is probably related to lack of interest of the patients to undergo a more invasive procedure when the option for a minimally invasive approach exists. White et al. [13] in their paper published in 2014 compare clinical outcomes of laparoscopic restorative proctocolectomy with those of conventional open surgery in one center. They included 207 consecutive patients between 2006 and 2011. Open surgery was performed in 131 patients (63.3 %) and laparoscopy in 76 patients (36.7 %). They found that the laparoscopic group had a shorter length of stay (6, 4–8 vs. 8, 7–12 days), $P < 0.001$ and, a decreased rate of minor complications (33 % vs. 50.4 %), OR 0.48 (95 % CI 0.27–0.87). There were no significant differences in total complications, anastomotic leakage, major morbidity, reoperation, and stoma closure rates. Duration of operation was shorter in the open group (208, 178–255 vs. 185, 255–325), $P < 0.001$. They reported a pouch failure in 14 of 181 patients, a conversion rate of 9 % (seven patients) and three deaths, which occurred in the open group.

Room Setup and Positioning

The surgeon must ensure correct positioning of the patient, which is of utmost importance when mobilizing the transverse colon. The patient will undergo general anesthesia and will need an orogastric tube, a Foley catheter, and compression pneumatic stockings. Arms should be tucked and the patient placed in the lithotomy position as in most colorectal surgeries, with the legs placed in stirrups to ensure access to the anus, and the capacity to perform intraoperative colonoscopic intubation as well as transanal stapling. Here the legs should be left lower than the hips to allow for sufficient space for the operators instruments to move freely. The surgeon should keep in mind that the patient will be placed in various positions (Trendelenburg, reverse Trendelenburg, airplaned towards the left and the right) depending on the stage of the procedure and adequate fixation of the patient is necessary as well as padding of all pressure points. A beanbag can ensure the patient from sliding on the operating table.

The operative technician or nurse needs to set up the instrument table in a way that allows the surgeon to move freely between the patient's legs, the right and the left side. In general, a total of four or five laparoscopic ports, two atraumatic bowel graspers, dissecting electrocautery scissors, an advanced energy device (i.e., Harmonic® scalpel or LigaSure®), a suction-irrigator device, and an endostapler will be needed. Of course a tray for an open instrumented approach should be readily available should the case convert. Two monitors will be needed which are usually located on either side of the patient's shoulders or legs depending on the surgeon being located between the patient's legs or on the right of the patient.

Port Placement and Extraction Sites

The patient should be prepped and draped allowing for enough room for lateral port access as well as conversion to an open procedure. A Veress needle or open Hassan technique can be utilized to gain entry to the intraperitoneal cavity. Generally a 10–12 mm periumbilical port is placed and the peritoneal cavity surveyed. Initially a 0-degree camera is utilized – remembering to assess for entry site injury. A 30-degree camera is useful particularly when taking down the splenic or hepatic flexure and performing adhesiolysis. Four more ports are placed, all under direct visualization. Two 5 mm ports in the left and right upper quadrants (LUQ, RUQ) shying away from the costal margin in order to avoid unnecessary postoperative pain, a right lower (RLQ) and left lower quadrant (LLQ) ports (see port configuration Chapter 18). The RLQ can be 12 mm to allow for an endoscopic stapler to be inserted if used for division of the rectosigmoid junction. With the left LLQ port, the surgeon has more leeway and the size of the port will depend on the surgeon's instrument preference. Energy devices used for cautery dissection come in 5 or 10 mm sizes which can be used for the ileocolic pedicle, a stapler could also be used, in which case an 11 mm port is needed. The lower quadrant ports are placed a cm medial and cephalad from the anterior superior iliac spine. As always, care should be taken not to place the superior and inferior ports in close proximity, allowing at least 10 cm between them so to avoid "fencing."

An important part of port placement is planning the "exit" strategy or extraction site. Frequently used is the umbilical port site and developing it once the specimen is ready to be extracted (see Fig. 13.1). An alternative to this is performing the surgery with the "hand-assisted" technique as described in the next chapter. In this case a lower midline or a Pfannenstiel incision is made at the beginning of the case. The incision size will vary on the size of the operating surgeon's hand that will need to fit the hand port. The rest of the ports are placed in a similar fashion except that this hand port site may be used as the extraction site.

Operative Steps (Table 20.1)

The common steps for both described surgeries in this chapter will be addressed here. Following that, we will discuss the particulars, including the anastomosis for both procedures separately.

Exploratory Laparoscopy

After insertion of the camera, it is mandatory to survey the entire intraperitoneal cavity. This becomes particularly relevant when performing these procedures for inflammatory bowel disease as well as for cancer, assessing for carcinomatosis and liver metastasis.

Mobilization of the Cecum and Ascending Colon and Ligation of the Ileocolic Vessels

The surgeon stands on the left side of the patient, using the two left-sided ports, and the operating table is placed in the Trendelenburg position. Using two atraumatic bowel graspers, the large omentum as well as the small bowel is carefully pushed to the upper abdomen. This will allow better exposure of the terminal ileum and the ileocolic pedicle. If the terminal ileum is still not visualized correctly, the patient can be tilted towards the surgeon allowing for the small bowel to fall away from the surgical field. At this time, the assistant standing opposite to the surgeon will grasp the ileocolic junction and elevate it laterally and towards the right hip. This will stretch the ileocolic vessel by lifting it up from the retroperitoneum, defining the pedicle and exposing them to the surgeon. A sulcus will be demonstrated between the medial side of the ileocolic pedicle and the retroperitoneum. The surgeon will have an atraumatic grasper in his or her left hand and an advanced cautery device in his or her right. Cautery is used to open the peritoneum along both aspects of the pedicle, and with some blunt dissection the vessel is lifted away from the retroperitoneum. This is an avascular plane, and there will be no more need for sharp dissection. Bluntly, dissection continues to open the underside of the ascending colonic mesentery with exposure of the second portion of the duodenum. This is done by lifting the colonic mesentery with the left-handed instrument and dissecting the tissues off this plane with the right-hand instrument. Care is taken to keep the plane of dissection anterior to the congenital layer of peritoneum lying over the retroperitoneum, duodenum, and ureter. Dissection of the mesentery is now carried to the opposite side of the pedicle in order to isolate the vessel completely. A cautery device is used to clean the vessel from the mesenteric fat. At this time a clip (two proximal and one distal), energy device, or stapler may be used to transect the pedicle.

The assistant will re-grasp the distal end of the transected pedicle and lift it up allowing for continued dissection of the medial aspect of the ascending colon mesentery. With countertraction on the proximal transverse colon by the surgeon, the hepatic flexure will become apparent and division of the hepatocolic ligament using cautery or sharp dissectors is accomplished. During dissection of the ligament, the direction will be shifting so appropriate repositioning of the tensile forces for better exposure is mandated. This includes elevating with medial traction by the assistant of the transverse colon and medial traction of the ascending colon by the surgeon. This allows the surgeon to dissect through the tented peritoneum into the previously opened virtual space underneath. Once it has been taken down, the only remaining attachment is the lateral peritoneal attachment (white line of Toldt) along the ascending colon. This is divided using electrocautery all the way down to the cecum, with mobilization of the appendix. This frees the colon from the underlying duodenum and retroperitoneum and allows for complete medial retraction of the right colon.

The mobilization of the ileocecal junction is accomplished by first placing the patient in the Trendelenburg position, with

Table 20.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy	1
2. Mobilization of the cecum and ascending colon and ligation of the ileocolic vessels	4 (medial to lateral) 3 (lateral to medial and no high ligation)
3. Mobilization of the hepatic flexure and transverse colon and ligation of the middle colic vessels	6 (inferior) 3 (superior)
4. Mobilization of the sigmoid colon, descending colon, and splenic flexure and ligation of the inferior mesenteric artery	5 (medial to lateral) 3 (superior) 5 (lateral to medial)
5. Transection of the colon, anastomosis, and reinspection	4
(Alternative) Rectal mobilization and transection	8
6. Exteriorization and IPAA	6

the small bowel reflected superiorly. The mesentery of the terminal ileum is elevated and the union between the visceral peritoneum and retroperitoneum are identified. There is a thin layer of peritoneum that will need division, which can be accomplished with sharp dissection or electrocautery (see Video 20.1). This dissection plane extends from the ileocecal junction towards the superior mesenteric vessels, thus connecting the inferior aspect of dissection and the previously performed superior colonic dissection. The inferior ileal dissection is continued medially to expose the third part of the duodenum, with care not to enter the retroperitoneal layer and avoiding unnecessary embarrassment with the ureter. Now the colon is medially rotated and any leftover attachments are easily divided completing the ascending colon mobilization.

Mobilization of the Hepatic Flexure and Transverse Colon and Ligation of the Middle Colic Vessels

This step can be done before or after mobilization of the left colon. It is usually considered the more difficult step in a total colectomy. The patient will need to be placed in the reverse Trendelenburg position with the surgeon standing between the patient's legs. The surgeon will have an atraumatic grasper in the left hand and an advanced energy device in the right hand placed through the lower ports. The cameraman will stand on the patient's right and use an atraumatic grasper through the RUQ to elevate the omentum of the mid-transverse colon. The second assistant will be standing on the patients left and use an atraumatic grasper through the LUQ port and grasp the gastrocolic omentum and retract it cephalad. This displays the omentum like a curtain and allows the surgeon to dissect the bowel from the omentum using an energy source of his preference. Using counter tension the transverse colon is drawn caudal, and the lesser sac entered at the middle of the transverse colon through the avascular plane (see Video 20.2). From right to left the omentum is dissected of the colon, towards the splenic flexure.

The surgeon switches instruments between his left and right hand, and the dissection continues from the middle transverse colon towards the mobilized hepatic flexure. Dissection may continue through the avascular plane or through progressive ligation of the omentum depending on the patient's anatomy. All remaining attachments of the colon should be divided to allow for the middle colic vessel ligation as the next separate step. Having mobilized the entire transverse colon, the assistants grasp the proximal and distal transverse colon – through the upper quadrant ports, and retract it upwards. In a same fashion as to mobilize the omentum from the transverse colon, this creates a curtain-like display, which allows the surgeon to identify the middle colic pedicle in the mesocolon. An opening in the mesocolon is created with attention to respect the more posterior structures encountered at this level, including the pancreas and fourth part of the duodenum. The middle colic vessels are then ligated from the left to the right, treating each branch with care and allowing for proximal control of the vessel with the bowel grasper. It is mandatory to confirm that it is the middle colic pedicle prior to division, since the superior mesenteric artery and vein are situated just posterior to the dissection plane.

Mobilization of the Sigmoid Colon, Descending Colon, and Splenic Flexure and Ligation of the Inferior Mesenteric Artery

At this point it is advisable to rotate the patients towards the right side and allow gravity to help expose the lateral attachments of the splenic flexure. Dissection continues around the splenic flexure to the proximal aspect of the descending colon. Once the splenic flexure is freed, attention then turns to the proximal transverse colon. Alternatively, the splenic flexure is taken from the superior approach (see Video 20.3).

The surgeon continues his rotating dance and moves to the patient's right, and his assistant stands opposite to him. The camera assistant moves next to the surgeon and to his left. The patient is placed in the Trendelenburg position and tilted with the left side up which helps to expose the base of the sigmoid mesentery. An atraumatic grasper is used by the assistant to grab the rectosigmoid mesentery at the level of the sacral promontory and lifts it up towards the LLQ port. This will stretch the vessels away from the retroperitoneum. In most cases this demonstrates a groove between the right or medial side of the inferior mesenteric pedicle and the retroperitoneum. An energy device is then used by the surgeon to open the peritoneum along this line and take it cephalad to the origin of the inferior mesenteric artery and inferiorly past the promontory. This plane is continued from medial to lateral under the inferior mesenteric artery and sigmoid mesentery. This plane is easy to follow caudally, and the surgeon should avoid aggressive mobilization of the rectum if not needed. It is important here to keep in mind the anatomical sequence of structures that will present themselves as dissection follows, from medial to lateral: left ureter, left gonadal vessels, and the psoas tendon, also being mindful of the iliac vessels deep to this plane. It is imperative that the surgeon recognizes the ureter before the division of any important structures. Once the ureter is identified, the inferior mesenteric artery may be divided, or when preserving the left colic vessel, division of the sigmoid vessels is carried out. For benign disease, a low ligation of the mesenteric pedicle is performed. The fatty tissue around it is thinned out and an Endo GIA or energy device is used to divide the vessel. Holding the distal divided end with a grasper by the assistant, the surgeon now continues with the medial dissection of the underside of the colon all the way to the lateral abdominal wall. With a bowel grasper in the surgeon's hand and an energy device or endoshears, dissection is carried from the pelvic brim, taking down the lateral sigmoid adhesions and carried cephalad to the splenic flexure through the avascular white line of Toldt. The surgeon then connects the medial and lateral planes and connects it with the mobilized splenic flexure. At this point it is about connecting all the dots, so with the assistant standing on the patients left side, he or she will grasp the descending colon with a bowel grasper and retract it upwards, creating tension on the mesentery, while the surgeon standing on the patients right side dissects the remaining descending colonic mesentery. The dissection is thus continued until the proximal aspect of the descending colon, which has already been freed up.

Transection of the Colon, Anastomosis, and Reinspection

There should be no change in patient or surgeons position. As stated before, there is no need for aggressive mobilization of the rectum, and transection should be limited to the upper third or rectosigmoid junction. The surgeon will grasp the sigmoid colon and reflect it upwards towards the abdominal wall, visualizing the fusion of the taenia coli and the conformation of the rectum. Some mobilization may be necessary of the upper rectum, freeing it up from its lateral attachments and the mesorectum. The assistant facilitates dissection by providing countertraction with a bowel grasper, while the surgeon using a bowel grasper and an advanced heating device or scissors dissects through the peritoneal reflection. The area of transection is then chosen and the sigmoid is grasped and retracted superiorly and laterally by the assistant. The surgeon grasps the sigmoid mesentery with the left hand and makes a passage between the posterior surface of the rectum and the superior rectal vessels joining it with the peritoneal opening on the left side previously created. An Endo GIA stapler is used to divide the rectum at this point and two firings might be needed. The remaining mesorectum is divided with an advanced energy device.

Before exteriorizing the specimen, the surgeon confirms that everything has been freed up. Special attention should be taken to ensure that the splenic and hepatic flexures are free since there can be sometimes remnant attachments. The mobility of the terminal ileum should also be ensured.

Rectal Mobilization and Transection

There are two options for selecting the dissection plane when mobilizing the rectum for ulcerative colitis and IPAA formation. The first is to stay close to the rectum on all sides and dissect through the mesorectum. This approach has been facilitated by the availability of advanced energy devices, which allow secure hemostasis as the fatty mesorectum and various collateral blood vessels adjacent to the rectal wall are encountered. This dissection path reduces the risk of pelvic nerve injury leading potentially to improved continence and sexual function. It also further reduced the potential dead space in the pelvis, which may reduce issues related to pouch leaks and sinus tracks, albeit not supported by high-level data. The second approach is the more traditional mesorectal plane. This approach is likely faster and results in fewer encounters with the vascularity seen within the mesorectum. The theoretical disadvantage of this plane is proximity to the pelvic nerves either directly or by thermal spread and a potential increased risk of worsened continence and sexual function. Both approaches have advocates, but the latter is probably easier to master by the surgeon seeking to gain experience primarily due to the lower risk of bleeding and the existence of an actual plane to follow while dissecting.

Whichever technique is chosen the dissection needs to extend well down the rectum so that a precise and complete transection of the rectum can be performed just proximal to the dentate line, consistent with the well-described "double-stapled" IPAA construction. The assistant is best used to maintain rostral traction on the rectum as well as the necessary distraction opposite the site of rectal dissection (i.e., anterior, lateral, etc.). The surgeon should employ one hand for a grasper (used alternately for retraction and pushing the bowel wall to assure countertraction) and one hand with an advanced energy device to allow a blood-free dissection plane (regardless of the actual plane selected). In the female pelvis it is usually possible to deploy a 45 cm endoscopic linear stapler to the appropriate level for transection of the rectum. This can be inserted either from the RLQ port site or via an additional port placed in the suprapubic location depending on the access to the pelvis. In the more difficult male pelvis, it may be necessary to make a small Pfannenstiel incision to allow placement of a standard linear stapler to assure precise transection. A final alternative is to transect the rectum transanally and place a distal purse string of 2-0 polypropylene at the transection line. The circular stapler can then be brought through the anal canal, married to the anvil, and then used to guide the pouch into position so that the distal purse string can be tied on the anvil rod [14]. The stapler is then closed and fired in standard fashion.

Exteriorization and IPAA

The colon and rectum should now be free from all attachments, which needs to be verified prior to exteriorizing the specimen. Some of the key areas to note are the hepatic and splenic flexure, as well as complete ligation of the middle colic vessels. It is also important to confirm mobility of the terminal ileum and allow enough length for a tension-free ileoanal anastomosis. This dissection should include mobilization of the SMA pedicle to the level of the pancreas. Assessment of reach of the intended apex of the pouch should be performed prior to exteriorization so that, if needed, lengthening maneuvers can be performed. The typical tips such as peritoneal incisions of the mesentery or division of specific redundant vessels can be performed on the exteriorized pouch segment.

The options for exteriorization include the site of the intended ileostomy, a small umbilical incision, a small infraumbilical midline incision, or a Pfannenstiel incision (especially if needed for rectal dissection and/or transection). While still with pneumoperitoneum, the transected rectum is grasped with a bowel grasper through the RLQ port and directed towards the umbilical port site. The insufflation is turned off and the umbilical port is removed. This incision is extended for 4–5 cm via a midline mini laparotomy. The RLQ grasper is pushed towards the new laparotomy incision and Babcock graspers are used to bring the specimen out. The terminal ileum is transected between two Kocher clamps and vascular viability assessed. To construct the ileal J pouch, an enterotomy is performed at the apex of the folded ileum. An 80–100 mm GIA stapler is then passed through both limbs of ileum and opposed in anti-mesenteric fashion and fired. Multiple fires are required to obtain a 15–20 cm pouch. The distal aspect of the ileum is transected with another firing. The pouch is then inspected for any bleeding and distended with saline for integrity. A purse-string suture with 0 polypropylene is performed at the apex enterotomy and a 28–29 mm anvil (of the circular stapler) inserted and secured. The pouch is then returned to the abdomen, and the midline incision is partially closed for re-insufflation, with the 10 mm port reinserted.

A key to the construction of the pouch is to be able to perform a tension-free ileoanal anastomosis. This is particularly important in the obese patients as well as patients with previous small bowel resection where mobility could sometimes be a challenge. Some maneuvers include ligation of the ileocolic artery at its origin, making a serious of transverse incisions on the meso over the superior mesenteric artery, and mobilization of the duodenum through a Kocher maneuver.

The abdomen is re-insufflated and the pouch directed towards the anal canal. It is mandatory to observe the correct orientation of the pouch to avoid torsion of the superior mesenteric artery and prevent small bowel internal herniation. The instruments on the left hemiabdomen are used to retract the bladder, prostate, or vagina anteriorly for adequate visualization of the rectal stump. The body of the 28/29 mm circular stapler is introduced through the anal canal and advanced cautiously until the staple line is reached. Using two Allis clamps through the RUQ and RLQ ports, the surgeon directs the anvil to the main body of the stapler. The spike on the stapler is deployed and the anvil is married to the main body. Adequate orientation is again confirmed and the stapler is fired. The stapler is removed avoiding any excessive torque and the surgical "doughnuts" are visually inspected. Finally a leak test is performed to assess for anastomotic integrity. All ports are removed under direct visualization and the ports larger than 5 mm ones should be closed in two layers.

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Total Colectomy and Proctocolectomy: Hand-Assisted Laparoscopic Approach

21

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Introduction

Laparoscopic surgery has been shown to potentially have several advantages over an open approach, including reduced postoperative pain, faster postoperative recovery and shorter hospital stay, reduced complication rates, and improved cosmesis. Nevertheless, a steep learning curve and the need for specialized equipment have somewhat limited the adoption of minimally invasive colorectal surgery. Hand-assisted laparoscopic surgery (HALS) has been proposed as an alternative to conventional laparoscopy to overcome some of these limitations, in particular for challenging procedures, such as total colectomy and restorative proctocolectomy.

This chapter describes the technique and reviews some of the evidence in the literature for the HALS total colectomy with ileorectal anastomosis and the HALS proctocolectomy with ileoanal pouch.

Background

During the last two decades, laparoscopy has progressively become the approach of choice for many gastrointestinal diseases [1–4]. In colorectal surgery, recent reviews and meta-analysis [5–9] have consistently shown better short-term results in terms of intraoperative outcomes (i.e., reduced blood loss) and early postoperative outcomes (i.e., reduced postoperative pain, improved postoperative pulmonary function, shorter postoperative ileus and length of stay, and reduced surgical site infections) in favor of minimally invasive surgery.

Nevertheless, lack of tactile feedback and difficulties with exposure especially in the obese patient are two major limitations of the laparoscopic approach that result in longer operative time and a steep learning curve. As a consequence, widespread adoption of laparoscopic colorectal surgery has been relatively slow across the United States [10, 11]. This is particularly true for complex procedures such as total colectomy and proctocolectomy that require multiple quadrant dissection, manipulation of a long and mobile organ, the colon, and the dissection and division of several large blood vessels.

In the early 1990s, laparoscopic hand-assisted surgery (HALS) was developed in order to overcome these limitations maintaining the benefits of a minimally invasive approach [12].

HALS is used in selected cases for total colectomy with ileorectal anastomosis for inflammatory bowel disease of the colon with rectal sparing and synchronous colonic cancers, while restorative proctocolectomy with ileoanal pouch remains the procedure of choice for patients with ulcerative colitis and familial adenomatous polyposis involving the rectum. HALS is particularly useful in the obese and morbidly obese patients. The presence of the hand in the abdomen seems to facilitate retraction and exposure.

Several studies have tried to compare HALS, conventional laparoscopy, and the open approach in colorectal surgery [13]. However, the majority of these studies are limited by the sample size. In 2008, Aalbers et al. conducted a systematic review and meta-analysis [14] including three non-randomized clinical trials that compared HALS (52 cases) to laparoscopic (59 cases) total colectomy and proctocolectomy [15–17]. While no statistically significant differences were observed between the two approaches in terms of conversion to open surgery, estimated intraoperative blood loss, and incision length, a significantly shorter operative time was reported in favor of the HALS procedure (mean time

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_21. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_21, © Springer Science+Business Media New York 2015

difference: 61 min). However, in all these studies the HALS abdominal colectomy was then followed by an open proctectomy and pouch performed through the Pfannenstiel incision. After pooling the data in the meta-analysis, no differences were found in terms of postoperative outcomes, including length of hospital stay and morbidity.

In 2004 Nakajiima et al. [15] conducted a retrospective analysis of 23 consecutive patients. Twelve patients undergoing HALS and 11 patients undergoing laparoscopic colectomy were included. Both groups were well matched for age, sex distribution, body mass index, previous surgery, medical comorbidities, and steroid dependency. Indications for surgery were ulcerative colitis (9 HALS vs. 8 laparoscopic), familial adenomatous polyposis (2 HALS vs. 3 laparoscopic), and one case of colonic inertia in the HALS group. The types of surgical procedures performed in each group were similar: 12 total proctocolectomies (5 HASL vs. 7 laparoscopic) and 11 total abdominal colectomies (7 HALS and 4 laparoscopic). The authors found that significantly fewer trocars were required in 12 HALS compared to 11 laparoscopic procedures (3.0 vs. 5.0, $P<0.0001$) and that the operative time was significantly shorter in HALS (217 vs. 281 min; $P=0.03$). There was no significant difference in terms of intraoperative blood loss (208 vs.265 ml; $p=0.33$), conversion rate (0 vs. 9.1 %), and incision length (8.1 vs. 6.8 cm; $P=0.15$). No intraoperative complications occurred in both groups. No differences were seen between the two groups postoperatively in terms of both postoperative minor (17 % vs. 27 %) and major (17 % vs. 18 %) complications, need for epidural analgesia (2.8 vs. 3.4 days; $P=0.33$), time required for bowel function recovery (2.2 vs. 2.4 days; $P=0.71$), and length of hospital stay (7.6 vs. 8.1 days; $P=0.65$). There was no mortality in both groups.

Three studies [16–18] specifically evaluated the benefits of HALS proctocolectomy. Rivadeneira et al. [16] compared 10 HALS vs. 13 conventional laparoscopic restorative proctocolectomies in a nonrandomized clinical study. The surgical indications were ulcerative colitis in 21 patients (9 HALS vs. 12 laparoscopic) and familial adenomatous polyposis (1 HALS vs. 1 laparoscopic). Both groups were well matched for age, sex, body mass index, and comorbidities. The median operative time was significantly shorter in the HALS group (247 vs. 300 min, $P<0.01$). No differences were recorded in terms of median estimated blood loss (200 vs. 250 ml) and length of incision (8 cm in both groups). Even though the return of bowel function was significantly quicker after a HALS procedure (2 vs. 3 days; $P=0.02$), the median length of hospital stay was similar (4 vs. 6 days). The rate of postoperative complications was similar in both groups (40 % vs. 31 %).

Polle et al. [17] compared 35 patients who underwent total laparoscopic restorative proctocolectomy to 60 patients from a previously conducted randomized, controlled trial comparing 30 HALS and 30 open proctocolectomies. Both groups were similar in terms of demographic and clinical data. There were no intraoperative complications in this series. Median operative time was significantly shorter in the HALS group compared to the laparoscopic group (214 vs. 298 min; $P<0.001$). Postoperative minor (3.3 % vs. 8.6 %) and major (16.7 % vs. 20 %) complications rates were comparable between the HALS and laparoscopic groups. Length of hospital stay was similar (10 vs. 9 days), even though the laparoscopic group had a significantly shorter period to oral intake (3 vs. 5 days). Finally, no differences were observed in terms of narcotics requirement.

Finally, Tsuruta et al. have conducted a retrospective study comparing 30 patients undergoing a HALS proctocolectomy with 40 patients undergoing a laparoscopic proctocolectomy. The two groups were similar in terms of demographic and clinical data. The authors reported a significantly shorter operative time (356 vs. 505 min; $P<0.001$) and a reduced length of incision (6.5 vs. 7.8 cm; $P<0.001$) in the HALS group. All other intraoperative and postoperative outcomes were comparable among the two groups.

Only one study in the literature [17] analyzed costs, including the cost for surgery and hospital admission. Even though total costs for surgery were significantly higher in the laparoscopic group, secondary to the higher costs of disposable instrumentation and the longer operative time, overall costs were lower, although not significantly, in this group compared to the HALS group due to shorter hospital stay.

More recently, Marcello et al. [19] published the results of a multicenter (involving 5 hospitals and 11 surgeons), prospective, randomized trial comparing 14 HALS (10 total colectomies and 4 proctocolectomies) to 15 laparoscopic total colectomies (9 total colectomies and 6 proctocolectomies). Both groups were similar in terms of age, gender, BMI, previous surgery, and surgical indications. They found a significantly shorter operative time in favor of HALS (127 vs. 184 min, $P=0.015$), with no differences in terms of conversion rate to open surgery. Similar postoperative outcomes (time for bowel function recovery, tolerance of diet, complication rates, length of hospital stay, postoperative pain scores, or narcotic use) were observed in both groups. This is the only prospective randomized study available. Their findings are limited by the sample size. Fewer studies have compared HALS with open total colectomy or proctocolectomy with even more conflicting and confounding results. Maartense et al. [20] reported in 2004 the results of a randomized clinical trial comparing 30 HALS vs. 30 open proctocolectomies. HALS procedures took significantly more time than open surgery (214 and 133 min, respectively; $P<0.001$). No significant differences were found in terms of postoperative pain, complication rate, and postoperative hospital stay between the two groups. A trend toward higher costs for HALS was reported (€ 16.728 vs. € 13.406; $P=0.095$).

Zhang et al. [21] confirmed a significantly longer operative time in 21 HALS total colectomies vs. 23 open colectomies (282 vs. 210 min) in a comparative nonrandomized study. No differences were observed regarding intraoperative blood loss (107 vs. 159 ml), return of bowel function (2.9 vs. 3.7 days), and postoperative morbidity (5 % vs. 22 %) or mortality (0 % in both groups).

Room Setup and Positioning

After induction of general anesthesia and placement of all monitoring devices, the patient is placed in the lithotomy position and secured to the bed. The patient should be positioned low enough on the table to allow access to the anus for endoscopy and insertion of a stapling device. Both arms are tucked at the patient's side. A single dose of preoperative antibiotic and subcutaneous heparin are administered. A urinary catheter is inserted and rectal irrigation with diluted iodine solution is completed as indicated. The patient is prepped and draped in standard fashion.

Port Placement and Extraction Sites

The procedure starts at the umbilicus for exploration of the abdominal cavity to assess the feasibility of a laparoscopic approach before proceeding with placement of the suprapubic hand-assisted device. The monitors are placed at the head of the table ensuring good visualization for the entire surgical team. An open technique is used to enter the abdominal cavity just below or above the umbilicus. A 5-mm trocar is inserted and secured in place with a purse-string suture. Alternatively, a Veress needle or optical view access technique is acceptable.

In most cases the hand port can also be placed directly avoiding potential complications of initial trocar placement and safe placement of the periumbilical camera port via hand guidance as described in a previous chapter.

Two working ports L1 and L2 are typically placed in the right lower quadrant (RLQ) and left lower quadrant (LLQ) and can be moved up slightly to be in a transverse line with the camera port (see port configuration in Fig. 21.1). Therefore, the hand-assisted approach typically reduces the need for the four working ports described in the previous chapter of a total laparoscopic approach to this procedure (Box 21.1).

> **Box 21.1 Tip**
> An advanced technique utilizing only one working port through a planned ileostomy site will be described in the following single-port chapter; a "clockwise" mobilization can be combined with the hand port through a Pfannenstiel incision.

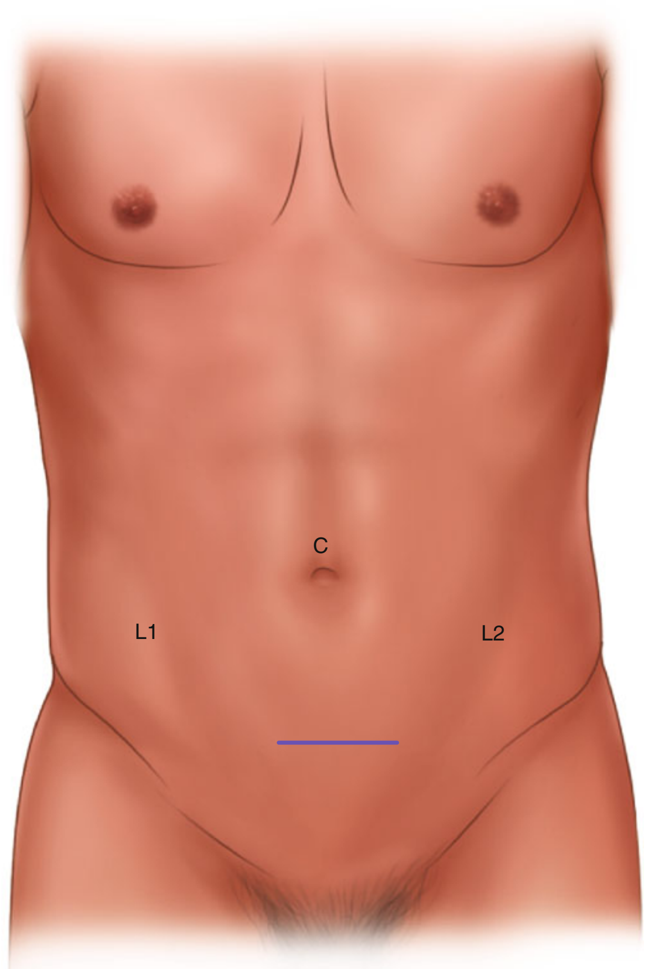

Fig. 21.1 Port configuration. Hand port left or right hand, *L1* working port, *L2* optional working port

The hand port typically serves as the extraction site. It can be placed in the Pfannenstiel incision, which has the benefit of reduced incisional hernia rates. A lower midline incision has the benefit that it can be easily converted into a midline laparotomy if necessary. Both of these extraction sites allow easy access for an ileorectal anastomosis.

Operative Steps (Table 21.1)

The operative steps of a hand-assisted laparoscopic colectomy are similar to the steps described previously in the total laparoscopic chapter. It essentially combines a right, transverse, and left hemicolectomy.

Exploratory Laparoscopy and Insertion of the Hand Port

Pneumoperitoneum is established with carbon dioxide gas and maintained at 15 mmHg. After exploration of the abdominal cavity, additional 5-mm trocars are placed on either side of the umbilicus or in the RLQ and LLQ. A thorough exploration of the abdominal cavity is then completed.

After feasibility of a laparoscopic approach is confirmed, a Pfannenstiel incision is performed two fingerbreaths above the pubis. Dissection is carried out through the subcutaneous tissue down to the fascia. The fascia is opened transversely and subfascial planes are developed superiorly and inferiorly. The midline is identified and opened. The pneumoperitoneum is evacuated. The hand-assisted device is inserted and secured in placed.

Mobilization of the Cecum, Ascending Colon, and Hepatic Flexure and Ligation of the Ileocolic Vessels

Pneumoperitoneum is reestablished and the patient is placed in the reverse Trendelenburg, right lateral decubitus position. Typically the surgeon stands between the patient's legs and uses the left hand for intra-abdominal retraction and the right for the energy device or bowel grasper through the LLQ port L2. The camera operator is typically on the left side of the patient with a 30-degree 5 mm laparoscope. The ligament of Treitz is identified, and the small intestine is evaluated in its entirety in patients with inflammatory bowel disease. By doing so the small bowel is placed in the left upper quadrant away from the operating field, thus facilitating the initial mobilization of the ileocolic vascular pedicle.

Table 21.1 The operative steps of a hand-assisted laparoscopic colectomy

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy and insertion of the hand port	1
2. Mobilization of the cecum and ascending colon and ligation of the ileocolic vessels	3 (medial to lateral) 2 (lateral to medial)
3. Mobilization of the hepatic flexure and transverse colon and ligation of the middle colic vessels	5 (inferior) 2 (superior)
4. Mobilization of the sigmoid colon, descending colon, and splenic flexure and ligation of the inferior mesenteric artery	4 (medial to lateral) 3 (superior) 2 (lateral to medial)
5. Transection of the colon, anastomosis, and reinspection	3

The surgeon moves to the patient's left side next to the camera operator, the assistant stands on the patient's left side, and the patient is placed in steep Trendelenburg and left lateral decubitus position. The ileocolic vascular pedicle is then identified, placed under tension with the left hand through the suprapubic hand port. The right hand can then dissect, divide, and ligate the pedicle with a vessel-sealing device after identification of the duodenum (see Fig. 21.2 and Video 21.1). Next, medial to lateral mobilization of the ascending colon is completed all the way up to the hepatic flexure in the submesenteric avascular plane (see Fig. 21.3 and Video 21.2). Attention is then turned to the lateral peritoneal attachments, which are taken down from the hepatic flexure to the cecum (see Video 21.3). The terminal ileum is completely mobilized to allow a tension-free anastomosis (see Video 21.4).

Occasionally, preservation of the ileocolic pedicle for the ileoanal pouch is desired. In this case a lateral mobilization of the entire cecum, ascending colon, and hepatic flexure can be performed from lateral to medial. In this case the surgeon uses the right hand through the suprapubic hand port to retract and dissect with a left-handed instrument through the RLQ port L1. Sometimes, the surgeon can use the left hand for retraction and finger dissection along the line of Toldt similar to open surgery. The assistant can divide the peritoneal attachments through the RLQ port L1. The mesentery of the cecum is then divided close to the bowel wall.

Mobilization of the Transverse Colon and Ligation of the Middle Colic Vessels

With the surgeon now on the patient's right side, the operating table is placed in reverse Trendelenburg and the transverse colon is mobilized from the hepatic (see Fig. 21.4 Video 21.5) to the splenic flexure by sequentially dividing and ligating the greater omentum just distal to the gastroepiploic arcade and the transverse mesocolon (see Video 21.6) (Boxes 21.2

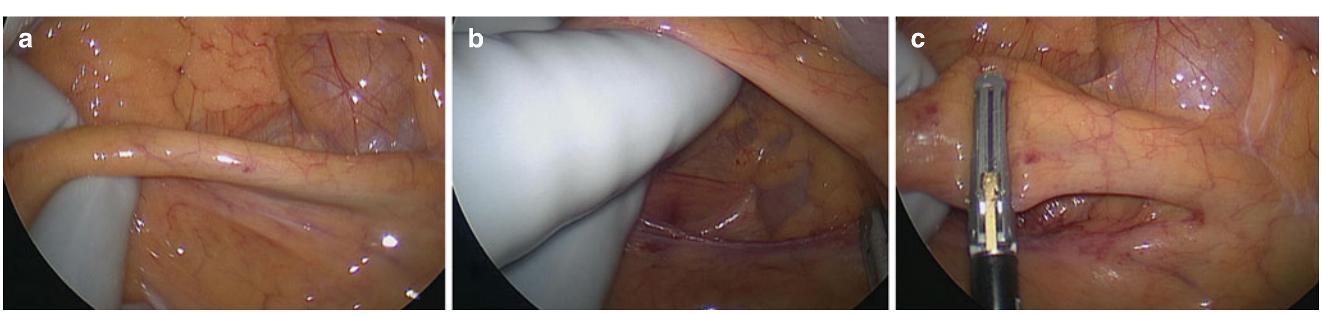

Fig. 21.2 Ileocolic division (**a**–**c**)

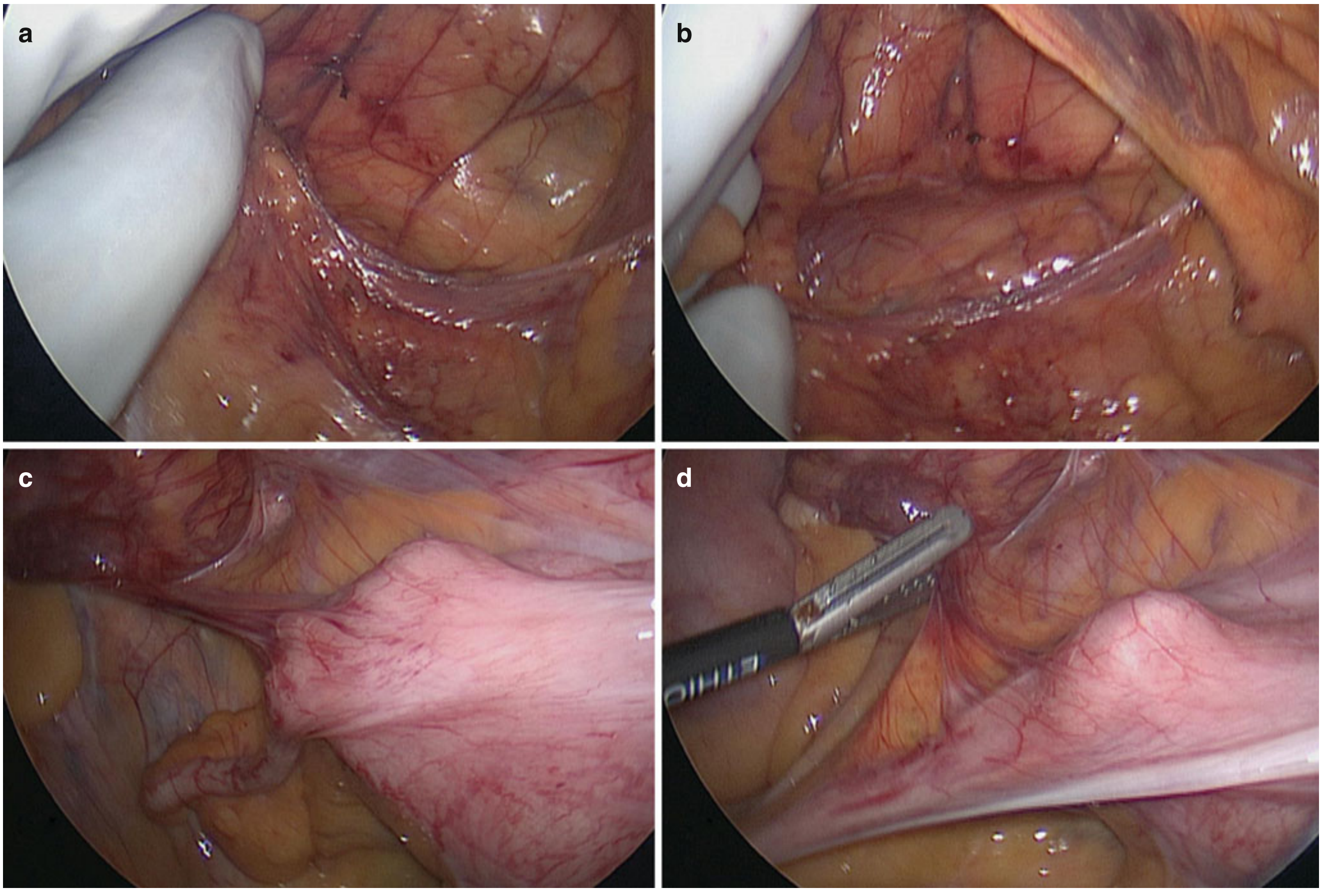

Fig. 21.3 Cecal mobilization (**a**–**d**)

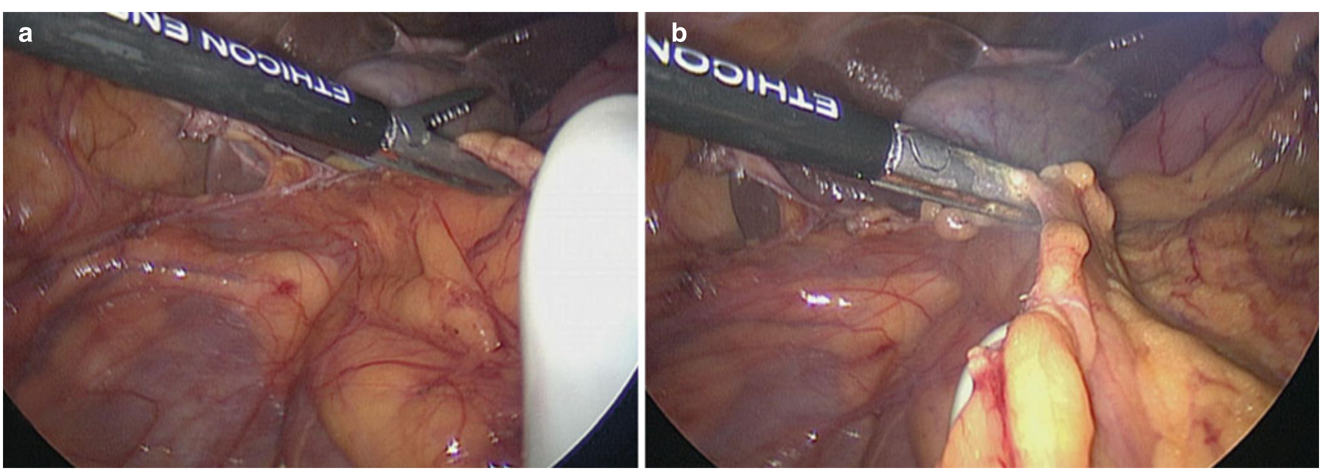

Fig. 21.4 Transverse colon mobilization (**a**, **b**)

and 21.3). The right hand retracts the transverse colon inferiorly and left laterally, while a left-handed instrument through the RLQ port L1 enters the lesser sac and subsequently divides the omentum. The omentum is taken with the specimen, thus facilitating and expediting the dissection. The transverse colon mesentery is taken close to the bowel wall in benign cases from the superior approach. The mesentery is located under the omentum as the next plane. For malignant cases isolation of the middle colic trunk from an inferior approach may be necessary. Therefore, an additional trocar may be needed for adequate retraction and exposure as described in a previous chapter ("Ole maneuver").

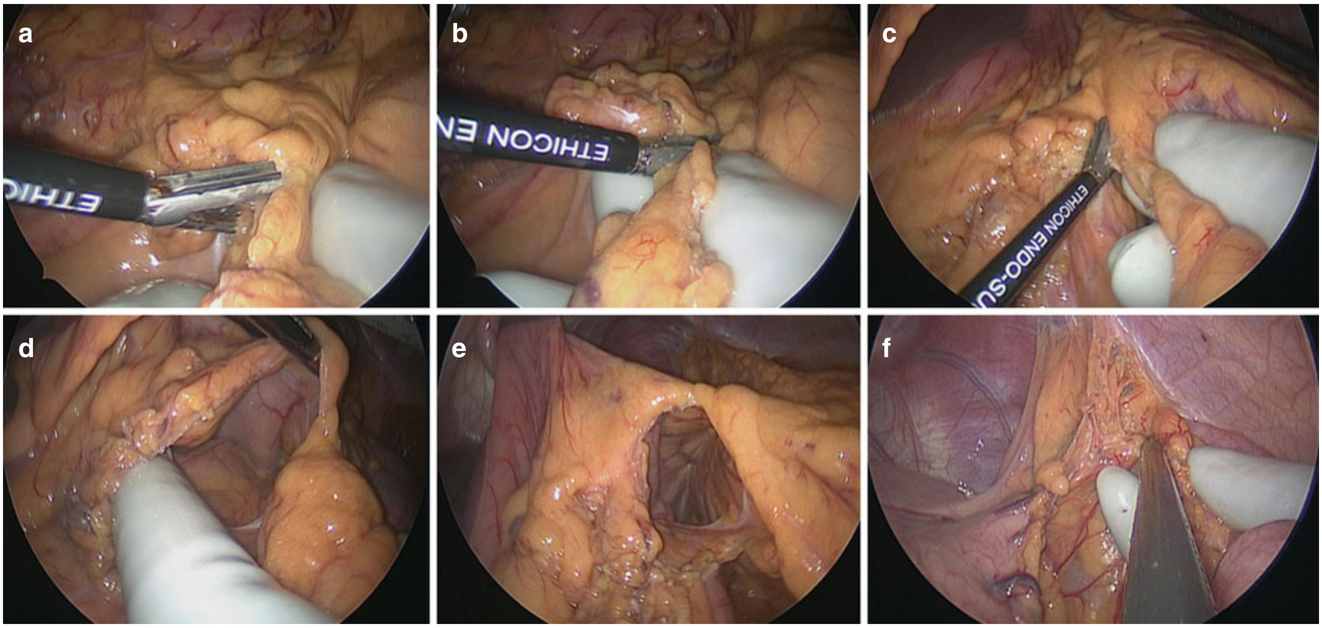

Fig. 21.5 Splenic flexure mobilization (**a**–**f**)

Box 21.2 Tip
The hand facilitates dissection in the lesser sac exposing the omentum. At the same time the colon wall can be palpated to avoid injury from the energy device.

Box 21.3 Caveat
Identify the transverse colon mesentery versus small bowel mesentery at all times to avoid a devastating complication.

Mobilization of the Sigmoid Colon, Descending Colon, and Splenic Flexure and Ligation of the Inferior Mesenteric Artery

The splenic flexure is taken down bluntly and sharply usually in a superior fashion. Continuous, but careful downward, traction of the colon allows for division of the splenocolic ligament through the RLQ port and continuation along the line of Toldt. The colon mesentery is divided close to the bowel wall (see Video 21.7).

In difficult cases, especially with limited instrument reach from the right, a combination of superior (from the transverse colon) and lateral to medial (from the descending colon) mobilization is sometimes needed (see Fig. 21.5). In this scenario the surgeon is operating between the patient's legs. The sigmoid and descending colon is mobilized all the way to the level of the rectosigmoid junction by sequentially dividing and ligating the lateral attachments and the mesentery through the LLQ port. The inferior mesenteric artery is typically preserved to maintain good vascularization of the distal stump for the anastomosis specifically in benign cases. For malignant cases a high ligation of the IMA is performed. This follows the medial to lateral technique described in a previous chapter of hand-assisted laparoscopic sigmoid resection. The surgeon's right hand is retracting the sigmoid colon, while an instrument through the RLQ port L1 allows for dissection, isolation, and division of the IMA pedicle.

Transection of the Colon, Anastomosis, and Reinspection

At this point pneumoperitoneum is evacuated, and with a wound protector in place, the specimen is exteriorized through the Pfannenstiel incision (see Fig. 21.6). The terminal ileum is dissected off of the mesentery and divided with a GIA stapler. The ileal staple line can be reinforced with 4-0 nonabsorbable sutures.

The abdominal cavity is protected with moist laparotomy pads and bowel clamps are placed proximally and distally. A side-to-end two-layer hand-sewn ileorectal anastomosis is constructed. The rectosigmoid junction is dissected and divided between clamps. The posterior outer layer of 4-0 nonabsorbable sutures is placed. An enterotomy is performed, and the circumferential inner layer of 3-0 absorbable running Connell suture is completed. Subsequently the anterior outer layer of 4-0 nonabsorbable suture is placed.

Fig. 21.6 Specimen extraction

Alternatively a side-to-end stapled ileorectal anastomosis can be constructed by placing the EEA anvil in the small bowel and the shaft of the stapler through the rectal stump. The anastomosis is checked with a flexible sigmoidoscope for hemostasis and patency and a leak test is performed. The abdominal cavity is irrigated until clear. The Pfannenstiel incision is closed in layers. The skin is closed with subcutaneous sutures.

Laparoscopic Hand-Assisted Proctocolectomy with Ileal Pouch Anal Anastomosis

Room setup and positioning is similar as above. If the procedure is started with an exploration of the abdominal cavity to assess the feasibility of a laparoscopic technique, access to the abdominal cavity is gained just above/below the umbilicus or at the stoma site if fecal diversion is planned. A 12-mm trocar is used at the stoma site; otherwise a 5-mm trocar is inserted at the umbilicus.

Operative Steps (Table 21.2)

The mobilization of the intra-abdominal colon follows the previously described steps 1–4 all the way to the pelvis.

Rectal Mobilization

The monitors are moved to the foot of the table. The surgeon is on the patient's right side with the assistant on the opposite side helping with retraction (Box 21.4). The surgeon retracts the rectum or rectal stump with the right hand out of the pelvis and dissects through the RLQ trocar L1. The assistant helps with countertraction through the LLQ trocar L2.

Table 21.2 Laparoscopic hand-assisted proctocolectomy with ileal pouch anal anastomosis

Operative steps	Degree of technical difficulty (scale 1–10)
1. Exploratory laparoscopy and insertion of the hand port	1
2. Mobilization of the cecum, ascending colon, and hepatic flexure and ligation of the ileocolic pedicle	3 (medial to lateral) 2 (lateral to medial and no high ligation)
3. Mobilization of the transverse colon and ligation of the middle colic vessels	5 (inferior) 2 (superior)
4. Mobilization of the sigmoid colon, descending colon, and splenic flexure and ligation of the inferior mesenteric artery	4 (medial to lateral) 2 (superior) 4 (lateral to medial)
5. Rectal mobilization	8
6. Transection of the rectum and IPAA	6

Box 21.4 Tip

Once the entire colon is mobilized, exteriorize and divide the rectosigmoid junction. The superior rectal artery can be then easily divided through the hand-port incision in an open fashion. This will facilitate the rectal dissection.

Typically a medial to lateral approach to the mobilization of the inferior mesenteric artery is undertaken if malignancy is present. The peritoneum overlying the sacral promontory is incised on the patient's right side, and the left ureter is clearly identified and mobilized off the operating field. The hypogastric plexus is also identified and preserved. Only after these structures have been identified the inferior mesenteric artery is divided and ligated with a vessel-sealing device as described for step 4. The level of transection of the inferior mesenteric artery and vein follows the oncologic principles in case of cancer diagnosis.

Otherwise the sigmoid colon mesentery can be divided close to the colon wall. The superior rectal artery is then easily palpated and the total mesorectal excision plane is then entered. Even for benign disease it is recommended to follow this plane of dissection because it allows for a precise and bloodless rectal mobilization. After this plane is entered, the superior rectal artery is ligated using a vessel sealer and the dissection planes connected to the previously divided sigmoid colon mesentery.

Care is taken to identify the *nervi erigentes* bilaterally. The dissection proceeds initially posteriorly, then laterally, and finally anteriorly. Effort is made to dissect the rectum posteriorly all the way to the levators at the pelvic floor. Then, the lateral rectal stalks, often including the middle

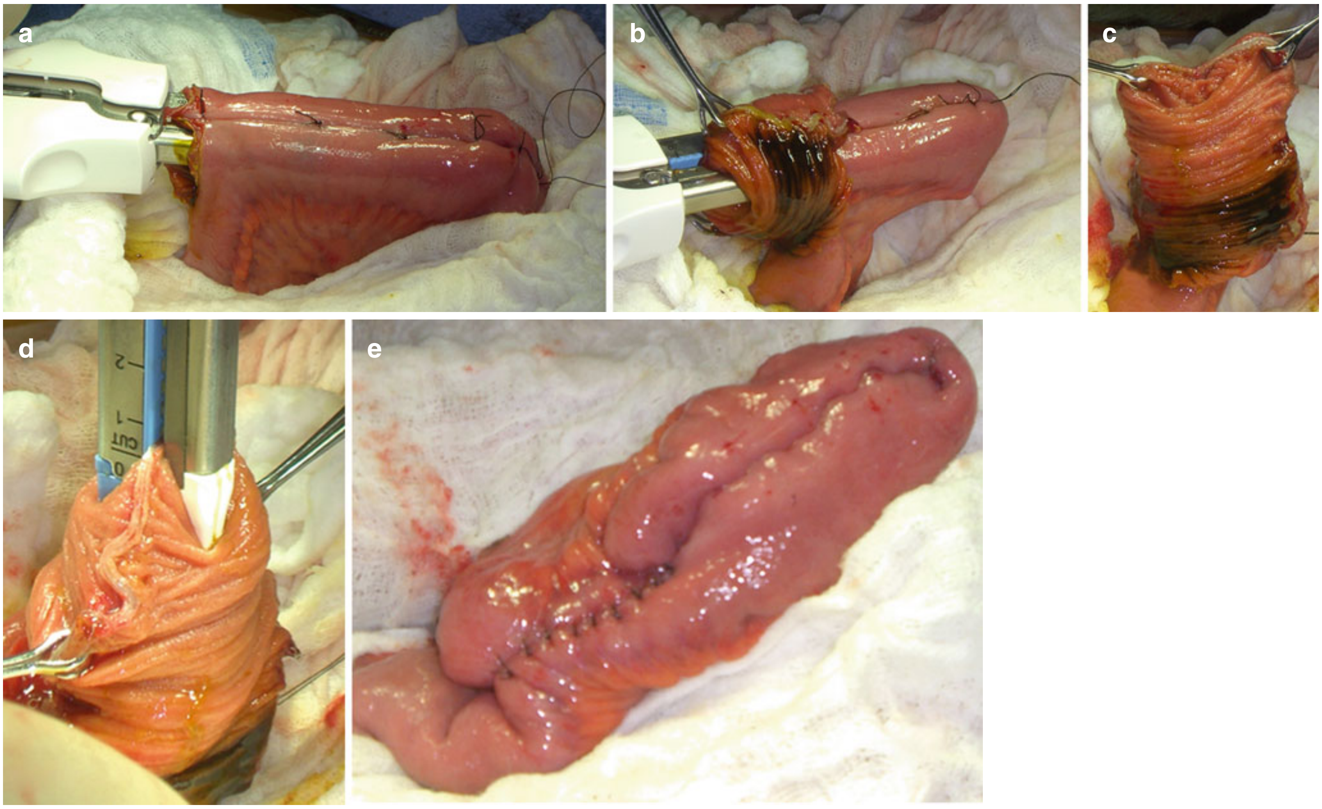

Fig. 21.7 Pouch extraction (**a**–**e**)

rectal artery, are divided all the way to the levators, and finally the anterior dissection is completed, in a male patient posterior to Denonvilliers fascia. At this point, when the rectum is adequately mobilized distally, the pneumoperitoneum is evacuated.

Transection of the Rectum and Ileal Pouch Anal Anastomosis

The rectum will be divided at the pelvic floor either with a stapler in the case of a stapled ileoanal pouch anastomosis or sharply in case of mucosectomy and hand-sewn ileoanal pouch anastomosis (Box 21.5).

> **Box 21.5 Tip**
> The Pfannenstiel incision allows utilizing an open curved stapler for transection of the anorectal junction with a single staple load and in an exact transverse fashion.

The indication for preservation of the anal transitions zone varies between surgeons. Mucosectomy and hand-sewn ileoanal pouch anastomosis can be recommended in presence of dysplasia irrespective of location and degree in inflammatory bowel disease or in case of familial polyposis with involvement of the very distal rectum.

Several pouch designs have been described, but it is most common to perform a J pouch. It is important to mobilize the small bowel to ensure a tension-free anastomosis. Therefore, the small bowel mesentery is mobilized to the duodenum during Step 1 of the procedure. The terminal ileal mesentery is then properly oriented and the most dependent loop of small bowel identified. A 3-0 silk 30-in. long suture is placed at the apex, and the two loops are approximated with 4-0 nonabsorbable sutures. The abdominal cavity is protected with moist laparotomy pads, and a bowel clamp is placed on the proximal small bowel. Enterotomies on the two loops are performed. The pouch is constructed as previously described [13]. Sequential fires of an 80 mm or 75 mm GIA stapler are applied through the enterotomies, and the pouch is progressively everted as stapling progresses toward the apex of the pouch for accurate placement of the rows of staples as well as to achieve hemostasis. When the pouch is completely constructed, it is inverted back and the two enterotomies are closed in layers (see Fig. 21.7). By using this technique the apex of the pouch, future site of the anastomosis, is not manipulated or traumatized. In case of a stapled ileoanal anastomosis, the anvil is placed at the apex of the pouch and a standard double-stapled end-to-end anastomosis is constructed with an EEA stapler. In the case of a hand-sewn ileoanal anastomosis, a completion mucosectomy is performed transanally. The pouch is then carefully advanced to the pelvis, and after adequate hemostasis, a two layer interrupted pouch anal anastomosis is constructed. The anastomosis is checked with a flexible sigmoidoscope for hemostasis and patency, and a leak test of the anastomosis is performed.

After irrigation and hemostasis in the abdomen and pelvis, if an ileostomy is deemed necessary, a suitable loop of small bowel is identified and a 14-French red rubber catheter is placed through the mesentery. The loop is delivered through the previously developed ileostomy site and secured in place by suturing the red rubber catheter to the skin with nonabsorbable sutures. The Pfannenstiel incision is closed in layers and the skin is closed with subcutaneous sutures. The incision is protected and the ileostomy matured in the standard Brooke fashion with 3-0 chromic interrupted sutures.

Summary

In conclusion, HALS maintains the benefits of a minimally invasive approach, while reducing the operative time and the need for conversion, particularly in the most complex cases such as total colectomy and proctocolectomy.

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Total Colectomy and Proctocolectomy: Single-Port Laparoscopic Approach

22

M. Nicole Lamb and Ovunc Bardakcioglu

Introduction

Single-port laparoscopic approaches to colorectal procedures have been extensively reported for partial colectomies. Using a diverting or end ileostomy site might be especially useful for a proctocolectomy avoiding an additional extraction site with subsequent complications. We will review the single-port laparoscopic technique for a total colectomy and proctocolectomy.

Background

The single-incision laparoscopic colectomy is part of a growing field of emerging surgical procedures. The first SILS was performed as a hysterectomy in 1992 [1]. During the late 1990s other SILS procedures were performed, the first SILS cholecystectomy (1997) and appendectomy (1998) [1]. In 2008 the first SILS right colectomy was performed, and from this point on a variety of SILS, colorectal procedures have been performed including everything from a right colectomy to sigmoidectomy to low anterior resection to total abdominal colectomy and proctocolectomy [1–3].

One of the advantages of a SILS total abdominal colectomy, in particular, is that the incision for the port can be placed in the site of the future ileostomy, creating an operation that appears "incision-less" upon completion. Most of the existing literature, on the topic of SILS total abdominal colectomy, is based primarily upon case series and case reports. In combination with the author's experience and the collective experience reported in the literature, this chapter will attempt to create salient objective guidelines for how to approach and perform a single-port total abdominal colectomy.

Preoperative Planning

When first learning this technique, certain patient factors can further optimize the ease of performing the operation: patient body habitus and disease state. The existing literature has performed single-port laparoscopic total colectomy in patients with a BMI 20–30 (kg/m^2) [3–6]. Excluding the obese patients and the difficulties inherently associated with the increase in abdominal wall and intra-abdominal/mesenteric adiposity are helpful during the learning curve phase of this surgery. Both benign and malignant disease processes as well as emergent and elective surgeries have been successfully attempted. Currently the most common indication for attempting a single-port approach has been inflammatory bowel disease, ulcerative colitis, or Crohn's disease [1, 3, 4].

Patients should receive antegrade bowel preparation, the day before surgery. This helps to reduce the diameter of the colon, making extraction easier [7]. Also prior to surgery, a site for the ileostomy should be identified and marked. Antibiotic and DVT prophylaxis should be instituted prior to surgery, the day of surgery. Orogastric tube and Foley catheter are placed to decompress each respective organ.

Room Setup and Patient Positioning

The patient is placed supine in modified lithotomy on a beanbag, with both arms tucked to the sides of the patient. The legs are secured in leg boots to avoid peroneal nerve compression [8]. The surgeon will begin the operation on the

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_22. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*, DOI 10.1007/978-1-4899-7531-7_22, © Springer Science+Business Media New York 2015

patient's left and will need to reposition himself/herself throughout the procedure. The operating table will be tilted from side to side and placed in Trendelenburg and reverse Trendelenburg, along the course of the operation, to allow the small bowels to fall off the field of view of different parts of the colon. This passive retraction is crucial to the success of the procedure even more so than during conventional laparoscopy. It is important to make certain that the patient is secured to the table and will not move when placed in these positions. Two video screens can be positioned on both sides of the patient along the "axis of the left and right shoulders" [8]. The general course of the operation will start with mobilization of the right colon and proceed clockwise to the sigmoid colon [9]. Currently two case series describe starting mobilization at the sigmoid colon and progressing counterclockwise toward the ascending colon; this technique will not be discussed here [10, 11].

There are three product options for selecting a port to perform the surgery through. A commonly available port is the GelPort® or GelPOINT® (Applied Medical, Rancho Santa Margarita CA). This type of product is commonly used in hand-assisted laparoscopy and may already be onsite at many institutions. Both devices allows the surgeon to determine where each trocar will be placed, improving instrument positioning. Another commercial product available for use are the multi-instrument access devices, the SILS® Port (Covidien, Mansfield, MA, USA), Triport and LESS Quadport (Olympus Corporation, Tokyo, Japan), or SSL access system (single-site laparoscopic system) (Ethicon, Cincinnati, USA) [3]. These devices come with pre-created ports inside the main single-access port.

The most recently developed option is the "self-made" port. In order to avoid the added cost of purchasing a commercial single-access port, several surgeons have reported the creation of a "glove port" [5, 11, 12]. The glove port consists of a sterile latex-free size 6 surgical glove. The tip of the 1st, 3rd, and 5th digit is excised on the glove. A 12 mm trocar and 2–5 mm trocars are inserted into the fingers of the glove, without the obturator in place [12]. An airtight seal is created by taking a latex strip from another glove and tying it around the trocar sleeve. The cuff of the glove is snapped onto the outer ring of a standard wound protector-retractor that has been placed into the wound [12].

An articulating laparoscope such as the 5-mm flexible tip Olympus EndoEYE laparoscope (Olympus, Center Valley, PA) can aid in maneuvering within the confined space of the single incision. Alternatively, the standard rigid 30° laparoscope and rigid laparoscopic instruments (atraumatic bowel graspers) can also be used with success. A laparoscopic bipolar energy sealing and cutting device such as a Ligasure (Covidien, Boulder, CO) or Enseal (Ethicon) should be available. A standard laparoscopic linear stapler, EndoGIA, and Circular stapler will be used.

Operative Steps (Table 22.1)

The operative steps follow an approach, which has been described as the "rollover technique" [13]. The colon mobilization will start with division of the terminal ileum and progressive clockwise mobilization and transection of the entire colon and possible rectum.

The singular access port, places the assistant holding the camera in close proximity to the operating arms of the surgeon, which may make range of motion for the surgeon more difficult. The single-access port also limits the space between the laparoscopic instruments and the camera, which can lead to "sword-fighting," the overlapping of instruments, and confining the range of motion of those instruments and the camera. The keys to successful completion of are proper patient selection, optimization of laparoscopic instrumentation, and positioning within the single-access port.

Single-Port Insertion and Exploratory Laparoscopy

If the intention of the procedure is to perform an end ileostomy at the completion of the operation, then the port may be placed through a circular incision of a diameter ranging 2.5–3.5 cm, in the right lower quadrant in the pre-marked site of the ileostomy. The incision is carried down to the anterior rectus sheath, which is then sharply incised, the abdominus rectus muscles are bluntly retracted, and the posterior rectus sheath is identified and incised. The GelPOINT device (Applied Medical, Rancho Santa Margarita, CA) is inserted and pneumoperitoneum created. Three trocars are inserted into the port, a 12 mm trocar and two 5 mm trocars. The 12 mm trocar will be the insertion site

Table 22.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Single-port insertion and exploratory laparoscopy	1
2. Mobilization of the cecum and ascending colon and ligation of the ileocolic vessels	5
3. Mobilization of the hepatic flexure and transverse colon and ligation of the middle colic vessels	5
4. Mobilization of the sigmoid colon, descending colon, and splenic flexure and ligation of the inferior mesenteric artery	5
5. Transection of the colon and ileorectal anastomosis	5
6. Rectal mobilization, transection of the rectum, and IPAA	9

for the 30° laparoscope and stapler. The laparoscope will be positioned at the medial aspect of the GelPOINT. Each 5 mm trocar will be placed along either side of the camera to triangulate their position. If the patient is to receive a primary anastomosis without ileostomy, then a 2.5–4.5-cm longitudinal periumbilical incision is created or an incision between the umbilicus and the pubic symphysis. The incision is carried down to the fascia, and the fascia is opened under direct visualization. Placement of the single-port device and trocars proceeds in the same manner as stated in the previous paragraph.

Mobilization of the Cecum, Ascending Colon, and Hepatic Flexure and Ligation of the Ileocolic Vessels

Mobilization of the right colon may potentially be the most challenging aspect of the operation because it is located directly under the access site (in the case of creation of the end ileostomy) and is at a greater risk for conversion.

In benign disease the mesentery can be ligated close to the bowel wall and the rollover technique can be utilized. The operating table is placed in Trendelenburg and tilted to the left, until the small bowels fall out of the pelvis, exposing of the right lower quadrant. The operation begins with creation of an ileal window and transection of the terminal ileum flush to the cecum for inflammatory bowel disease or 10 cm proximal to the ileocecal valve. The mesenteric edge is now progressively ligated with an energy device toward the cecum. The cecum and mesentery are mobilized laterally and the mobilized mesentery ligated again (see Video 22.1). The back and forth lateral mobilization and mesenteric ligation is performed identifying the duodenum and mobilizing the hepatic flexure. The cecum and subsequent colon are rolled over to the right side of the patient and then inferiorly.

For malignant disease high ligation of the mesenteric vessels is necessary, and the technique follows the medial to lateral or lateral to medial approach previously described. The overall principles of the lateral to medial mobilization are that the lateral attachments are exposed and dissected off of the cecum and ascending colon, then the ileocolic and right colic pedicles are located and divided. The cecum and ascending colon are retracted medially, exposing the white line of Toldt. The white line is incised in a caudad to cephalad direction, approaching the hepatic flexure. During this avascular dissection both the right ureter and duodenum are to be clearly identified before pursuing ligation of the vascular pedicles. The cecum is retracted anteriorly and laterally, which allows the ileocolic pedicle to be visualized, isolated, and divided with the Ligasure device. The mesenteric division is continued medially through the small bowel mesentery to approximately 10 cm proximal to the ileocecal valve. The general principles of the medial to lateral mobilization are that the ileocolic pedicle is identified and ligated, and then the colon is mobilized medially to laterally in a submesenteric plane. The cecum is retracted anteriorly and laterally, placing the ileocolic pedicle on slight tension. The right ureter and duodenum are visualized prior to ligation of the pedicle. The pedicle is isolated and divided with a bipolar energy device. The right colic artery is also identified and ligated. Mobilization of the ascending colon occurs in an avascular plane below the mesentery and above Gerota's fascia, medially to laterally, where the white line of Toldt is incised, laterally, in a caudad to cephalad direction toward the hepatic flexure.

Mobilization of the Hepatic Flexure and Transverse Colon and Ligation of the Middle Colic Vessels

The patient is then placed in reverse Trendelenburg. The operating surgeon repositions to a site between the legs of the patient. The GelPOINT is rotated inferiorly, so that the camera is angled cephalad, to better visualize the right upper quadrant and transverse colon. The hepatic flexure is retracted medial and caudad. The dissection is carrier through the hepatocolic ligament and continues toward and into the lesser sac, being mindful not to injure the pancreas. The greater omentum is dissected off the transverse colon, while persistent medial and caudad traction is placed on the colon. The mesentery is divided either close to the colon or achieving a high ligation of the right and middle colic vessels depending on the indication of the procedure.

Mobilization of the Sigmoid Colon, Descending Colon, and Splenic Flexure and Ligation of the Inferior Mesenteric Artery

The GelPOINT is rotated, allowing the camera port to be located in the lateral position, to visualize the splenic flexure and descending colon. The dissection is continued toward the splenic flexure, with lateral traction of the colon or superior traction on the greater curve of the stomach, as needed. Care is taken not to tear the capsule of the spleen. As mobilization along the descending colon occurs, the patient will need to be placed into Trendelenburg with the right side of the colon rotated downward. The descending colon is mobilized by diving the lateral attachments, separating Gerota's fascia from white line of Toldt's with blunt dissection. The mobilized colon is progressively retracted toward the pelvis, which allows visualization of the left ureter.

For malignant disease a high ligation is performed following a classic medial to lateral dissection. The inferior mesenteric vessels are identified, while the descending colon is retracted laterally. The left ureter is identified, and care is made not to take the dissection plane into the plane of the iliac vessels. Then the inferior mesenteric artery and vein are ligated and the dissection plane is continued, medial to lateral between the colonic mesentery and Gerota's fascia and along the white line of Toldt. The sigmoid colon is retracted medially and mobilized laterally along the white line of Toldt. This dissection plane is a continuation of the previously dissected plane from the mobilization of the descending colon. A window is created at the distal resection margin, and the distal sigmoid colon is divided using a 450 mm EndoGIA stapler (Ethicon Endo-Surgery, Cincinnati, OH) [13]. Occasionally, a very long and redundant colon will not allow placement of the specimen, which has been resected so far into the pelvis. A mesenteric window is created from medially and the specimen transected at the rectosigmoid junction. The remaining colonic mesentery including the IMA and IMV pedicles are then ligated starting at the divided end of the colon from a lateral approach using continuous medial and cephalad traction of the distally transected sigmoid colon (see Video 22.2).

Transection of the Colon and Ileorectal Anastomosis

The colon is extracted, starting from the divided ileal end through the base of the GelPOINT port. An intracorporeal end-to-end ileorectal anastomosis is created. The anvil of the circular stapler is inserted into the ileum, extracorporeally [14]. Then pneumoperitoneum is recreated and the circular stapler is inserted transanally, completing the anastomosis. If an end ileostomy is to be created, then after specimen extraction the ileostomy may be matured in a standard Brooke fashion.

Rectal Mobilization, Transection of the Rectum, and IPAA

If a proctocolectomy is performed for inflammatory bowel disease, the dissection is continued in a TME fashion (see Video 22.3). This is technically challenging as a proper TME relies on adequate traction and countertraction and only one retracting instrument is available through a single port. Even though technically not a single-port approach an additional 5 mm trocar at a left lower quadrant drain site is advisable. The single-port approach is also not advisable for malignant disease of the rectum.

Summary

Single-port laparoscopic total colectomy is a feasible operation but does have its own unique obstacles to be mindful of when setting out to perform such a complex operation. This procedure is probably the ideal procedure following the idea of single-port laparoscopy, if the procedure is performed through an ileostomy site completely avoiding an additional extraction site.

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Part VI

Stoma Construction (Loop Ileostomy, Loop and End Colostomy)

Stoma Construction: Laparoscopic Approach

23

Laurence R. Sands and Luis O. Hernandez

Introduction

While stomas are created traditionally with a formal laparotomy, more recently there have been many other means of creative and minimally invasive techniques that are now used to create a stoma. Laparoscopy has emerged as a front-runner in stoma creation because of the minimally invasive technique and the rather quick patient recovery. Many surgeons now believe that this should be the primary means of stoma creation. In this chapter, we will review general principles of stoma creation and describe the laparoscopic approach in detail.

Background

With the advent of advanced laparoscopic and robotic surgery, there are now many options available to the surgeon who chooses to use fecal diversion as a part of reconstructive intestinal surgery. Intestinal stomas have always served a great function for both the general and colorectal surgeon. They are considered a vital element for either a permanent means of stool evacuation or as a temporary bridge in order to treat complicated abdominal problems. In many cases stomas are used to heal more distal anastomoses. In addition, a stoma may be used in cases of salvage from abdominal catastrophes, and in these cases the stoma may be life saving.

Littre described the initial colostomy over 300 years ago whereby he created a diverting stoma for a patient with an obstructing colon cancer [1]. The next report of a colostomy actually appeared many years later when it occurred spontaneously due to a strangulated umbilical hernia whereby the skin sloughed leaving the bowel exposed and draining [2]. While this may not be considered an ideal stoma and by today's standards would be deemed a colocutaneous fistula secondary to the incarcerated loop of bowel, it nonetheless paved the way for the understanding that fecal diversion was a practical option. Bowel exteriorization became much more commonly used with associated battlefield injuries and it soon became obvious that long-term survival followed such injuries.

The ileostomy history is much more short lived and recent since early on there was no adequate means of capturing the caustic liquid effluent from the terminal ileum. Surgical options for mucosal ulcerative colitis made it necessary however for physicians to face the difficulties posed by an ileostomy. Initial reports of ablative surgery for fulminating colitis seemed to be unsuccessful, and it soon became recognized that patients would either die of their disease or need to function with an ileorectal anastomosis. The option of an ileorectal anastomosis was rather unsatisfying particularly in those patients with severe proctitis or those with long-standing disease with an increased cancer risk. In 1913, Dr. John Young Brown of St. Louis introduced the ileostomy as part of the therapy for ulcerative colitis [3]. His initial plan was to create a diverting stoma in order to obtain colonic rest in the course of this disease. However, once Gavin Miller popularized total proctocolectomy as a cure for ulcerative colitis, surgeons were forced to deal with the long-lasting effects of the ileostomy [4]. At that time ileostomies were constructed by creating a flush connection of the bowel to the skin. Obviously these patients were then plagued with complications of irritated skin, inflammation, and subsequent parastomal scarring that ultimately resulted in stomal stenosis due to the severe fibrosis and reaction. An innovative chemistry student by the name of Koernig who himself had

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_23. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_23,

Table 23.1 Indications for an ostomy

Intestinal obstruction
Bowel perforation
Inflammatory bowel disease
Proximal anastomotic protection
Functional and motility bowel disorders (i.e., colonic inertia, incontinence)
Infectious causes (i.e., necrotizing fasciitis)
Congenital disorders (i.e., imperforate anus, Hirschsprung's disease)
Abdominal or perineal trauma
Complex abdominal or perineal fistulae
Radiation damage to the bowel

an ileostomy for ulcerative colitis developed a bag and seal of rubber with a latex preparation in order to help protect his skin from the caustic effects of the ileostomy effluent. In 1952, Brooke created the rather simple everted stoma that revolutionized ileostomy care and allowed for the regular use of the ileostomy. His design allowed appliances to easily catch the stomal effluent and stop leakage thus preventing irritation of the surrounding skin and its subsequent horrible complications [5]. This ingenious design now allowed surgeons to liberally use the ileostomy.

An ostomy is simply a surgically created opening between a hollow organ and the body surface. It may also be a term used to describe the connection between any two hollow organs. The word, ostomy, comes from the Latin word, ostium, meaning mouth or opening. The suffix -tomy implies an intervention, either by surgery or injury. The word, stoma, comes from the Greek word for mouth and is used interchangeably with ostomy. An ostomy is further named by the organ involved; therefore, an ileostomy is an opening from the ileum to the skin, a colostomy is from the colon, a gastrostomy is from the stomach, appendicostomy is from the appendix, and so forth. When two organs are joined, the descriptive term incorporates both. For instance, an anastomosis between the small bowel and colon may also be called an ileocolostomy, while an anastomosis between the colon and the rectum may be termed a colorectostomy or coloproctostomy. Bringing an intact loop of bowel through the skin and then dividing the antimesenteric side forms a loop ostomy. It is then matured so that there are two open lumens, the proximal and the distal. By contrast, bringing the end of the involved intestine to the skin and maturing the bowel forms an end ostomy.

There are multiple indications for a stoma (see Table 23.1). Permanent stomas are created when there is a need for removal of the anus along with its associated musculature. This may be necessary in patients with low-lying rectal cancers who require an abdominoperineal resection or those with severe inflammatory bowel disease with involvement of the sphincter mechanisms. In addition to this, weak sphincter muscles and fecal incontinence regardless of patient age may be an indication for permanent fecal diversion in order to prevent perineal skin breakdown, improve perineal hygiene, and prevent decubitus ulcer formation.

Stomas may also be used on a temporary basis. Temporary stomas may be indicated in cases of intra-abdominal catastrophes and may act as a lifesaving bridge in critically ill patients. Patients with diffuse peritonitis from a perforated colon due to a colonic obstruction or an inflammatory condition such as diverticulitis or Crohn's disease are often at risk of anastomotic leak should a primary anastomosis be attempted. These patients are often best served with a temporary stoma in order to allow intra-abdominal healing and resolution of the acute condition and the inflammatory state.

Perhaps one of the most common and somewhat controversial indications for the creation of a temporizing stoma is for patients undergoing deep pelvic dissections, total mesorectal excisions, low-lying ileoanal or coloanal bowel anastomosis, or in patients who undergo a high-risk distal bowel anastomosis. High-risk anastomoses may be performed in immunocompromised patients, patients on chronic steroids, or those individuals who have received previous radiation to the pelvis or abdominal cavities. Stomas in these cases serve as a protection for anastomotic dehiscence.

Temporary stomas may be created as either an ileostomy or a colostomy. The type of stoma used is dictated by the circumstances found at the time of the initial surgery as well as the preference of the surgeon. Many colorectal surgeons prefer a protective loop ileostomy for low-lying anastomoses because of the relative ease of reversal, simpler stoma management by the patient, lower incidences of parastomal hernia formation, and lower incidence of peristomal sepsis [6, 7]. Others may argue that the more liquid ileostomy effluent could lead to greater incidences of dehydration.

Stomas may be created as either a loop stoma or an end stoma. Loop stomas are often used when they are intended to be temporary since such a creation will often facilitate reversal. Loop stomas are often larger than end stomas since both limbs of bowel must be exteriorized through the same abdominal wall defect. This large size may make it more difficult for the patients to care for the stoma with an appropriately sized appliance. In addition, loop stomas may be more prone to develop parastomal hernias and subsequent stomal prolapse because of the larger abdominal wall defect that is made for its creation.

End stomas are often smaller, easier to manage, and rarely prolapse. In addition, they have a much lower incidence of parastomal hernia formation compared to loop stomas. However, if the end stoma is created on a temporary basis, they often require more extensive surgery for reversal since the other end of the bowel may be buried within the abdominal cavity. Many surgeons opt to tack the distal limb if possible near the site of the end stoma in order to facilitate reversal.

Another alternative in stoma creation is the loop end stoma. This may be performed in the obese patient where it is difficult to bring up an end stoma because of the large thick abdominal wall and the greater stretch applied to the bowel mesentery in these patients. The stretched mesentery may result in ischemia of the end of the bowel if it is brought up as a simple end stoma. In such cases many surgeons prefer to bring the bowel up to the skin as a loop with the distal end being closed off in order to improve vascularity to this end of the bowel.

Preoperative Planning

A stoma should ideally be planned preoperatively if at all possible. This is best done for several reasons. First, there is no doubt that patients may experience a great deal of anxiety related to their surgery and the possibility of needing a stoma. Second, patient education is perhaps the best way in order to allay a patient's fears and concerns regarding the surgery and the possibility of needing a stoma. The patient should be provided with ample opportunity to ask questions related to the stoma and the overall surgery. Videos may be a useful tool in order to demonstrate to the patient the role and function of a stoma in order to assist with preoperative consultation. In addition, online websites may be provided to the patient as an additional resource. Often times it is beneficial for the patient to speak to other willing patients in a similar situation who have a stoma so that many of their questions may be appropriately addressed. Third, the patient should be appropriately marked for a stoma by a qualified enterostomal therapist in order to arrange for the best placement for the ostomy since each patient's body habitus is different. This will help ensure that the patient will have the best possible fit of the stoma device in order to make the stoma experience as pleasant and beneficial to the patient as possible. Stoma sites should be modified to avoid scars, skin creases, and other skin disorders. Stoma markings should be done with the patient in both the sitting and standing positions, and attention must be given to the beltline and pant height. Stomas should be placed through the rectus sheath and not lateral to it in order to have the rectus muscle provide support and reduce the incidence of parastomal hernias. In obese patients, a supraumbilical stoma placement may be necessary. Once the proper spot is determined for the stoma, the site is marked with indelible ink. In some situations of difficult placement, a stoma device may be placed on the skin at the proposed site and worn for 24 h in order to test the placement.

Siting through the umbilicus may be a reasonable alternative when there is no other good location. Raza and his colleagues felt that this was a good option based on their series of 101 patients; only four needed revision, and there were no parastomal hernias or prolapse [8]. Fitzgerald noted that after closure in infants and children, the scar resembles a normal umbilicus and is cosmetically superior to that of an ostomy placed elsewhere [9].

Stoma counseling is clearly an important part of stoma acceptance. This has been confirmed in a study that used multiple regression analysis to show that stoma adjustment was related to learning how to care for the stoma by the patient, interpersonal relationships that the patient has developed, and better stoma placement. The authors concluded that addressing the psychosocial concerns of the patient should become a part of the care routinely given to stoma patients, and preoperative counseling plays a major role in the care [10]. Such counseling will improve patient outcomes and patient satisfaction scores and may even reduce overall length of hospital stay.

Morbidly obese patients present a significant challenge in stoma creation. Some have advocated a loop end stoma in this patient group in order to prevent bowel ischemia [11]. Another technique that has been described to assist in the stoma creation in the morbidly obese patient utilizes an Alexis wound protector placed in the abdominal wall at the stoma site. This will facilitate the bowel to pass through the abdominal wall with less friction and resistance because of the extensive subcutaneous tissues in these patients [12].

The advantages of laparoscopic stoma creation include smaller incisions, thereby reducing the chance of large wound infections that may occur with formal laparotomy, less postoperative pain, and reduced use of pain medication thereby reducing the time to first stool and reduction of postoperative ileus. In addition, the laparoscopic technique is ideally suited to stoma creation since it often does not require specimen extraction making this one of the easiest laparoscopic procedures to perform. In addition there are no incisions except for the port sites thereby facilitating the placement of the stomal appliance over the stoma site without the need of placing the appliance over an abdominal incision.

Another advantage of the laparoscopic technique may be seen in the patient undergoing a concomitant bowel resection along with a planned stoma. In these cases, the surgeon should use a port at the site of the presumed stoma and then exteriorize the bowel through this area at the completion of the surgery. In these cases, the surgeon may spare the patient an abdominal incision. However, some care must be taken upon using the laparoscopic technique with regard to bowel orientation. Since many surgeons prefer placing the proximal portion of a loop stoma at the upper aspect of the skin and abdominal wall defect, one must ensure that the bowel is properly oriented upon delivery through the abdominal wall and that the bowel is not twisted or kinked. Even upon creating end stomas, twisting of the bowel at the fascial level may result in a mechanical obstruction of the bowel.

The surgeon should always reinsufflate the abdomen after the bowel has been exteriorized in order to best visualize the orientation of the mesentery and ensure that the bowel has not been twisted.

Most importantly, one must assure that the proper proximal portion of the bowel is exteriorized in those patients undergoing an end stoma. Division of the bowel and maturation of the incorrect limb will result in a complete bowel obstruction and will ultimately result in a return trip to the operating room to correct this problem. While this problem would rarely if ever occur in open stoma creation, it is a possibility in the laparoscopic technique if one fails to identify the proper orientation of the bowel especially in cases of colonic redundancy. This problem may be avoided by ensuring complete visualization of the bowel and by identifying the upper aspect of the rectum noted by the convergence of the teniae coli and following the bowel proximal from that point. Another technique that may be used is to insufflate the rectum with air at the time of stoma creation in order to identify which end is most distal. If one is still having trouble identifying the proximal and distal portions of the bowel, then a loop stoma should be performed in order to prevent maturation of the incorrect side. Alternatively, one can always convert to an open procedure if there is still uncertainty about the correct anatomy.

Laparoscopic stoma creation has been compared to open stoma creation in several studies. A study from Germany showed fewer operative complications from open stoma creation compared to laparoscopic stoma creation. However, the mortality associated with the laparoscopic group was considerably lower. They concluded that for palliative stoma creation, there were significantly advantages using the laparoscopic technique for stoma creation [13].

The Cleveland Clinic Florida reported their experience with laparoscopic stoma creation early on. In their study of 32 patients who mostly underwent loop ileostomy, they converted to open surgery in five patients (two because of a noted enterotomy at the time of surgery), while two patients required reoperation for stoma outlet obstruction. One of these patients experienced a twisting of the bowel at the level of the fascia. The mean operative time was 76 min, and the mean length of stay was 6.2 days [14]. This long length of stay is most often related to stoma teaching.

A recent study reviewing a 10-year period confirmed the benefits of laparoscopic stoma creation. In this review of 80 patients who mostly suffered from advanced unresectable colorectal cancer, all but one patient underwent successful laparoscopic stoma creation. While the majority of patients underwent loop stoma formation of either the ileum or colon, only five patients suffered complications requiring reoperation including parastomal abscess, stomal retraction, small bowel obstruction, postoperative bleeding, and port site hernia. The average length of stay was 10.3 days. While this length of stay may seem long, it is most often related to proper patient teaching in stoma use and care [15].

Room Setup and Positioning

The patient is placed supine on the OR table with the both arms tucked. The table is placed in Trendelenburg position and rotated to the side opposite the site of the stoma placement. This will help move the bowel more cranial and lateral for better visualization. The surgeon is positioned on the side of the patient opposite to the site of the stoma (i.e., the surgeon will stand on the patient's right side for colostomy creation and on the left side for ileostomy placement). Typically the monitors are positioned by the feet of the bed for better visualization. However, if a more proximal transverse colostomy is planned, it would be preferable to position monitor toward the shoulders of the patient. The bladder should be decompressed with a Foley catheter for assistance with visualization and avoidance of bladder injuries. A rectal tube may be placed with a large syringe attached and positioned under the drapes for those patients undergoing an end colostomy or Hartmann's type procedure. Insufflation by the operating room staff prior to stoma maturation will help ensure proper orientation of the bowel and allow for maturation of the correct limb of bowel as well. The tube will be removed at the conclusion of the operation.

Port Placement

There have been a variety of techniques described for laparoscopic stoma creation using zero, one, or more ports. Hellinger and his colleagues at the University of Miami have described a laparoscopic technique through a trephine incision and without a port and without gas insufflation for stoma creation in those patients who may not be able to tolerate a pneumoperitoneum [16]. This technique simply uses abdominal wall retraction and placement of the laparoscope within the trephine opening in order to identify and orient the bowel. The downside to this technique is that it does not allow a great deal of mobilization of the white line of Toldt due to limited visibility in cases where the bowel is not very redundant.

Most laparoscopic stomas however are created using two or more ports [see port configurations for colostomy (Fig. 23.1) and ileostomy (Fig. 23.2)]. The camera port C, which can be a 5 or 10 mm trocar, is placed in a periumbilical location and the working ports L1 an L2 on the opposite side of the abdomen to facilitate a triangulation in order to have room to work within the abdominal cavity and identify, dissect, and raise the limb of bowel for the stoma. An additional port L3 is optional and typically placed at the site of the stoma.

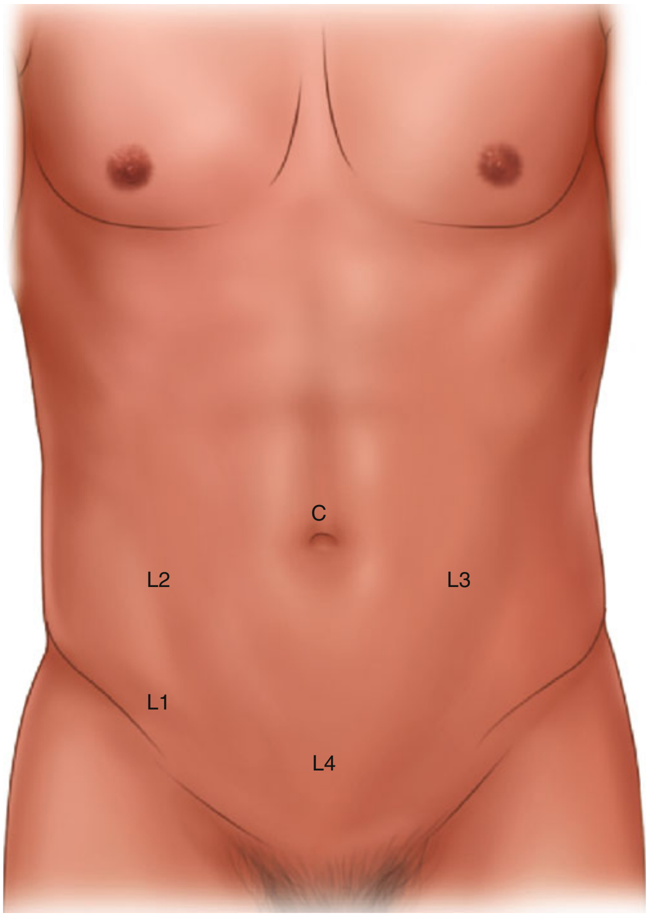

Fig. 23.1 Port configuration for colostomy. *C* 5 or 12 mm camera port, *L1* 5 mm working port right hand, *L2* 5 mm working port left hand, *L3* 12 mm optional assistant port through stoma site, *L4* 5 or 12 mm (for stapler) optional assistant port

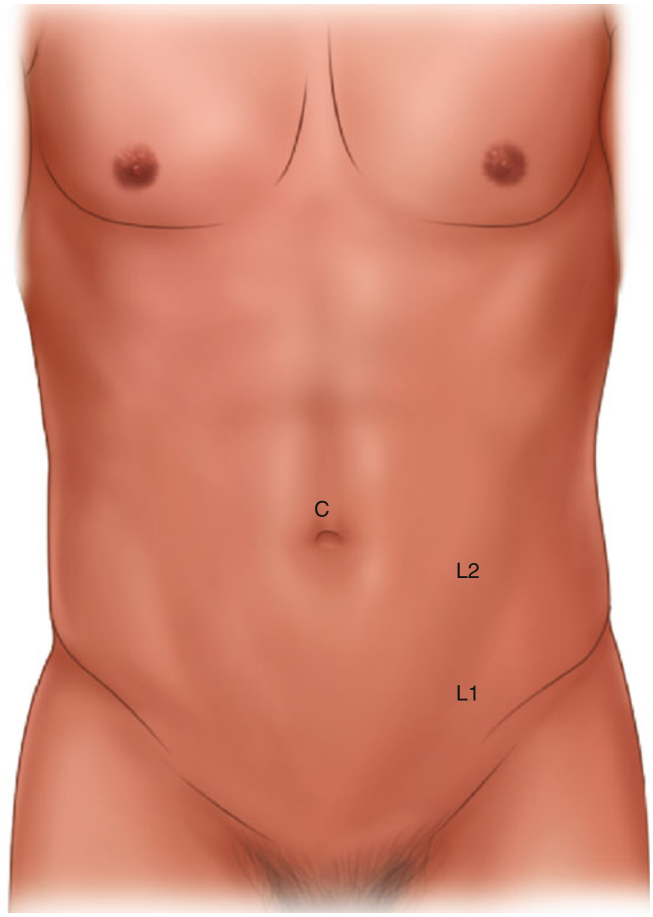

Fig. 23.2 Port configuration for *ileostomy*. *C* 5 or 12 mm camera port, *L1* 5 mm working port right hand, *L2* 5 mm working port left hand

Operative Steps (Table 23.2)

Table 23.2 Operative steps

Operative steps	Degree of technical difficulty (scale1–10)
1. Exploratory laparoscopy	1
2. Identification and mobilization of bowel (laparoscopic division of bowel)	2 4
3. Exteriorization of bowel	2
4. Reinspection and port closure	1
5. Ostomy maturation	1

Exploratory Laparoscopy

The first trocar is placed via the umbilicus with a 12 mm port using the standard Hasson technique or a 5 mm port using a Veress needle and/or optical trocar. A 5 or 10 mm zero or 30° laparoscope is used. The abdomen is inspected for adhesions, masses, carcinomatosis, or any other pathology. The second trocar can be placed in the previously marked and planned ostomy site (see Figs. 23.3 and 23.4). This port is often a 10/12 mm trocar since it will eventually be matured to accommodate the bowel. Care should be performed to not injure the epigastric vessels during the placement of this port. The working ports are placed on the opposite site at least 10 cm apart to allow triangulation.

Identification and Mobilization of Bowel to Be Exteriorized

The proper loop of bowel is clearly identified (see Fig. 23.5). This loop of bowel is mobilized as necessary using additional ports on the side opposite of the stoma in order to ensure proper reach to the abdominal wall (see Fig. 23.6 and Video 23.1). Care must be taken to avoid inadvertent injury

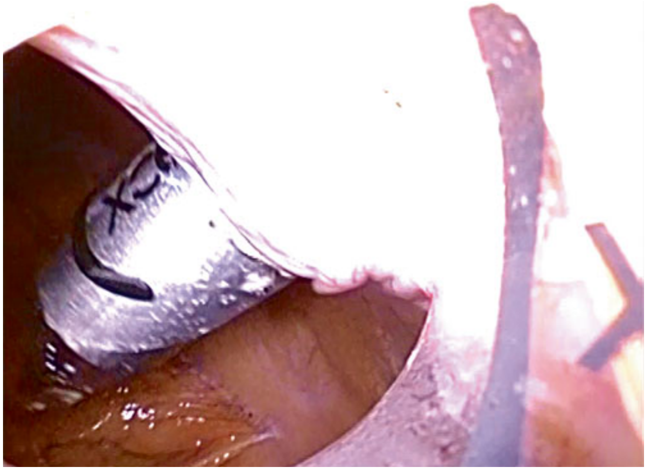

Fig. 23.3 Trocar placement at colostomy site

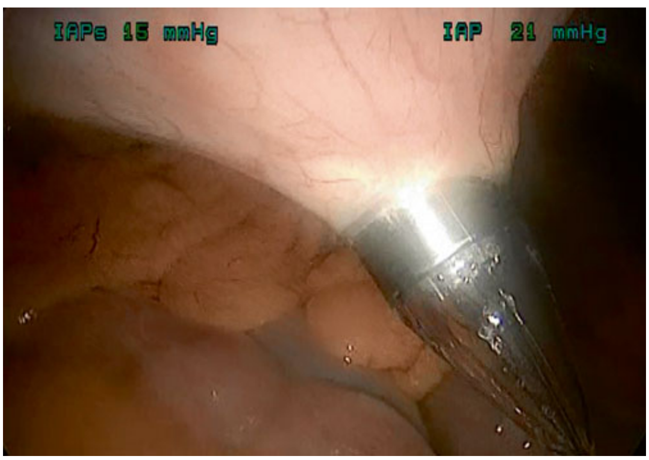

Fig. 23.4 Trocar placement at ileostomy site

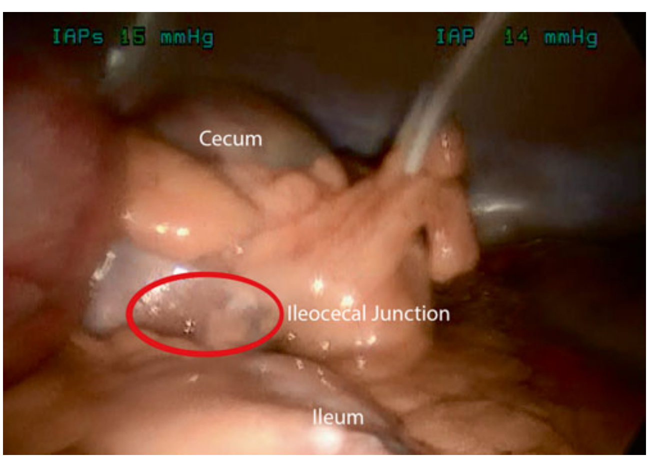

Fig. 23.5 Identification of ileal loop

to other loops of bowel as well as the ureters in the retroperitoneum (Box 23.1). The bowel must reach the skin without tension in order to prevent stomal retraction and necrosis.

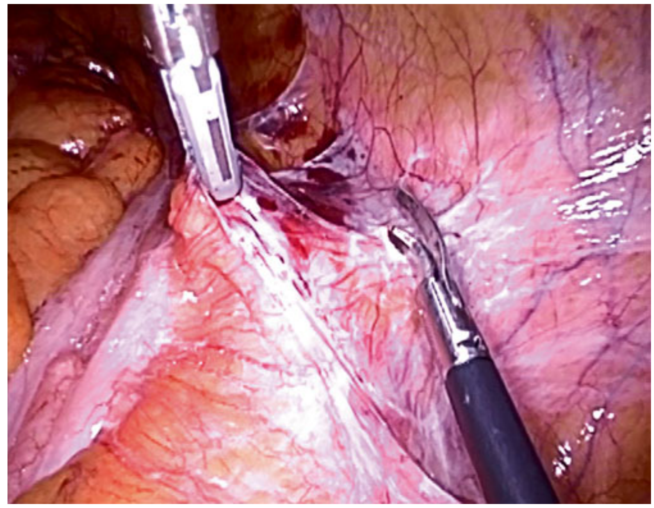

Fig. 23.6 Mobilization of colon

The bowel to be exteriorized must be well vascularized, and the mesentery must not be severely stretched or twisted in order to prevent obstruction, stomal ischemia, or necrosis. For an end colostomy if a laparoscopic transection is desired and/or lysis of adhesions or mobilization of the colon is needed, more ports can be used to facilitate the dissection. A fourth port L4 can be placed in the suprapubic region. This can be a 5 mm trocar unless a stapler will be used via this location, and then a 12 mm trocar will be required. The extra trocar allows for a second grasper to be used to mobilize the lateral attachments of the descending colon with electrocautery and sheers, bipolar devices, or ultrasonic scalpel. Once the white line of Toldt has been freed, a window in the mesentery can be created with thermal dissection, and a laparoscopic linear stapling device is placed across the segment of colon that is going to be transected.

Box 23.1 Tip
If a loop stoma is performed, marking the proximal and distal limb using monopolar energy or suturing prevents and helps with orientation and subsequent maturation.

Exteriorization of Bowel

A laparoscopic blunt grasper is placed via the trocar left abdomen port, and the desired portion of colon can be drawn toward the abdominal wall to evaluate for positioning and adequate length (see Fig. 23.7). If this is satisfactory then the laparoscope can be removed, and insufflation can be discontinued once the blunt grasper has been locked on the desired bowel (see Fig. 23.8). The intestine must be brought through the rectus sheath, and the opening should be just two fingerbreadths in width in order to reduce the incidence of

Fig. 23.7 Evaluation of length of colon

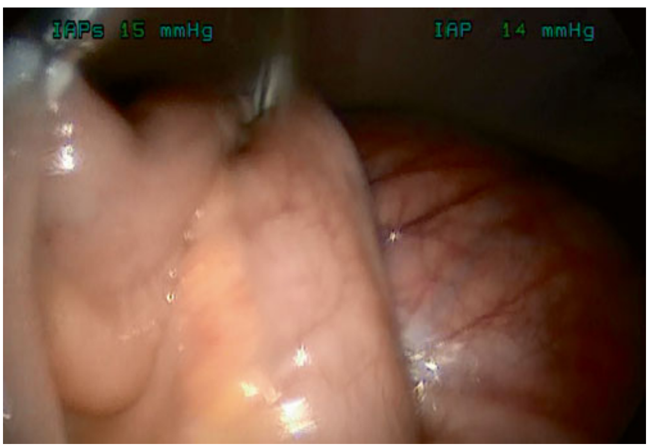

Fig. 23.8 Loop of ileostomy locked on grasper

parastomal hernia on one hand and prevent obstruction of the bowel as it exits through the opening on the other hand.

A disk of skin is removed from around the site of the trocar where the bowel will be exteriorized. A disk of skin should always be excised where the stoma is to be placed rather than simply creating a slit in the skin. This will prevent stomal stenosis and obstruction.

Then the anterior and posterior fascia is opened in an up and down manner until approximately two fingerbreadths in order to accommodate the portion of bowel. Some surgeons prefer to make a cruciate incision within the fascia instead. Care should be taken to avoid the inferior epigastric vessels as the surgeon enters the posterior rectus sheath. If these vessels are injured, they should be amply ligated. The bowel is then grasped with a Babcock clamp and exteriorized. In loop stomas some surgeons prefer making a mesenteric window just underneath the bowel edge and placing an umbilical tape around the bowel and then pulling this through the abdominal wall with the bowel. Stricture at the fascia level can also

Fig. 23.9 Inspection of proper orientation

cause clinical obstruction and can be prevented by adequately opening the fascia before maturation of the ostomy is completed. The trocar and grasper can then be drawn through the wound and secured with a Babcock. A small window is created in the mesentery for placement of an ostomy rod.

Reinspection and Port Closure

At this point the abdomen is reinsufflated and inspected with the laparoscope for adequate positioning of the bowel. It is important to make sure there is no tension and proper orientation of the proximal and distal bowel (see Fig. 23.9 and Video 23.2). Once satisfied, insufflation can be discontinued, and the camera and umbilical port can be removed. The umbilical port site fascia is then closed with figure of eight suture, and the skin is closed with subcuticular suture or staples if desired.

Ostomy Maturation

After exteriorization of the bowel and once the abdomen is closed, the stoma is matured. A stoma rod is typically placed under a loop stoma, while end stomas are matured with a simple eversion technique using an absorbable suture material. While eversion is essential in ileostomies because of the more liquid and voluminous effluent, not all colostomies need to be everted. The ostomy can be matured by creating an enterotomy with electrocautery, which is half the diameter of the colon, closer to the distal portion of bowel. The proximal end is then retracted back, and interrupted absorbable sutures are placed through the fascia, seromuscular layer of the bowel, and full thickness of the cut edge of the enterotomy and equidistant intervals. This is done circumferentially and tied down after satisfied bites have been obtained.

For creation of end colostomy, the aforementioned instructions apply up until the colon is exteriorized. If the bowel was not divided laparoscopically as described above, then a linear stapler can be placed across the colon before it's divided. The distal end is returned to the abdomen, and the open proximal portion is matured as an end colostomy.

Some surgeons may choose to tack the mesentery to the lateral sidewall to prevent internal hernia formation around the stoma site, while others may suture the stoma to the undersurface of the fascia in an attempt to prevent parastomal hernia formation or prolapse. While there is no data to suggest that these techniques may in fact be effective, Goligher in the 1950s advocated delivering the bowel via an extraperitoneal approach in order to reduce the incidence of these complications [17].

Trephine Stoma and Endoscopic-Assisted Stoma

Hellinger described performing an operation via a trephine incision through which the bowel will ultimately be brought up to form the stoma [18]. The benefits include limited abdominal incisions and the ability to perform the procedure under local or regional anesthetic if needed. The downside is the exposure. Working through the small incision makes it difficult to orient the bowel and impossible to inspect the abdomen. Complication rates as high as 25 % have been reported [19].

The patient is placed in lithotomy position. Incising a disk of skin and subcutaneous tissue at the previously marked site makes the opening. This is typically performed at the lateral half of the rectus abdominus muscle. Both layers of fascia are divided. The anterior fascia is divided in a cruciate fashion and the muscle split along its fibers. Once the peritoneum is entered, the sigmoid colon is identified and grabbed using a Babcock forceps. If an end sigmoid colostomy is desired, Hellinger [19] describes using rectal air to identify the distal limb, either via rigid sigmoidoscope or bulb syringe. Once the distal limb is identified, the bowel is divided using a gastrointestinal anastomosis stapler. The proximal limb is used to create the ostomy after the distal limb is positioned subfascially. The ostomy is then created either in an end stoma fashion or looped depending on the approach taken.

Mattingly and Mukerjee have reported a modification to the trephine stoma; endoscopic-assisted colostomy without general anesthesia and laparotomy [20, 21]. A colonoscope was used to identify a loop of sigmoid colon that could be used without tension for the ostomy. It was confirmed by transillumination to be in adequate position against the anterior abdominal wall. A disk of skin is removed at this location, and the fascia is divided and the loop of bowel exteriorized with the assistance of the colonoscope. No complications related to this technique were noted in a 5-year follow-up [21].

Gasless Laparoscopic Stoma

Gasless laparoscopic stoma formation combines the limited incision of the trephine approach and the increase visibility of the laparoscopic approach [22]. The patient is placed in the lithotomy position for a sigmoid colostomy and supine if an ileostomy is being performed. The incision is made as described previously, at a pre-marked stoma site. A disk of skin and subcutaneous tissue is excised, and the anterior and posterior fascia is separated in cruciate orientation or cranial-caudal. The peritoneum is entered, and a laparoscope is inserted into the wound after wound retractors are placed, and the abdominal wall is retracted up. Through the trephine incision, in addition to the laparoscope, a Babcock forceps or desired instrument can be inserted to manipulate the bowel as needed. Once adequate length is obtained, correct orientation can be confirmed under direct visualization with the laparoscope, and the desired bowel can be exteriorized. Loop or end ostomy can then be created with minimal abdominal incision and no pneumoperitoneum required.

Single-Site Laparoscopic Stoma

Another laparoscopic approach for stoma creation has been proposed as being incision-less. Attallah used a single-incision laparoscopic port for their stoma creation [23]. As described before, the stoma location should always be marked before surgery. This location will be the location of the port. A skin incision is made in a circular fashion about 2 cm in diameter. The incision is continued down through the subcutaneous tissue until the rectus sheath fascia. The fascia is divided in a vertical fashion, and the rectus muscles are spread laterally, and the posterior fascia is then divided as well, and the peritoneal cavity is entered. Attallah uses this as a point of entry for the single-incision laparoscopic port. This port has three working ports in a single introducer port. Once the port has been inserted and pneumoperitoneum has been accomplished, a 5 mm 30° scope and two bowel graspers are inserted. Once the loop of bowel is identified, the bowel grasper can be oriented to distinguish between the proximal and distal bowel. The insufflation is discontinued, and the port and graspers are withdrawn from the wound with the loop or bowel correctly oriented and ready for maturation of the loop ostomy.

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24 Stoma Construction: Single-Port Laparoscopic Approach

Seth Felder and Phillip Fleshner

Introduction

Laparoscopic stoma creation has become a favorable alternative to conventional open stoma construction, proving to be safe and effective [1]. Laparoscopic techniques permit full visualization of the abdominal cavity, minimize surgical trauma, and afford the potential benefits of improved cosmesis, reduced pain, and shorter recovery time [2]. The indications for laparoscopic stoma formation do not differ from those of open surgery [2]. A variety of intestinal sites may be chosen for stoma formation, although the terminal ileum and sigmoid colon are most commonly used.

While stomas are created traditionally with a formal laparotomy, more recently there have been many other means of creative and minimally invasive techniques that are now used to create a stoma. Laparoscopy has emerged as a front-runner in stoma creation because of the minimally invasive technique and the rather quick patient recovery. Many surgeons now believe that this should be the primary means of stoma creation. In this chapter, we will review general principles of stoma creation and describe the single-port laparoscopic approach in detail.

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_24. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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Background

Single-incision laparoscopic surgery (SILS) has been described for many general surgery and colorectal surgery procedures. Single-port laparoscopic fecal diversion surgery appears to be both a feasible and safe alternative to standard laparoscopy, affording similar benefits with the additional advantage of a scarless, single incision [1]. Full laparoscopic access to the abdominal cavity is maintained, and if necessary, the procedure can easily be converted to a standard laparoscopy with placement of additional trocars. Several methods have been introduced over recent years, each reported in small case series using slightly modified techniques. In all cases, the stoma is fashioned through the port site, preoperatively selected with aid of an enterostomal therapist. By using this single-port technique, the probability of stoma site herniation and prolapse is minimized, and no additional wounds are at risk for infection or incisional hernia, and secure placement of the stoma appliance is simplified [3, 4]. Based on the favorable results from several small case series, larger studies comparing single-port laparoscopic stoma construction to standard laparoscopic stoma construction will further clarify its role.

Room Setup and Positioning

Two video monitors are placed angling towards the patient at shoulder level. The patient is most commonly positioned in the supine position; however, the modified lithotomy position is also acceptable. If the latter position is utilized, the hips and knees are gently flexed to an angle no greater than 15° to avoid the patient's thighs interfering with the laparoscopic instruments [2]. Lithotomy is useful for identification of the distal limb, either via intraoperative proctosigmoidoscopy or air insufflation.

O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_24, © Springer Science+Business Media New York 2015

Operative Steps (Table 24.1)

Table 24.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Port placement and exploratory laparoscopy	3
2. Identification and mobilization of bowel	4
3. Exteriorization of bowel	2
4. Ostomy maturation	1

Port Placement and Exploratory Laparoscopy

A 2.5-cm incision is made in the right lower quadrant at the predetermined ileostomy site. The incision is carried down to the anterior rectus sheath, which is then divided in a cruciate fashion. The skin and subcutaneous fat are excised as a cone of tissue down to the anterior rectus sheath (see Fig. 24.1). The rectus abdominis muscle is spread in the direction of its fibers exposing the posterior rectus sheath and peritoneum (see Fig. 24.2) which are also divided in a cruciate fashion over a distance of 2.5 cm, wide enough to accommodate two fingers. The single-port access system (see Figs. 24.3 and 24.4) is then inserted through this incision. The abdomen is insufflated with CO_2 to 15 mmHg. A 5-mm laparoscope with a flexible steerable tip is used to visualize the abdomen. Single-incision laparoscopic instruments may be used, but standard laparoscopic instruments are suitable in most cases.

Fig. 24.1 Anterior fascia

Fig. 24.2 Posterior fascia

Fig. 24.3 Triport

Identification and Mobilization of Bowel

The terminal ileum is located, and a point on the small bowel about 15–20 cm proximal to the ileocecal valve is identified laparoscopically. Visualization of the ligament of Treves, located on the antimesenteric border of the terminal ileum just proximal to the ileocecal valve, is also helpful in identifying the anatomy (see Video 24.1 and Fig. 24.5) [2]. The terminal ileum is inspected for any pathology as well as length of mesentery available for loop stoma creation. The proximal side (one serosal thermal burn) and distal side (three serosal thermal burns) of this point on the small bowel are marked by using laparoscopic electrocautery [1] (see Video 24.2 and Fig. 24.6).

The bowel should be marked close to the ileocecal valve if the stoma is permanent. On the other hand, if the stoma is temporary, the bowel should be marked at least 15 cm proximal to the ileocecal valve to facilitate subsequent closure. Alternatively, the future ileostomy site may be marked with different colored sutures for orientation [2]. If the procedure involves a creation of a laparoscopic sigmoid colostomy, the white line of Toldt is mobilized as needed [2]. When an end stoma is indicated, intracorporeal mesenteric division may be performed either with laparoscopic clips or an endoscopic vascular linear stapler, if necessary [5, 6].

Exteriorization of the Bowel

With a laparoscopic grasper (e.g., Babcock), the bowel is delivered through the ileostomy incision and exteriorized, with attention to maintaining proper orientation. Because the ascending colon usually tethers the ileocolic vessels to the right lower quadrant, optimal positioning of the stoma requires the placement of the proximal end along the inferior aspect of the stoma site (see Fig. 24.7).

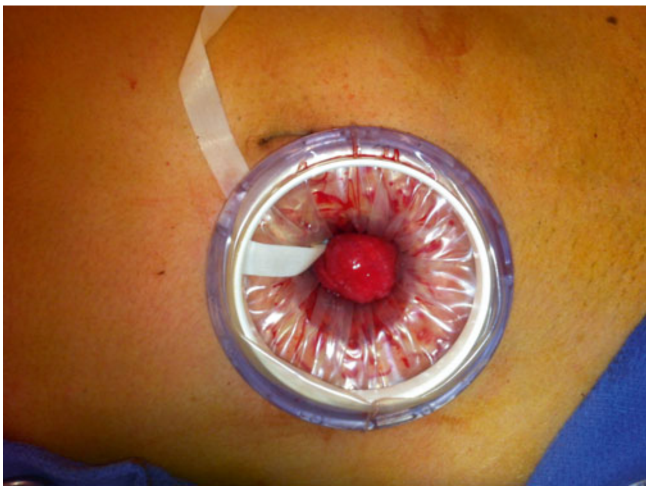

Fig. 24.4 Triport placed

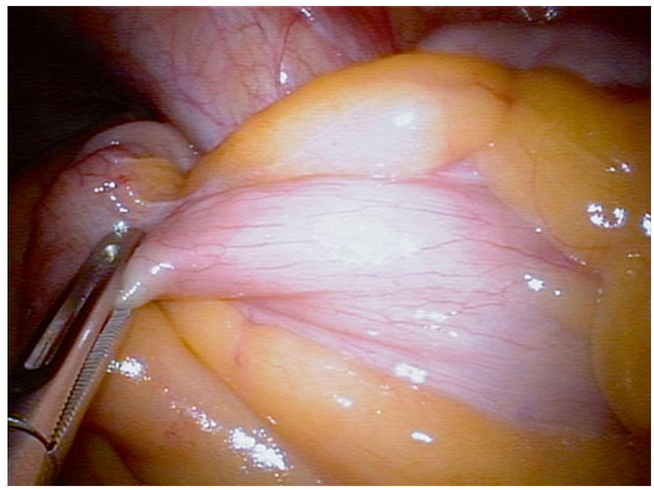

Fig. 24.5 Treves fold

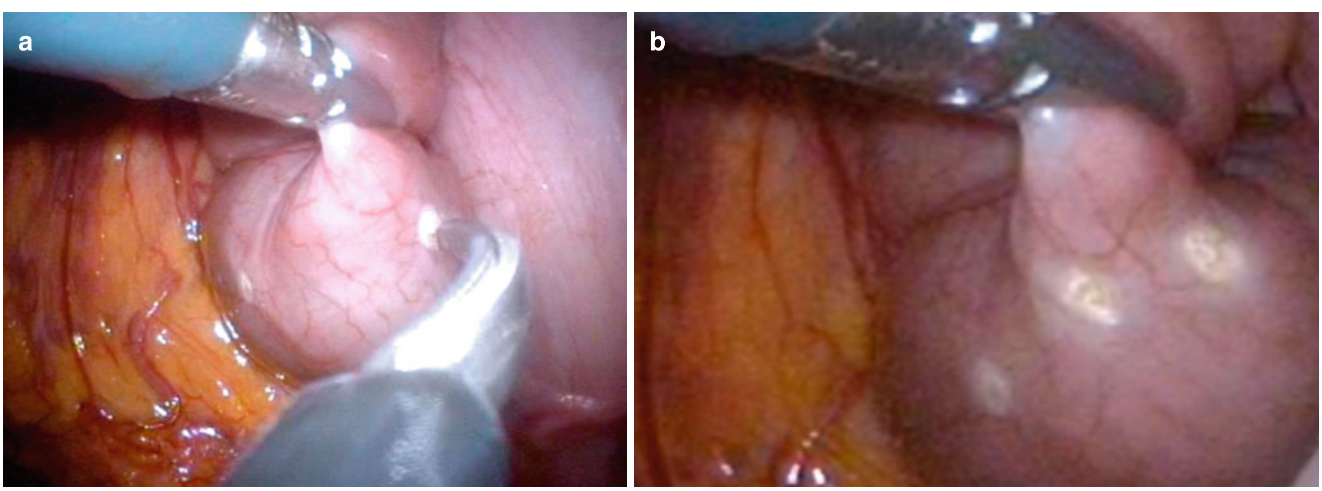

Fig. 24.6 (**a**) Replaced thermal burns, (**b**) thermal burns

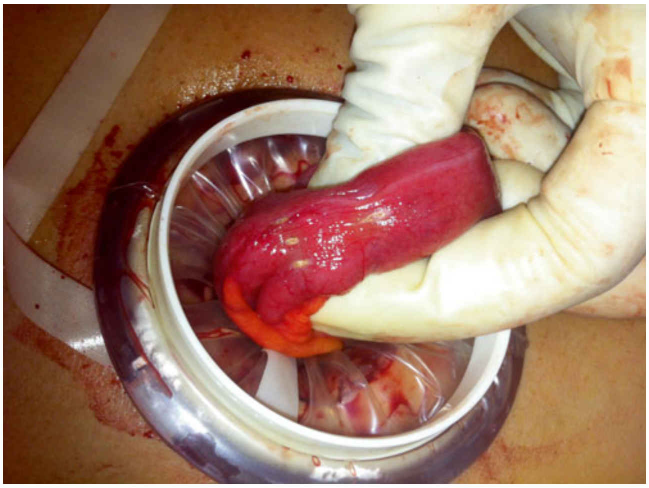

Fig. 24.7 Orientation stoma

Ostomy Maturation

The single-port access system is removed. The ileostomy is then matured in the usual fashion (see Fig. 24.8). The surgeon places an index finger both along the side of the stoma down to the fascia as well as into the stoma itself and beneath the peritoneum to ensure the fascial opening is not excessively tight and the stoma is not angulated.

Description of Alternative Operative Approach

A technique described by Hellinger et al. [4] is essentially a hybrid laparoscopic-open procedure. A circular incision is made in the skin at the predetermined stoma site, and the skin and subcutaneous fat are excised as a cone of tissue down to the anterior rectus sheath. A cruciate incision is made in the anterior rectus fascia, and the rectus abdominis muscle is spread in the direction of its fibers exposing the posterior rectus sheath. The posterior rectus sheath and peritoneum is then divided in a cruciate fashion to permit introduction of 2 fingers. To improve visualization, the operating table is then rotated approximately 30° away from the stoma site and into Trendelenburg position. A right-angle retractor is placed at opposite ends of the incision for elevation of the abdominal wall. The zero-degree laparoscope is introduced to identify the appropriate bowel segment. Once the appropriate loop of bowel is identified, a non-laparoscopic clamp (e.g., Babcock) is introduced alongside the laparoscope to grasp and exteriorize the chosen segment. Visualization and bowel manipulation can be performed with the assistance of a sponge stick. When necessary, dissection of the white line of Toldt can be done

Fig. 24.8 Stoma final

with long Metzenbaum scissors and subsequent blunt finger dissection. The laparoscope is used to follow each limb confirming the correct orientation and verifying that the loop of bowel is raised tension-free. Proctosigmoidoscopy or distal air insufflation is helpful for identification of the distal limb of a sigmoid colostomy. The ileostomy or colostomy is then matured in the usual fashion. The surgeon places an index finger along the side of the stoma down to the fascia as well as into the stoma itself and beneath the peritoneum to ensure the fascial opening is not excessively tight and the stoma is not angulated.

Special Considerations and Complications

The Reoperative Abdomen

This procedure is limited in patients with extensive adhesions. The options are to proceed with standard two-port or three-port laparoscopy or convert to a formal laparotomy [4].

Morbid Obesity

It may be necessary to divide the mesentery and colon in order to perform an end colostomy. Intracorporeal division of the intestines can be accomplished by introducing a laparoscopic GIA stapler. Alternatively, a mobilized loop of the sigmoid colon can be exteriorized and divided extracorporeally using a GIA stapler [2].

Crohn's Disease

Not only can mesentery be particularly friable in the Crohn's patient, the mesentery may be foreshortened, creating a challenge in exteriorizing a stoma through the abdominal wall. In these circumstances, an end stoma may not allow exteriorization without significant mesenteric stretch, and a loop stoma may allow for a tension-free ostomy. The intestinal segment selected for stoma maturation must also be inspected for absence of gross disease. Meticulous technique should be practiced when maturing the stoma, carefully avoiding full thickness suturing of the skin, as this may result in enterocutaneous fistulae formation.

Summary

Single-port laparoscopic ostomy construction offers the potential for improved cosmesis with full laparoscopic visualization and access to the abdominal cavity, allowing adequate intestinal mobilization with attention to preserving the blood supply to the exteriorized segments [1]. Single-port laparoscopy for fecal diversion is technically feasible and can be performed with minimal blood loss and acceptable operative time [1]. Prudent attention to correct limb orientation and creation of a generous fascial opening with judicious laparoscopic manipulation of the bowel is crucial in reducing the potential for vascular congestion and resultant stoma ischemia [1]. This procedure may be difficult to perform in patients with extensive intra-abdominal adhesions or patients with medical comorbidities precluding general anesthesia. Additionally, one must take into account the additional cost for the single access port.

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Part VII

Transanal Endoscopic Surgery

Transanal Endoscopic Surgery (TES) 25

Joseph E. Bornstein and Patricia Sylla

History and Evolution

Colorectal cancer is the fourth most common cancer in the United States with an estimated 40,290 new cases of rectal cancer in 2012 [1]. Advances in screening and therapy have likely led to a reduction in mortality from colorectal cancer by up to 35 % [2].

The evolution of surgical treatment for benign and malignant conditions in the last 30 years has been remarkable. Advances in minimally invasive techniques and equipment have led to significant progress in the specialty of colon and rectal surgery. The morbidity and mortality of open surgery for rectal cancer is substantial with associated detriments to patients' quality of life. This includes, but is not limited to, urinary and sexual dysfunction, functional disorders including fecal incontinence, temporary or permanent stomas, and wound complications. Urinary and fecal incontinence can be present in up to 33.7 and 38.8 % of patients after total mesorectal excision (TME) [3]. Furthermore, rectal cancer surgery can be technically difficult given the narrow, deep operating environment of the pelvis. Consequently, alternative, less invasive treatments for early rectal cancer therefore are highly desired. Laparoscopic TME has been popularized by its published successes in decreasing morbidity of rectal cancer surgery. Comparison of laparoscopic TME vs. open TME has shown decreased blood loss, decreased length of stay, and less narcotic use in the with laparoscopy [4, 5]. Importantly, technical (i.e., anastomotic leak, specimen margins, extent of lymphadenectomy) and oncologic outcomes (disease-free survival, local recurrence) were similar. Despite these improvements, surgeons have continually looked for less invasive and less morbid procedures.

Transanal rectal cancer surgery traditionally was limited to a small number of patients with distal rectal pathology that was accessible with anoscopy. Multiple techniques for anal canal and rectal surgery have been available including: transanal excision (TAE), Kraske procedure, and trans-sphincteric dissection. Each of these procedures is technically feasible in a minority of patients, but has not provided a robust alternative to transabdominal surgery. TAE, while good for distal rectal lesions, becomes limited in the mid and proximal rectum where visualization and access is poor with anoscopy. Alternatively, the Kraske procedure requires coccygectomy for access to the rectum which has been associated with a high fecal fistula rate in addition to the morbidity of coccygectomy [6]. The invention and development of transanal endoscopic surgery (TES) platforms over the last 30 years has provided surgeons with a more versatile set of tools that have been widely applied in both benign and malignant conditions. Dr. Gerhard Buess developed transanal endoscopic microsurgery (TEM), the first TES platform (transanal endoscopic surgery), in 1983. The initial driving force behind its development was the resection of rectal adenomas too large for standard endoscopic resection and too proximal for transanal excision. In these circumstances, abdominoperineal resection (APR), low anterior resection (LAR), or standard posterior approaches imposed excessive morbidity. The first study of 12 cases showing efficacy and safety was published in 1985 [7]. Since then, the indications for TES have expanded substantially (Table 25.1).

Since its initial development, equipment and access techniques for TES have evolved considerably leading to technical advances and increased adoption. The original rigid metal platforms (Richard Wolf Medical Instruments Corporation, Illinois, USA) include a beveled rigid proctoscope (40 mm wide), side ports for CO_2 insufflation, airtight

Electronic supplementary material The online version of this chapter (doi:10.1007/978-1-4899-7531-7_25) contains supplementary material, which is available to authorized users.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_25, © Springer Science+Business Media New York 2015

Table 25.1 Current applications of transanal endoscopic surgery (TES)

Adenomas
Carcinoid tumors
Anastomotic stricture
Anastomotic leak
Rectovaginal and rectourethral fistula repair
Retrorectal tumors
Drainage of pelvic abscess
Rectal foreign body removal
Low-risk T1 rectal cancer
Palliation of advanced rectal tumors
Transanal NOTES (natural orifice transluminal endoscopic surgery)

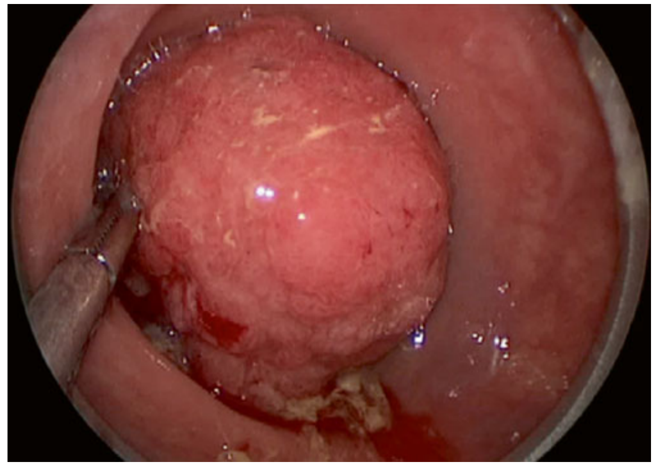

Fig. 25.1 Transanal endoscopic resection of a large villous lesion of the upper rectum

face plate, stereoscopic camera, three ports for instrument placement, and customized operating tools. An alternative rigid platform is the TEO platform (KARL STORZ GmbH & Co. KG, Tuttlingen). Since its inception, enthusiasm has brought the development of newer platforms under the term transanal minimally invasive surgery (TAMIS) [8]. New access devices utilize standard laparoscopic equipment making adoption for surgeons already using single-incision laparoscopic platforms easier.

Indications

Rectal Adenoma

TES is now the procedure of choice for removal of endoscopically unresectable adenomas of the rectum. The initial indication for TES was to aid in removing endoscopically unresectable adenomas that were in the mid to proximal rectum, unreachable by conventional anoscopy, and that would otherwise require low anterior resection. Relative to standard transanal excision, TES has been shown to be having improved outcomes. Moore et al. in 2008 compared TEM to standard transanal excision for rectal neoplasms most of which were adenomas or pT1 carcinoma. TEM was more likely to yield clear margins (90 % vs. 71 %) for all specimen types and lower recurrence (5 % vs. 27 %) specifically for patients with an adenoma [9]. Overall, local recurrence rates of adenomas following TES vary depending on the specific study population but are reported to be 4–12 % [10–13]. Concern for increased recurrence risk in patients with larger adenomas (>3 cm) has been reviewed. Only positive margins were an independent predictor of recurrence [14].

Rectal adenomas can alternatively be removed by piecemeal endoscopic mucosal resection (EMR). Barendse et al. reviewed the recurrence and complications of resection of adenomas at least 2 cm in size that were on average 6.9 cm from the dentate line [15]. Multiple endoscopies were often necessary for complete tumor resection, and the early recurrence rate was substantially higher in the EMR group vs. TES (31 and 10.2 % respectively), a result of incomplete resection.

TES has been particularly successful at removing very large adenomas (>5 cm). Given the limited size of the rectoscope and concern over the size of the resulting rectal wall defect, resection of large sessile adenomas (>5 cm) was initially avoided. Schafer et al. in 2006 showed that removal of these large adenomas is safe in a group of 33 patients with lesions from 5 to 13 cm in largest diameter [10]. These patients were followed closely by proctoscopy given concern about possible suture line dehiscence. Fifteen percent of patients had some suture line insufficiency, which was managed nonoperatively. No episodes of sepsis occurred in the study group. One of the 15 patients required repair of the suture line by redo-TEM and ultimately underwent fecal diversion. A major advantage of TES is the ability to obtain a more complete and accurate tissue diagnosis since the entire rectal wall can be excised, thus curing early cancer contained in a polyp (Fig. 25.1).

Rectal Cancer

The selection of appropriate patients with biopsy-proven early stage rectal cancer for TES can be challenging. Accurate staging aims to exclude patients who will not benefit from local resection alone. A malignant polyp on pathology shows invasion through the muscularis mucosae into the submucosa. Current NCCN guidelines state that transanal excision is appropriate in cases of cT1N0 tumors (Table 25.2) [16]. At this time, there is insufficient evidence to support routine local excision alone for radiologically staged T2N0

Table 25.2 National Comprehensive Cancer Network (NCCN criteria for transanal excision of rectal cancer (2012)

<30 % circumference of bowel
<3 cm in size
Margin clear (>3 mm)
Non-fixed, mobile lesion
Within 8 cm of anal verge (unless TES platform used)
T1 only
Endoscopically removed polyp with cancer or indeterminate pathology
No lymphovascular invasion or perineural invasion
Well to moderately differentiated
No evidence of lymphadenopathy on imaging

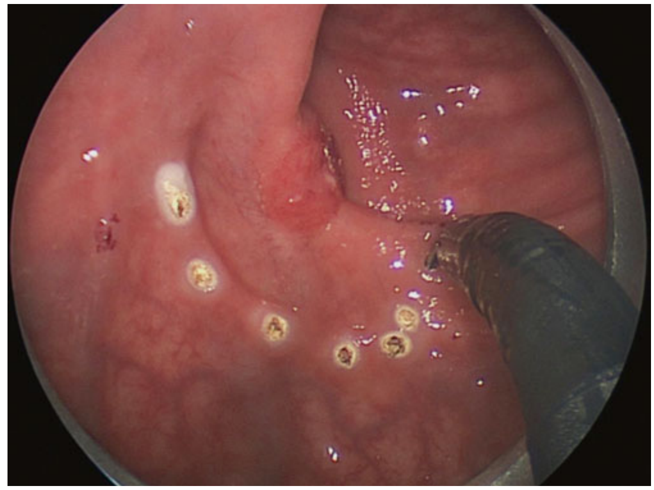

Fig. 25.2 Transanal endoscopic excision of a T1 rectal cancer of the mid-rectum

tumors or T1 tumors with adverse features as the risk of lymph node involvement and recurrence is significant. The incidence of positive lymph nodes in poor prognosis T1 rectal cancers is up to 13 % [17]. The recurrence risk for pT2 tumors after TES can be as high as 29.3 % in published series [18]. Serra-Aracil et al. in 2008 reported similar rates of recurrence and long-term survival for pT1N0 tumors with survival of 100 % at 2 years [19]. In a retrospective review at Memorial Sloan Kettering, the disease-specific survival was 87 % vs. 96 % at 5 years for transanal vs. radical rectal resection for pT1 cancers [20].

Risk factors for local recurrence after local excision of pT1 tumors have been evaluated extensively. Tumor size, submucosal invasion depth and tumor budding, lymphovascular invasion, and poorly differentiated histology were all significant predictive factors for locoregional failure after TEM for stage T1 cancer (Fig. 25.2) [21].

With a goal of increasing the pool of patients that can benefit from lower morbidity resection, surgeons have started to use TES on more advanced tumors, specifically T2 when combined with neoadjuvant therapy. A recent publication of 70 patients who underwent laparoscopic TME vs. TES for T2N0 rectal cancer treated with neoadjuvant therapy reported a local recurrence rate of 5.7 % vs. 2.8 % at 84 months following TES vs. laparoscopic TME which was not significant [22]. There were no significant differences in survival or complication rates.

Several ongoing trials are evaluating the short- and long-term oncologic outcomes of TES following tumor downstaging with neoadjuvant treatment for T2 and T3 rectal cancer. Garcia-Aguilar J et al. recently reported a series of 77 T2-staged rectal cancer patients who underwent neoadjuvant therapy followed by TES, which showed a 44 % pathologic complete response in the surgical specimen [23]. Kundel et al. reviewed a small sample of patients with locally advanced rectal cancer with pathologic complete response and retrospectively reviewed results of radical surgery and those that underwent local excision. The rate of regional disease was 3 % in radical excision groups suggesting that local excision may be sufficient in this circumstance for many patients [24]. Callender et al. published their results of 26 patients with T3 rectal cancer who underwent local excision (Kraske or TAE) after neoadjuvant therapy [25]. At a follow-up of approximately 4 years, there was no difference in disease-specific survival or the rate of local recurrence between local excision and TME.

Local recurrence is managed in a variety of ways depending on disease extent. Small studies have shown no difference in overall survival between patients undergoing salvage radical resection for locally recurrent pT1 rectal tumors originally treated with TES vs. those that underwent upfront radical surgery [26]. This suggests that there is little downside to proceeding with local resection as first-line therapy; however, adequate patient follow-up and surveillance protocols are necessary to identify local recurrence early. Local recurrence after TES should be treated by salvage radical resection and not TES re-excision as oncologic outcomes are better with radical resection.

Palliation of Rectal Cancer

Palliative strategies for locally advanced and symptomatic rectal cancer include: fecal diversion, stenting, surgical debulking or cryosurgery, embolization, and radiotherapy. TES provides an additional alternative method of palliating bleeding and obstructive complications of unresectable end-stage rectal cancer. Turler et al. in 1997 reported 29 cases of TES for rectal cancer palliation [27]. The main indications for TES were rectal bleeding and intestinal obstruction, which were relieved in all patients. One intra-abdominal perforation occurred. Hence, TES is a viable option for palliation. Certainly its role in this setting depends on patient-specific goals of care (Fig. 25.3).

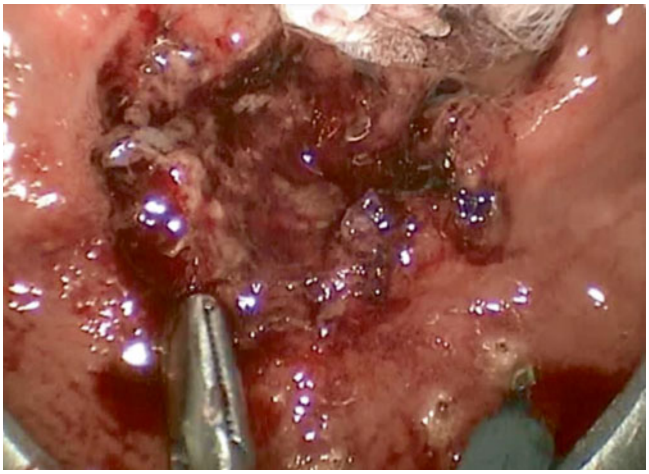

Fig. 25.3 Palliative resection of a T2 mid-rectal cancer with TES in a patient with significant medical comorbidities precluding radical resection

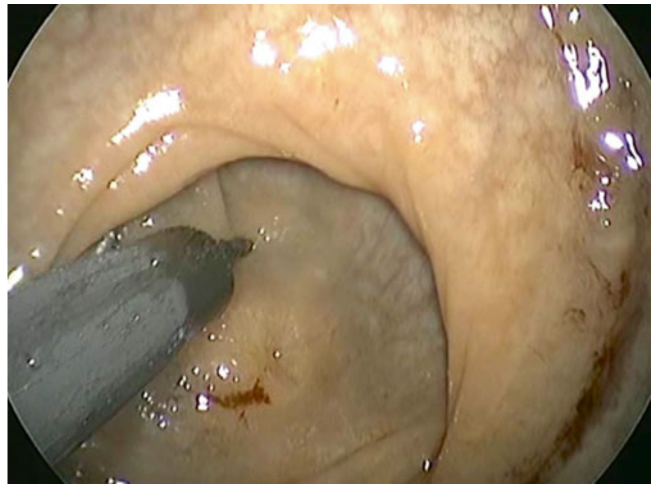

Fig. 25.4 Resection of a 0.2 cm residual carcinoid tumor located in the upper rectum using TES

Carcinoid Tumors

The incidence of gastrointestinal neuroendocrine tumors (NETs) has increased substantially over the past four decades owing to improved detection with screening endoscopy. The 5-year disease-specific survival for rectal carcinoids is 90.3 % [28]. In the SEER database, of 19,669 GI NETs, 6,796 were in the rectum, a majority of which were in the age group of 40–59 with nearly equal distribution to males and females. The primary treatment for rectal carcinoids is surgical resection. Of 202 patients in a multi-institutional study of outcomes in rectal carcinoids, 101 patients underwent local resection with 6 patients who underwent TES [29]. The presence of adverse histologic features such as lymphovascular invasion, invasion of the muscularis propria, and tumors larger than 1 cm requires resection of associated lymphatic tissue with mesorectal excision. The survival of T1 node-negative tumors is 100 %. Small tumors that are node negative can be removed by endoscopic means or transanal surgery alone. Endoscopic submucosal dissection has proven better than standard endoscopic polypectomy in for a complete histologic resection, but no comparison to TES has been made (Fig. 25.4).

Retrorectal Tumors

Recently, groups have been expanding the role of TES to include resection of retrorectal tumors. Retrorectal tumors, often congenital in origin, are rare. Standard operative approaches have been either transabdominal or transcoccygeal. Resection of retrorectal lesions involves creating a defect in the posterior rectal wall to enter the retrorectal space. TES has now been used as a minimally invasive alternative [30, 31].

Rectovaginal and Rectourethral Fistulas

TES has recently been applied to repair of rectovaginal fistulas. D'Ambrosio et al. reviewed 13 patients who underwent repair of rectovaginal fistulas using a TES platform [32]. Fistulas were complications of transvaginal hysterectomy in seven patients, LAR in five patients, and radiotherapy in one patient. The median distance was 7 cm from anal verge (4–10 cm). This group included nine cases of failed transperineal repair, and four patients had multiple repairs with a combination of transabdominal, direct suture, or transperineal approaches. All 13 patients were previously diverted, and the recurrence rate following TES repair was only noted in 1/13 patients during the follow-up period. One of the operative pearls for this particular application was the use of vaginal packing to prevent leakage of CO2. Additionally, to keep the lesion in the appropriate field for ideal ergonomics, the authors recommend the patients be positioned prone. Importantly, TES provides excellent visualization of the fistula to allow for complete excision of the sclerotic tissue and flap coverage. This study group and the resultant success in patients who had already failed more conservative management attempts speak to the potential for TES-based repair.

Rectourethral fistula (occurring after radical prostatectomy) usually required major surgery, and TES has been explored as a minimally invasive alternative approach. To date, there have been a few case reports of rectourethral fistula repair. Similar to rectovaginal fistula repair, the surgical tenant is to excise the tract and perform flap closure of the rectal wall [33].

Anastomotic Leak

Anastomotic leak is a devastating complication in colorectal resections that often requires fecal diversion and abdominal washout. The cumulative morbidity associated with reoperation and stoma creation and subsequent stoma reversal is significant. TES has been used to manage early postoperative suture line dehiscence associated with leak in patients whose lesions were originally removed with TES. The use of this approach in patients undergoing standard rectal surgery seems ideal when technical expertise and clinical conditions are appropriate. So far this application has only been reported in a few case reports. Beunis et al. in 2008 reported a case of anastomotic leak following laparoscopic rectosigmoid resection with end-to-end stapled anastomosis for diverticular disease where the 1.5 cm anastomotic defect on CT was closed primarily using TES [34]. The patient did not require diversion or reoperation. Further studies on this approach are needed to determine whether this technique is safe and more widely applicable in the management of anastomotic leaks.

Pelvic Abscess

In colorectal surgery, pelvic abscesses pose a challenging problem. The utility of routine pelvic drainage remains controversial. Percutaneous drainage by interventional radiology is largely preferred over surgical drainage due to lower morbidity. TES has been described as an alternative minimally invasive method using transrectal drainage of low pelvic abscesses.

Martins et al. in 2011 described the use of TES to drain a pelvic fluid collection through a rectal stump after undergoing a Hartmann procedure for perforated rectal cancer [35]. In each case, a drain was placed through the rectal wall defect. This has been successfully applied in drainage of abscesses from a variety of causes.

Benign Strictures

Benign rectal strictures have now been successfully treated with stricturoplasty performed using TES. The most common cause of benign rectal strictures results from a prior colorectal anastomosis; however, additional etiologies have been treated as well including strictures caused by anal administration of medications or caustic enemas [11, 36]. Baatrup et al. reported a series of six patients who underwent resection of all fibrotic tissue, and five patients had clinical improvement.

Advanced Applications (Advanced Resection and NOTES)

Transanal NOTES (natural orifice transluminal endoscopic surgery) have been an area of active investigation over the last few years. The TES platforms have shown to be versatile tools to gain endoscopic access to the peritoneal cavity, specifically to treat colorectal pathology. In addition, transanal specimen extraction during laparoscopic colorectal resection has been re-popularized with the use of TES techniques [37]. The potential benefits of transanal extraction derive from a smaller abdominal incision, hence reduced postoperative pain, wound infections, and incidence of incisional hernias [38, 39]. The theoretical concern of deep surgical site infection from utilizing the rectum as a means of specimen extraction has not borne out in the literature [40, 41].

The feasibility and safety of transanal NOTES colorectal resection is in its early phase of clinical evaluation. Several case reports and series on TES-approached TME performed with laparoscopic assistance have been published [42–46]. Laparoscopy serves two roles at this time – (1) to improve safety of transanal TME via retraction and visualization of at-risk pelvic structures and (2) to perform splenic flexure mobilization and mesenteric division. Perceived benefits include establishing a tumor-free distal margin and improved exposure compared to transabdominal approaches in the narrow pelvis. Ultimately, improvement in technique and equipment will hopefully eliminate the need for an abdominal incision and decrease morbidity. Long-term functional and oncologic outcomes of this novel approach are needed.

Patient Selection and Workup

TES can be successfully utilized in a wide array of rectal lesions. Patients of all ASA classes have been treated with TES, and efficacy and safety have been recently shown with patients with a BMI as high as 66 [47]. The exact preoperative workup is dependent on the lesion being treated; however, a number of principles hold for all patients. A complete history and physical inclusive of a digital rectal exam is performed to assess for the target lesion and its characteristics. The location, distance from the anal verge, and mobility should be documented. A complete colonoscopy is necessary, and preoperative biopsies should be taken to evaluate the pathology to be resected where indicated.

As an alternative method for local excision, TES does not substitute for radical rectal cancer resection when required in the management of resectable locally advanced rectal cancer. When used for early rectal tumors, careful selection using preoperative staging is essential to determine if TES is an adequate means of resection. Evaluation is performed to assess for local and distant disease. CT scans and endoscopic rectal ultrasound (ERUS) and/or pelvic MRI is used for tumor staging [48].

There are few hard contraindications to TES. Inability to dilate the anus to the appropriate size for the rectoscope (40 mm – for TEM platforms) or access port would make the procedure impractical. Although not routinely used in asymptomatic patients with good resting anal sphincter tone and squeeze on DRE, anal manometry may be selectively used in symptomatic patients with evidence of sphincter dysfunction. Patients with no preexisting sphincter dysfunction do experience decreased maximum anal resting pressure in the months following surgery; however, on 1-year follow-up, all patients return to baseline values, and quality of life is unaffected [49]. Additionally, the procedure is not recommended in patients with preoperative sphincter dysfunction due to concern for worsening incontinence. Other contraindications depend on the specific pathology being treated.

Basic Operative Setup and Instrumentation

For success with TES, the operative setup must be optimized. Preoperatively, patients either undergo a complete mechanical bowel preparation or enemas in order to minimize fecal soiling during transanal procedures. Procedures are performed under general anesthesia, and complete paralysis is essential to help maintain adequate pneumorectum. A Foley catheter is placed, and perioperative antibiotics should be provided in accordance with SCIP guidelines.

Patient positioning depends on the location of the lesion and the TES platform utilized. Rigid proctoscopy should be performed to evaluate the exact location of the lesion along the rectal wall and its distance to the anal verge. For rigid platforms including TEM or TEO that incorporate angled scopes and beveled platforms, the patient is positioned such that the target lesion is in the 6 o'clock position relative to the surgeon's frame of reference. Thus the patient may be positioned in lithotomy, prone, or lateral decubitus for a lesion located along the posterior, anterior, or lateral rectal wall, respectively. For TAMIS platforms, lithotomy position is usually sufficient. Traditional lithotomy is most advantageous in this circumstance for operating comfort and anesthesia management. Proper positioning can be achieved using split-leg OR tables or stirrups if needed. If using stirrups (Fig. 25.5), the legs should be abducted and flexed to obtain good exposure and room for instrument manipulation. Steep Trendelenburg may be used, and careful padding of the patients is necessary.

Prior to insertion of the rectoscope, the anus must be lubricated and dilated to accommodate the platform. Digital dilation is often utilized, and the rectoscope or access channel is inserted with a cone to prevent rectal trauma. For rigid metal TES platforms (TEM and TEO), the faceplate attached to the rectoscope and a fixed support arm hold the apparatus in place. The faceplate is designed to have multiple ports with rubber caps to prevent leakage of carbon dioxide. The intraluminal CO2 pressure is maintained at 9–15 mmHg. This may be increased as required for adequate exposure. The use of the TEM stereoscope and binocular eyepiece allows excellent 3D visualization of the rectal anatomy. TEM platforms also require specific equipment with angled instruments to approach the pathology at the correct angle.

Commercially available TAMIS platforms include the SILS Port (Covidien), the TriPort (Olympus KeyMed), and the Gelpoint Path (Applied Medical). One of the main benefits of these platforms is the ability to use standard laparoscopic instruments already familiar to practicing surgeons. For these soft, flexible platforms, prior anal dilation of the anal sphincter is not routinely necessary [8]. In addition, TAMIS procedures can be performed in lithotomy position (Fig. 25.6).

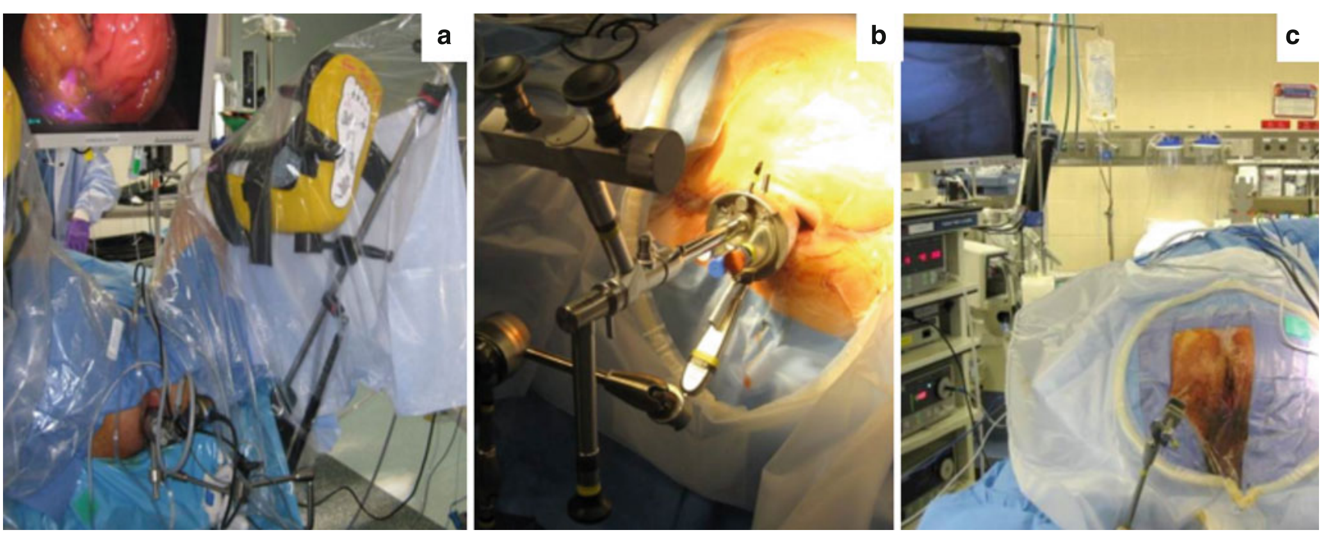

Fig. 25.5 Patient position during transanal endoscopic surgery (TES) using rigid transanal platforms. Positioning in lithotomy position using stirrups during transanal endoscopic excision of a posterior midline rectal tumor (**a**). Right lateral decubitus positioning using a split-leg OR table during transanal endoscopic excision of a right lateral mid-rectal adenoma (**b**). Positioning in prone position using a split-leg table during transanal endoscopic excision of an anterior rectal tumor (**c**)

These platforms may benefit from decreased postoperative discomfort and fecal incontinence although this hasn't been strictly evaluated (Table 25.3). When used, they should be affixed to the skin with a suture to prevent dislodgement. Additional advantages to TAMIS platforms include faster setup in comparison to rigid platforms. Given that flexible TAMIS platforms are new, studies validating its use for rectal pathology are now becoming available showing that it is a safe alternative to well-studied rigid platforms [50].

Procedural Technique

This is a brief overview of the procedural steps, which will be described in the next chapters in more detail. Following platform setup, rectal distention and visualization, the rectal lesion is first scored circumferentially using electrocautery to delineate 0.5–1 cm dissection margins depending on the specific pathology (Fig. 25.7a). Submucosal or full-thickness rectal dissection is then performed using a monopolar and/or bipolar cautery to minimize bleeding during dissection through the rectal wall (Fig. 25.7b, c). Stay sutures can facilitate orientation prior to specimen removal. Following full-thickness resection of the lesion, full-thickness rectal wall defects are typically closed with sutures (Fig. 25.7d). For TEM, specialized curved needle drivers are available to facilitate closure. Other specialized suturing devices are available. Automated suturing devices and auto-locking sutures, in combination with clips and bullets, greatly facilitate suture closure given the limited operative space and avoid intrarectal knot-tying which can be very challenging. When bleeding is encountered, it can usually be controlled using monopolar or bipolar energy, although laparoscopic clips and sutures can also be used.

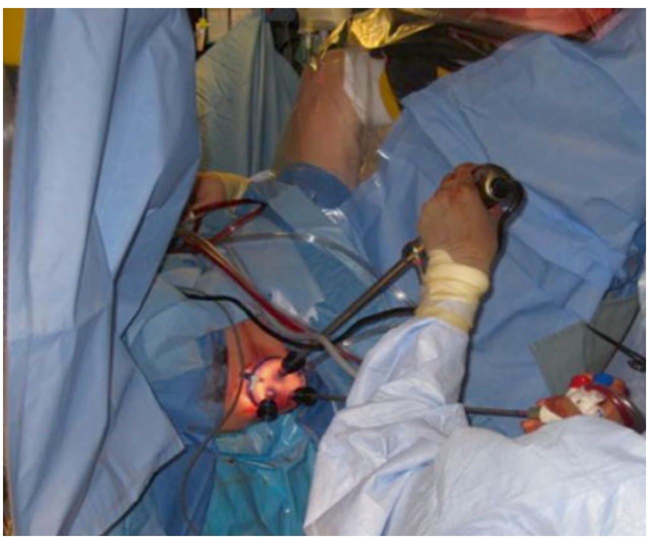

Fig. 25.6 Transanal minimally invasive surgery (TAMIS) procedure performed in lithotomy position

Postoperative Care and Complications

Despite significant variations in technique and perioperative protocols, most surgeons recommend overnight observation in the hospital, especially when full-thickness rectal resection has been performed. Patients can be safely discharged home on the same day if limited resection was performed with no peritoneal entry. Diet can be advanced in standard fashion. Stool softeners are useful to prevent constipation. If antibiotics are given postoperatively, they should be discontinued within 24 h unless additional infectious considerations are present. The necessity of endoscopic surveillance and any additional imaging is specific to the pathology and risk of recurrence.

The experience with TES has been steadily rising over the last decade showing great safety and efficacy for a variety of indications. Complications from TES are less frequent than their open counterpart and, however, are still prevalent (Table 25.4).

Early postoperative complications common to colon and rectal surgery include urinary retention and fecal incontinence. The rate of urinary retention for TES is generally between 5 and 10 % [9, 51, 52]. The rate of postoperative fecal incontinence or soiling with TEM is up to 4 % transient [53]. Flexible platforms appear less traumatic to the sphincter and likely have no significant impact on continence [50].

Table 25.3 Comparison of transanal endoscopic surgery (TES) platforms

Platform name	Type	Radius	Length	Number of working ports	Optics	Requires specialized equipment
TEM (Richard Wolf)	Rigid	40 mm	12–13.7 and 20 cm	3	3D stereoscope	Yes
TEO (KARL STORZ)	Rigid	40 mm	7.5, 15 (the 20 cm is not available in the United States)	3	Telescope	Yes
SILS (Covidien)	Flexible	20 mm	12 and 15 mm	2	Laparoscope	No
Gelpoint Path (Applied Medical)	Flexible	40 mm	4.5 cm	2	Laparoscope	No
Triport+ (Olympus)	Flexible	48 mm	12.5 cm	3	Laparoscope	No

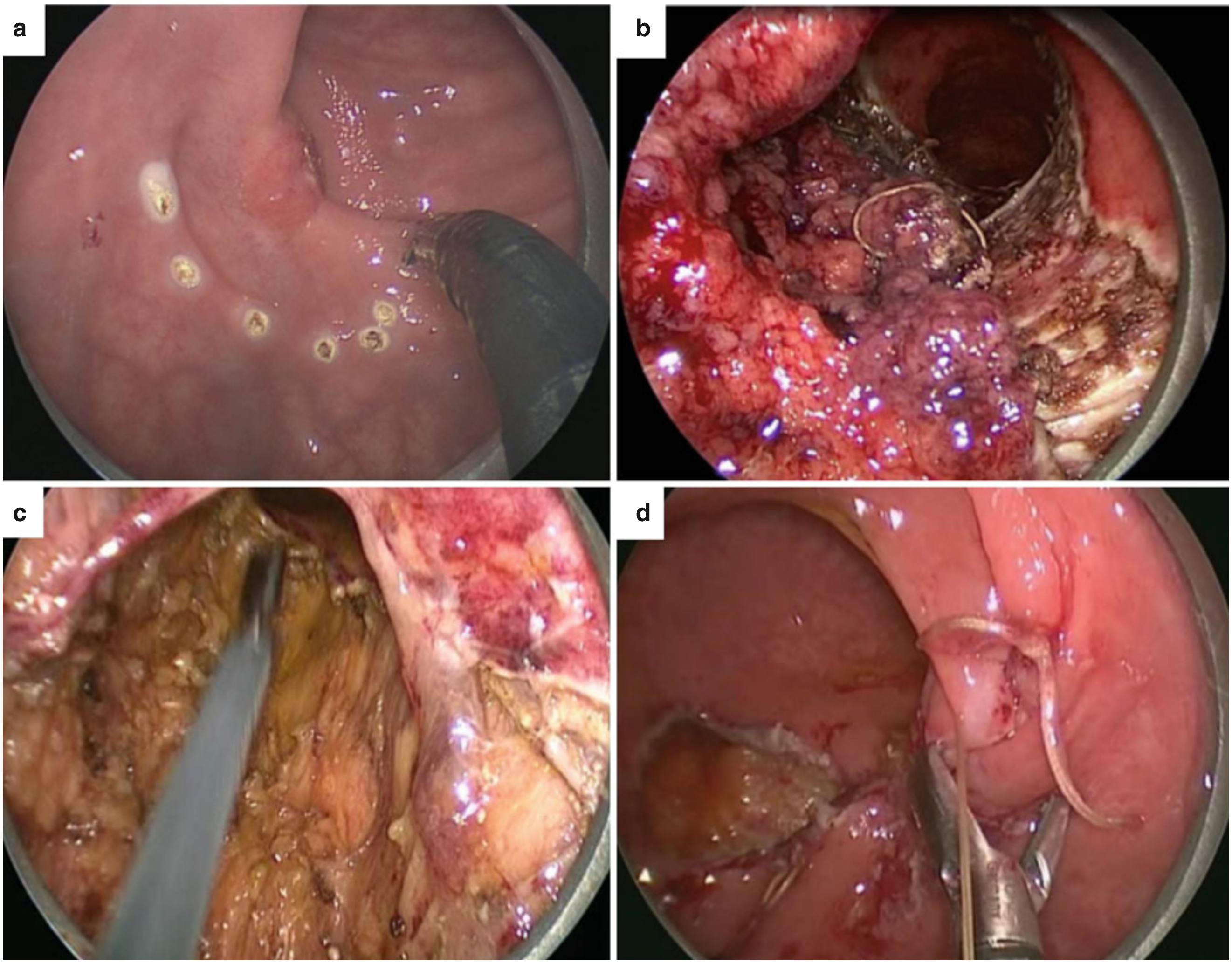

Fig. 25.7 Transanal endoscopic surgery (TES) procedural steps. The lesion is marked circumferentially margins using cautery in order to achieve negative margins (**a**). Submucosal resection of a giant carpeting villous adenoma (**b**). Full-thickness resection of a large villous adenoma with high-grade dysplasia (**c**). Suture closure of the full-thickness rectal wall defect following TES excision of a rectal cancer (**d**)

Table 25.4 Transanal endoscopic surgery (TES) complications

Complex peritoneal entry
Urinary retention
Fecal incontinence
Major bleeding
Suture line dehiscence/anastomotic leak
Perirectal, pelvic abscess
Adjacent organ injury (urethra, prostate, vagina, bladder, bowel)
Fistula (rectovaginal, rectourethral)
Stricture

Unplanned peritoneal entry has been a subject of specific study due to concern of intraperitoneal organ injury and peritonitis. The influence of peritoneal entry on the long- and short-term outcomes of TES surgery has been evaluated extensively. Peritoneal entry is associated with longer operative time and longer hospital stay [54, 55]. Oncologic outcomes to date appear to be unaffected. In early TES experience, unplanned peritoneal entry was considered a complication leading to transabdominal conversion; however, the peritoneum can often be repaired endoscopically without additional morbidity [56]. Patients with peritoneal entry should be monitored in the hospital overnight with serial abdominal exams. Expectedly, this occurs more often with anterior rectal resections due to the closer proximity of the peritoneal reflection.

When large lesions are removed, and suture line dehiscence is a concern, authors have prescribed a variety of practices. No optimal pathway has yet been suggested; however, in general, most suture line disruptions can be managed expectantly, and suture line leaks can be managed with repeat TES suture repair. In severe cases, fecal diversion may be necessary. A large Italian study by Geurrieri et al. in 2006 evaluated the results of 588 patients with rectal adenoma who underwent TEM [57]. Of the study group, only three intraoperative complications (0.5 %) occurred. The most common complication is suture line dehiscence – but in a majority of cases, this can be treated conservatively.

Major bleeding is rare and for most studies is reported to be less than 4 % [12, 49]. Not surprisingly, Kreissler-Haag et al. reported increased bleeding of lesions on the lateral aspect of the rectum consistent with known anatomic blood supply from the lateral stalks [58].

Given the initial desire for a minimally invasive procedure, one must be mindful when conversion to a standard transabdominal operation is necessary. This can include inability to complete the procedure technically, inability to close the rectal defect, unexpected pathology, and concern for an intra-abdominal injury such as to the small bowel. The conversion rate to an open procedure certainly varies depending on the location and character of the particular lesion as well as the experience of the surgeon. It is more likely to occur in the proximal rectum and distal sigmoid or if the lesion is circumferential [13]. In current series the rate of conversion to a transabdominal procedure is approximately 0–5.3 % [13, 52, 53, 59].

Summary

The value of TES continues to expand as minimally invasive techniques and equipment improve. A variety of rectal and colorectal pathology has been successfully treated with TES owing to superior visualization and better equipment. Further training and research will elucidate the complete scope of this technique as it continues to grow into an important niche in colon and rectal surgery.

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Transanal Endoscopic Microsurgery (TEM)

26

Lee L. Swanstrom and Eran Shlomovitz

Introduction

The transanal endoscopic microsurgery (TEM) technique, first described by Buess nearly three decades ago, has been increasingly adopted by colorectal and minimally invasive surgeons, who are progressively incorporating this minimally invasive approach into their practice. There are currently two main platforms for performing TEM: The Richard Wolf system (Richard Wolf GmbH, Knittlingen, Germany) and the Karl Storz (KARL STORZ GmbH, Tuttlingen, Germany) transanal endoscopic operation (TEO) system [1]. These systems were developed prior to the mainstream adaptation of laparoscopy into general surgery, in order to facilitate exposure and resection of mid and upper rectal lesions not amenable to routine transrectal techniques. Over time, modifications of the equipment have been introduced to incorporate some of the devices and lessons learned from laparoscopic surgery. This chapter will review the technique of transanal endoscopic microsurgery in detail. Additionally, indications, patient preparation, and equipment setup will be briefly reviewed.

Background

The best candidates for a TEM approach are those with an endoscopically unresectable benign lesion or with carcinoma in situ (T0-1; N-0) [2]. Full or submucosal resections have been described up to 24 cm from the anal verge. Deeper lesions, SM 2, SM 3, or more, or those having lymphovascular invasion have an increased risk of nodal metastases [3]. These patients must be carefully studied and counseled regarding their option: radical resection, TEM and observation or neoadjuvant chemoradiation, and TEM [4–6]. A thorough preoperative evaluation is performed using endoscopic ultrasound or MRI. Other indications for the use of TEM that have been reported include fistula closure [7, 8], transanal specimen retrieval [9], sleeve resection for prolapse [10], and gateway to transrectal procedures [11, 12].

Patient Preparation

Patients are typically referred for TEM after having undergone a flexible diagnostic endoscopy, as well as perhaps a biopsy or partial resection of the lesion. The documentation of the prior procedure should be carefully reviewed. If required, the physician who will ultimately perform the surgery should perform a repeat endoscopy. The size, location (i.e., anterior, posterior, or lateral walls), and distance from the anal verge should all be carefully assessed in order to determine the appropriateness of transanal resections and to facilitate proper patient positioning on the day of the procedure. A rigid sigmoidoscope may also be used to facilitate more accurate estimation of the distance from the anal verge [13], particularly in cases where tortuosity of the rectum makes accurate estimation using a flexible endoscope difficult.

Once deemed appropriate for transanal resection, patients are asked to start a low-fiber diet for a period of 1 week preceding their TEM procedure. Patients are generally given a full bowel prep prior to their procedure. In our experience, if patients are solely given rectal enemas, the downstream movement of fecal material to the surgical site may occasionally disrupt the procedure. Patients may also be given an optional on-table, iodine-based antiseptic enema prior to the start of the procedure or as a local tumerocidal agent following resection. Finally, patients are given standard preoperative antibiotics and DVT prophylaxis prior to the start of the procedure.

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_26. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_26, © Springer Science+Business Media New York 2015

Room Setup and Positioning

It is essential that the operating surgeon be involved with patient positioning, and familiar with the rather complex equipment setup. Inappropriate patient positioning or equipment malfunctions may significantly increase the length and difficulty of the procedure or result in complications. Adequate training and familiarization of the operating room (OR) staff with the equipment and procedure will prove invaluable during these sometimes challenging transanal procedures.

Patient positioning is predominantly dictated by the location of the lesion to be resected and is aimed to place the lesion as close as possible to the 6 o'clock position – which is the easiest to work from.

Anterior wall or anterolateral rectal lesions are therefore best done with the patient positioned in the prone position when possible. The patient's legs should be placed in the jackknife configuration, bringing the perineum to the table's edge, thus facilitating a more ergonomic procedure. The knees are supported on padded leg supports and are adequately secured. Lesions located on the posterior wall of the rectal lumen are best approached with the patient positioned in lithotomy, thus placing the lesions as close as possible to the dependent position. As stated previously, the patient's legs must be secured and appropriately padded in stirrups. The relatively prolonged operative time of transanal procedures makes efforts to avoid iatrogenic neuropathies of particular importance [14].

Patients with lesions on the lateral rectal wall can be placed in lithotomy, which may be a preferred ergonomic position compared to the prone jackknife or high lithotomy position. In general, however, it might not be necessary to use the lateral decubitus position.

Finally, in the case of circumferential lesions, the patient is typically positioned in the supine, high lithotomy position. Apart from the relative ease and ergonomics of positioning patients in the supine position, it would also serve to reduce any descent of small bowel loops into the surgical field in the not infrequent case of an intraperitoneal perforation during the procedure, thus facilitating easier closure. Occasionally, extensive lesions may require repositioning of the patient during the procedure.

Operative Platform Setup and Instrumentation

Holding System

A "U"-shaped articulating holding system is utilized (see Fig. 26.1). The long vertical bar of the holding system is secured firmly to a standard operating table's rail via a socket. Two rigid right angles in the holding arm allow attachment to the proctoscope from the bottom, thus minimizing interference during the procedure. The holding system includes enough freedom, thus enabling flexible positioning of the operating proctoscope. All five joint functions can be fixed through a single mechanical central clamp.

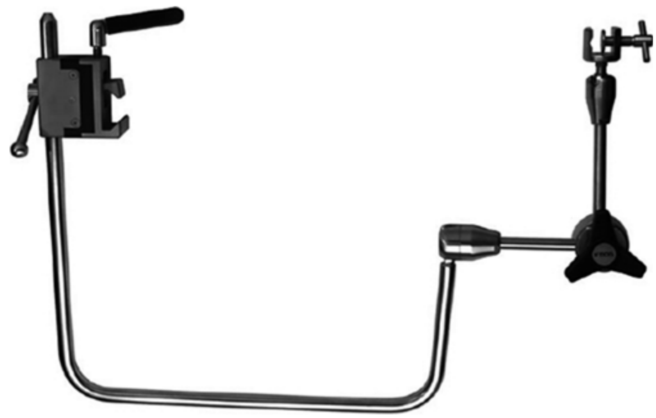

Fig. 26.1 U-shaped articulating holding system

Operative Proctoscope

The operating proctoscope is available in a standard 4 cm diameter. A variety of lengths are available (i.e., 7.5, 15, and 20 cm), which are typically selected depending on lesion location. The tip of the proctoscope is either straight or beveled and is introduced into the rectum using an appropriately sized obturator. The handle can then be secured to the holding system. The working faceplate of the device (see Fig. 26.2) contains the attachment for the telescope and three working channels. These include two smaller channels for 5 mm instruments and one larger channel that can accommodate up to 12 mm instruments. If needed, a stapler can then be introduced through the large working channel. Automatic sealing valves are used to prevent the loss of insufflation during the procedure and instrument exchanges. The proctoscope also has additional connectors for CO_2 insufflations and evacuation. High flow CO_2 insufflation through the proctoscope is initiated at 8 mmHg and can be increased up to 16 mmHg if required.

Optics

There are two options for imaging with the TEM. The original concept utilized a binocular with 30-degree optics (see Fig. 26.3). Visualization is through an attached eyepiece, and the binocular format gives a 3-D view for the surgeon, though not for the assistants. The binocular telescope can also be substituted for a 10 mm laparoscope with a corresponding sheath for rinsing and insufflation thus permitting on-screen visualization similar to laparoscopy [16]. The telescope is inserted through the appropriate optic port and spans the entire length of the proctoscope. The lens can be cleaned intraoperatively by instilling irrigation fluid through a Luer-Lok connector.

Fig. 26.2 Disposable working faceplate – the silicone sealing insert with the three channels covered with sealing caps is attached to the metallic faceplate

Operating Instruments

A variety of long operating instruments are available for use with the transanal operating platform (see Fig. 26.4). These include various 5 mm forceps and scissors with either straight or offset downward tips. The instruments are available in both 36 and 43 cm working lengths and are equipped with interchangeable handles with or without a connector pin for unipolar coagulation. Various double-curved or straight cautery and suction/cautery devices are also available. The available 5 mm ports also allow for the use of standard needle drivers and energy devices. The larger 12 mm port allows for the use of a stapling device and a 10 mm clip applier.

Lesion excision is commonly performed with a monopolar cautery device. Routine laparoscopic ultrasonic shears or electrothermal bipolar vessel sealing systems may also be used if preferred by the operating surgeon.

Partial-Thickness Excision

Partial thickness (i.e., submucosal excision) may be utilized in the setting of benign disease as an alternative to a full-thickness resection. This may be particularly

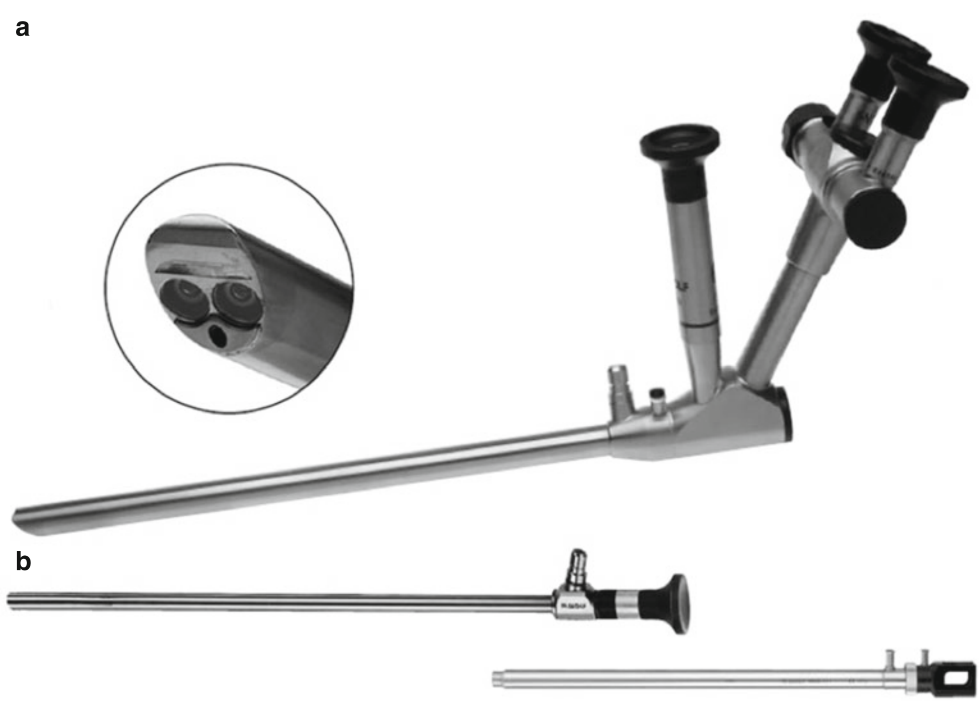

Fig. 26.3 *Optics* – (**a**) 30° binocular, 3D stereoscopic telescope with adjustable eyepiece. (**b**) 10 mm angled laparoscope with a corresponding sheath

advantageous inlocations where full-thickness excision may be associated with increased risk of perforation or morbidity, or where healing complications are of concern [15]. These locations include: (1) the anterior proximal rectum where intraperitoneal perforation is particularly possible, although it does not increase morbidity [16]; (2) the anterior lower rectum in females, due to the increased risk of vaginal injury and a rectovaginal fistula; and (3) the very distal rectum in order to limit the risk of damaging the underlying sphincter mechanism, particularly in females.

Importantly, submucosal transanal excision should not be performed in the setting of a rectal malignancy or a malignant polyp, due to the risk of incomplete resection and increased local recurrence rates. It is, however, particularly suitable in the setting of large, benign, carpet-like sessile lesions [17] that may be difficult to resect in a full-thickness fashion, due to the risk of luminal stenosis or a difficult closure under tension.

Due to the risk of unexpected malignancy on final pathology, partial-thickness excision should be reserved for cases in which the likelihood of malignancy is very low. Such cases include biopsy-proven benign lesions with no visually concerning features such as ulceration and no evidence of submucosal invasion on endorectal ultrasound or other imaging. However, when an occult malignancy is identified on final pathology, the options for a full-thickness TEM resection or routine transabdominal resection remain, given that the TEM planes are essentially undisrupted.

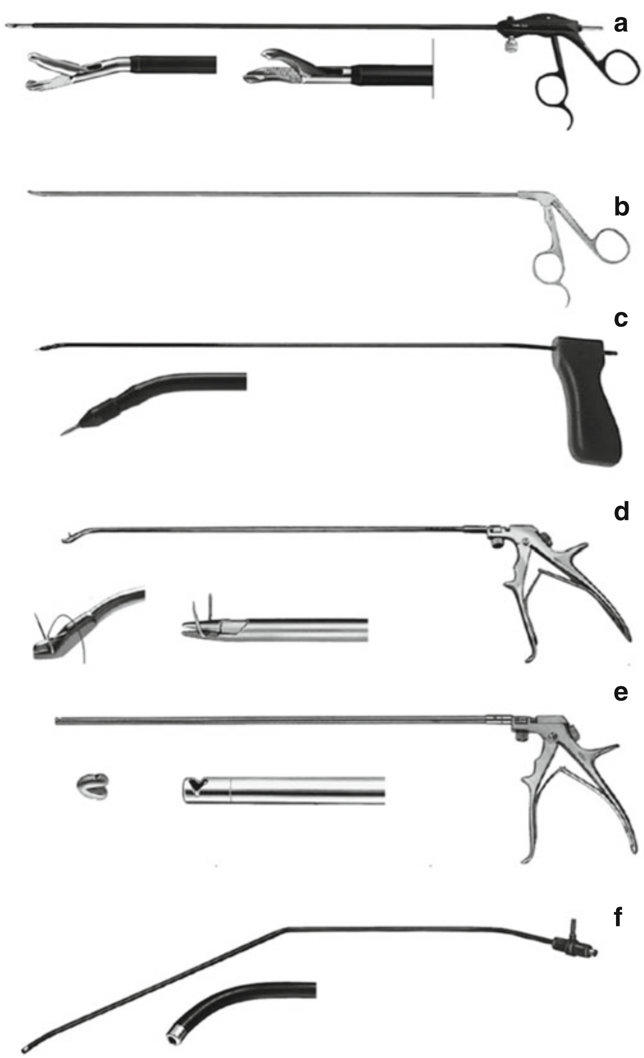

Fig. 26.4 *Operating instruments* – (**a**) grasping forceps with connection for monopolar cautery, angled and non-angled grasping tips are seen; (**b**) scissors; (**c**) needle tip monopolar knife; (**d**) needle holder, angled and non-angled tips are seen; (**e**) suture clip forceps, the silver suture clip is seen next to an enlarged image of the forceps tip; (**f**) angled coagulation/suction tube

Operative Steps (Table 26.1)

Establishing Access and Pneumorectum

The anus is dilated with three fingers prior to the insertion of the TEM platform. The bullitt obturator is locked into the proctoscope and well lubricated. It is inserted *per anus* as far as possible and the obturator removed. A faceplate with an insufflation and light cord attachment is used to identify the lesion to be excised and reexamine it to ensure its amenability to TEM excision. The proctoscope can then be attached to the table-mounted arm and the multiport faceplate attached. The bevel of the TEM cannula should be oriented to center on the lesion as much as possible.

Marking

One centimeter margins are marked circumferentially around the lesion using electrocautery on a "soft coag" setting (see Fig. 26.5, Video 26.1). A lifting solution consisting of a mix of saline, methylene blue, or indigo carmine with or without the addition of epinephrine is then injected into the submucosal space (see Video 26.2). Accurate injection into the submucosal space is crucial in order to obtain an

Table 26.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Establishing access and pneumorectum	2
2. Marking	3
3. Dissection and excision	6
4. Removal of specimen	2
5. Closure	8

Fig. 26.5 A resection margin of 1 cm is marked around the lesion using electrocautery (From the Oregon Clinic)

Fig. 26.6 Dissection is performed in the submucosal plane (From the Oregon Clinic)

adequate lift of the mucosal lesion, thus facilitating submucosal dissection. To allow for adequate lift, the injection may be started as the mucosa is punctured. This may improve the odds of infiltration of the lift solution at the proper submucosal space, as opposed to at the deeper layers. The quality of the lift should then be assessed, as non-lifting segments of the lesion may imply areas of deeper invasion and indicate the need of a full-thickness resection. Prior biopsies or tattooing of the lesion can result in a submucosal reaction, which may also manifest in a non-lifting segment and should be taken into consideration. For lesions oriented on the far side of a fold or very tangential to the scope, it may be helpful to first inject and lift the proximal margin in order to tilt it toward the endoscope.

Dissection and Excision

Dissection and resection of the lesion begins by circumferentially incising the mucosa along the marked margins – usually starting with the proximal portion first if at all possible. A submucosal plane is established, and the leading edge of the segment that is to be resected is grasped and elevated away from the underlying circular muscle layer (see Fig. 26.6). This traction facilitates better delineation of the correct dissection plane in the deep submucosa along the circular muscle layer. The submucosal dissection then proceeds proximally (see Video 26.3).

Removal of Specimen

Following the resection, the specimen is removed and must be mounted appropriately on a cork or wax board and submitted for pathologic examination (see Fig. 26.7).

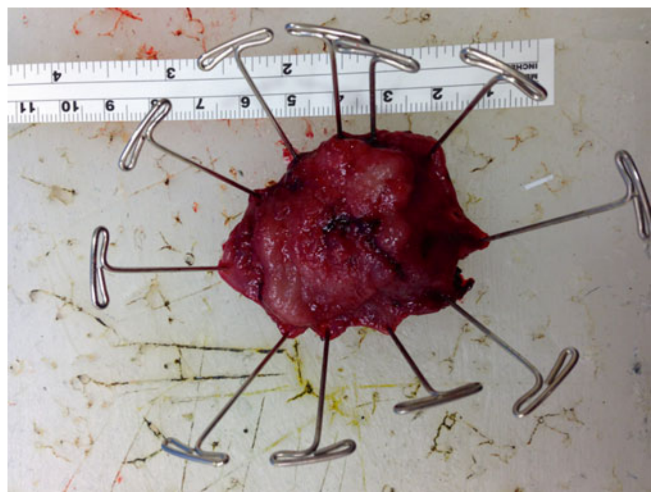

Fig. 26.7 Mounting of specimen for pathologic examination

Closure

Once the lesion has been excised, the site is inspected for bleeding or areas of full-thickness resection. A yellow color may be seen at the defect related to small amount of fat in the submucosal plane. This does not necessarily indicate a full-thickness perforation. Areas of full-thickness excision can be sutured closed. Areas of mucosal resection may be closed or left open at the surgeons' discretion and according to the size of the defect and the perceived risk of bleeding.

Full-Thickness Excision

Full-thickness resection is the technique most commonly utilized during the TEM procedure and is applied for all known or suspected malignant lesions. In fact, full-thickness excision can also be utilized for a benign lesion and may obviate the need for further excision if an occult malignancy is identified on final pathology of a presumed benign lesion. It has been well documented that resections with entry into and closure of the peritoneum are acceptable and well tolerated with good endoluminal closure techniques [18].

Patient positioning and placement of the TEM platform is performed the same way as a partial-thickness resection. If TEM is performed subsequent to a prior partial excision or polypectomy, it may be difficult to localize the residual lesion or scar. In such cases, flexible endoscopy with chromoendoscopy or narrowband imaging and retroflexion prior to positioning the TEM platform may prove useful.

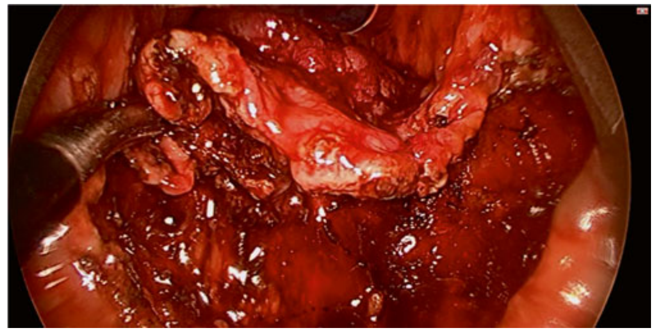

Fig. 26.8 The leading edge of the resection margin is retracted upward and dissection progresses from distal to proximal

Operative Steps

Marking

Even greater emphasis should be placed on obtaining a 1 cm margin of normal tissue. Resection margins are marked circumferentially around the lesion using electrocautery with a "soft coag" setting. A lifting solution is not needed in cases of a full-thickness excision.

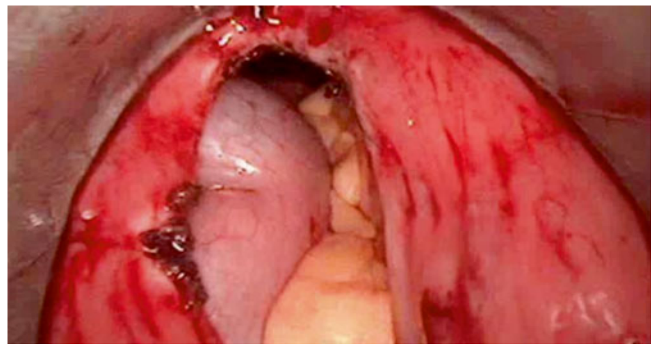

Fig. 26.9 Intraperitoneal full-thickness resection. Intraperitoneal organs are clearly seen. Trendelenburg position can help prevent the small bowel from entering the rectal lumen and facilitates completion of the dissection

Dissection and Excision

Dissection again begins with incising the mucosa along the marked margins. It is often helpful to start at the proximal margin to avoid later undercutting of the proximal bowel. The chosen depth of dissection may vary from the superficial perirectal fat in cases of benign lesions to deeper, full-thickness excision of the perirectal fat down to the TME plane in cases of malignant or otherwise strongly suspicious lesions (see Video 26.4). This can result in the addition of peri-lesion mesenteric nodes to improve staging and possibly treatment. If the lesion is located anteriorly, the dissection should be performed down to the prostatic capsule in males and the vaginal septum in females. Special care should be given to anterior dissections in females due to the risk of a rectovaginal fistula. Gentle, blunt dissection should be used in the rectovaginal septum, with limitation of the use of electrocautery. The operator's finger, or probe, may be placed in the vagina to facilitate accurate dissection. If an injury to the vagina is recognized intraoperatively, it should be sutured closed. The overlying rectal defect should be separately closed and the suture lines staggered to prevent the two suture lines from sitting one on top of the other. In a manner similar to partial-thickness resection, the dissection progresses from distal to proximal (see Fig. 26.8). In the superior rectum, the dissection may enter the intraperitoneal space. Visualization may then become somewhat more difficult due to the loss of pneumorectum. Placing the patient in the Trendelenburg position can help prevent the small bowel from entering the rectal lumen and facilitates completion of the dissection (see Fig. 26.9). Advancing the proctoscope to overlie the excision site will hold the wall open and allow suture repair.

Meticulous attention to hemostasis should be paid throughout all dissections, as bleeding can rapidly obscure visualization and obscure tissue planes. A variety of instruments can be used for hemostasis, including the specially designed needle cautery for the TEM platform, as well as "off the shelf" laparoscopic equipment (e.g., harmonic scalpel).

Removal of Specimen

Once excision is completed (see Fig. 26.10), the specimen is removed and oriented appropriately on a corkboard for pathologic analysis.

Closure

Following resection, a transverse running suture is used in order to prevent stenosis. A 2-0 or 3-0 absorbable suture is typically used. Suturing can be performed with specially

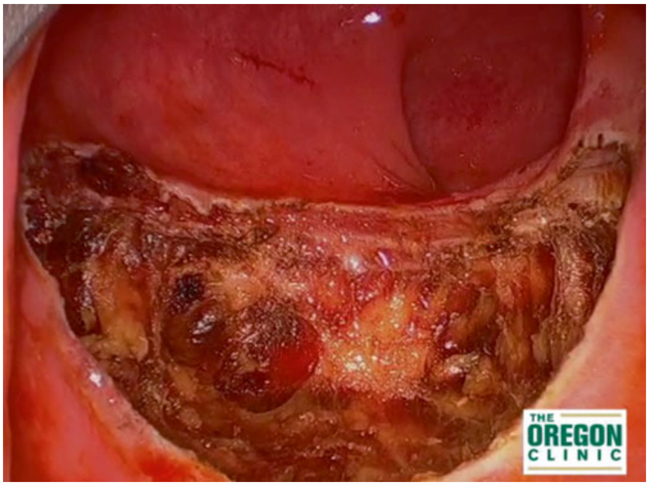

Fig. 26.10 Endoluminal view following removal of the full-thickness resection specimen. Some discoloration of the perirectal fat is due to the use of iodine solution as a local tumerocidal agent following resection (From the Oregon Clinic)

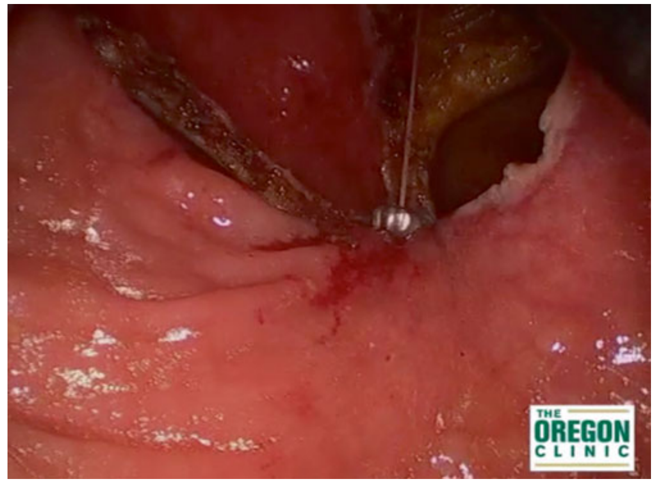

Fig. 26.12 A small silver clip is placed to anchor the suture in place negating the need to difficult intraluminal knot tying (From the Oregon Clinic)

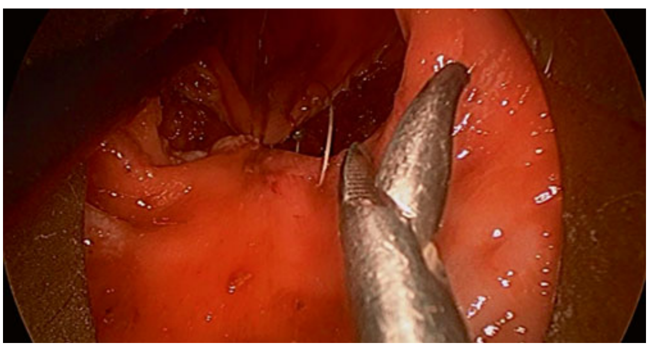

Fig. 26.11 A suture is first placed in the mid part of the incision to align the closure and relieve tension on the incision

Fig. 26.13 The closure is inspected to ensure adequate residual luminal diameter (From the Oregon Clinic)

designed angled TEM needle drivers, standard laparoscopic drivers, or even laparoscopic suturing devices, such as the Endo stitch™ suturing device (Covidien surgical, Mansfield, MA). A stay suture is placed in the mid part of the incision to align the closure and relieve tension on the incision as an initial step (see Fig. 26.11 and Video 26.5). Following this, a running transverse suture is continued laterally on both sides. If needed, CO_2 insufflation pressures can be reduced to improve luminal compliance and facilitate easier approximation of the edges. A small silver clip (see Fig. 26.12) is applied at both ends of the suture, alleviating the need for cumbersome intraluminal knot tying. Surgeons who are right handed may find it easier to place the sutures from proximal to distal on the right half of the incision (see Video 26.6). In contrast, throwing the sutures from distal to proximal more easily closes the left side (see Video 26.7). Meticulous closure technique is critical when the full-thickness excision has extended to the intraperitoneal space. At the conclusion of the procedure, the closure must be inspected to ensure adequate residual diameter (see Fig. 26.13). This is particularly important in cases of large or circumferential lesions where luminal diameter can be compromised following closure.

Sleeve Resection

Sleeve resection utilizing the TEM platform represents an additional layer of technical complexity extending beyond a "routine" full-thickness resection. The limitations of working within the confined space of the rectum, combined with poor instrument triangulation and limited visualization, present a significant technical challenge. A surgeon interested in performing these more advanced procedures should be facile and experienced with the use of the TEM platform for non-circumferential full-thickness resections. Furthermore, comfort with advanced laparoscopic skills and particularly suturing cannot be overemphasized, as the need for conversion to a laparoscopic or perhaps even an open approach is increased. The surgical team as a whole, particularly the OR nursing and support staff, should be comfortable with the use and troubleshooting of the complex TEM platform. Laparoscopic and/or laparotomy equipment should be available to allow for conversion if deemed necessary.

Rectal sleeve resection through the TEM platform is a viable technique for circumferential rectal polyps and has also been advocated for rectovaginal fistulas. Although circumferential rectal polyps are relatively rare, it is more common to have non-circumferential large rectal polyps, such that their excision with a 1 cm margin essentially requires a sleeve-type resection.

Operative Technique

The patient is most commonly placed in the lithotomy position, as it is the easiest to position the patient, as well as the most ergonomic for the surgeon. Occasionally, the patient may have to be repositioned during the procedure for a circumferential sleeve resection. The anus is dilated and the platform is positioned much in the same manner as was previously described. The resection margins, both proximal and distal, are marked with electrocautery. As with other full-thickness resections, a margin of at least 1 cm is maintained from the lesion. Some surgeons may inject the submucosal and deeper perirectal tissues with a diluted epinephrine solution to assist with hemostasis. Furthermore, to facilitate alignment and reanastomosis following the procedure, corresponding points in the proximal and distal colon can be tattooed with methylene blue. The circumferential dissection begins on the proximal resection margin. The rectum is divided by full-thickness dissection perpendicularly to the lumen. To assist with traction and alignment, four stay sutures are placed in the four quadrants along the free edge of the proximal colon. A silver clip is pre-placed at the end of each suture; the needles are then placed in the proximal colon away from the operative field. The full thickness of the rectum is then divided along the distal resection margin. Following this, the resection segment is dissected along the perirectal plane and removed through the anus. The resection bed is carefully examined to ensure that hemostasis is achieved. Reconstructive anastomosis is then performed using a previously placed absorbable suture on the free edge of the proximal rectum. It is vital to ensure that there is no excessive tension on the anastomotic suture line. Prior to performing the anastomosis, the mobility of the proximal segment can be evaluated by applying some tension to the previously placed traction sutures. If needed, the proximal segment can be further mobilized to obtain additional laxity. The anastomosis is created in a running fashion with each suture used to close one quadrant. Special care should be taken that there is no unintentional twisting of the anastomosis. If the proximal and distal segments were tattooed prior to the resection, these may now be used as markers for alignment. As each quadrant is closed, a second silver clip is placed on each of the sutures to secure these in position in lieu of endoluminal knot tying. If the sleeve resection is performed for rectal prolapse, the segment of colon resected should be long enough to have the anastomosis retracting slightly cephalad. Similar to routine full-thickness resections, the anastomosis should be inspected to ensure that adequate luminal diameter is maintained.

Natural Orifice Specimen Extraction

The benefits of the TEM proctoscope in providing a stable transanal operative platform that permits good visualization may be easily adapted for the natural orifice removal of a laparoscopically resected specimen [9]. This is particularly advantageous for low anterior and sigmoid resections, negating the need for a specimen extraction incision. There are numerous advantages of utilizing the TEM platform for this purpose. Namely, the operating proctoscope allows for gentle dilatation of the anus and stability during extraction. Furthermore, it protects the edges of the rectum and decreases the risks of anal canal injury during the extraction.

Operative Technique

In this technique, a standard laparoscopic resection is performed. The distal resection can be stapled in a standard fashion, in which case the stump staple line will be opened when the TEM system is inserted. Alternatively, it is also possible to occlude the distal colon with a temporary device, such as an umbilical tape tied laparoscopically. The colon can then be divided distally with an energy device, and the stump left open to allow for easy introduction of the operating proctoscope. Regardless of the particular method chosen, the TEM rectoscope with the introducer is advanced through the rectal stump (see Fig. 26.14). The colon is grasped and retrieved through the rectoscope with laparoscopic assistance. The anvil of an EEA stapler is introduced through the rectoscope and placed and secured into the proximal margin. If it is a low rectal anastomosis, the proximal bowel can be brought outside the anus and the anvil purse-stringed in by hand before returning it to the abdomen. For higher anastomosis, the anvil can be placed in the peritoneal cavity with a polypropylene suture fixed to the anvil spike. It can be inserted into the proximal colon after cutting the staple line. The resulting colotomy can be restapled to seal it. In very

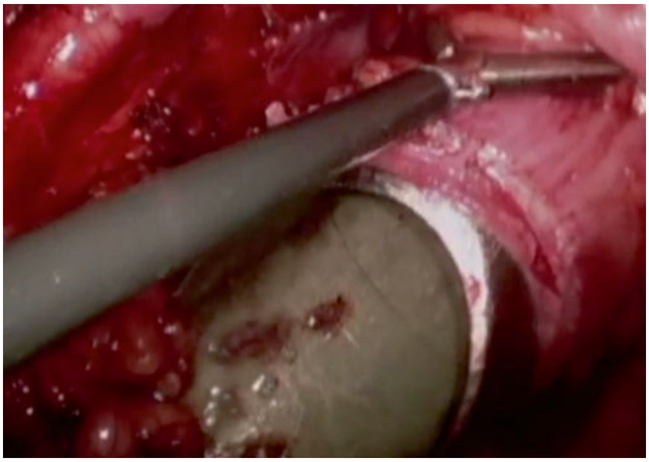

Fig. 26.14 Laparoscopic view during low anterior resection demonstrating the TEM rectoscope being introduced through the rectal stump to facilitate specimen removal

low rectal anastomosis, the rectum may be best stapled with one of the new 5 mm staplers (Cardica, Redwood, CA), which articulate 80° and can therefore transect close to the pelvic floor.

GIA staplers do not cut polypropylene suture; therefore the suture can be retrieved and used to draw the anvil spike through the staple line. The rectoscope is then withdrawn, the stump sealed using a stapler, and the EEA stapler is introduced through the rectum [19]. The anastomosis is then completed using the EEA stapler in a standard fashion.

Summary

TEM provides a versatile platform, which can be used for a variety of transanal procedures. Since its original inception, TEM has diffused rapidly and is increasingly adopted as a mainstream minimally invasive procedure. Comfort with advanced laparoscopic procedures and endoluminal suturing serve as important skills for surgeons seeking to incorporate TEM into their practice. As surgeons become comfortable with the TEM platform and technique, more challenging procedures such as sleeve resections may be tackled. Although the NOTES application of this exciting technology requires some further development prior to becoming a widespread clinical reality, the platform may be presently used to facilitate laparoscopic specimen extractions, thus further limiting patient discomfort and wound complications.

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Transanal Minimally Invasive Surgery (TAMIS)

27

Sergio W. Larach and Harsha V. Polavarapu

Introduction

The surgical approach for rectal neoplasms has come a long way from traditional resection to minimally invasive resections. Historically surgical approaches for rectal neoplasms were radical as described by Jacques Lisfranc, Paul Kraske, and Sir William Ernest Miles in the nineteenth century [1–3]. Because of the morbidity associated with these radical procedures, surgeons started looking for less radical ways to handle rectal neoplasms. This led to the development of transanal endoscopic microsurgery (TEM) platform by Professor Gerhard Buess in 1983 [4]. This platform helped resect the rectal lesions more precisely even in the mid and upper rectum with minimal morbidity. With the advent of laparoscopy in the late 1980s, the incisions were getting smaller while the instrumentation kept getting better. By pushing the limits of laparoscopy, surgeons developed single-incision laparoscopy and all the instrumentation to go with it. Once the surgeons gained skills in single-incision laparoscopy, it was just a matter of time that this skill set and instrumentation was applied to resect rectal neoplasms. The use of the single-port technology to resect rectal neoplasms is known as transanal minimally invasive surgery (TAMIS), developed and first reported by Larach, Albert, and Atallah in 2010 [5].

Despite development of the TEM system for 30 years, it is being used only by a handful of surgeons. High initial cost, complex instrumentation, steep learning curve, and the necessity for specialized training remain significant obstacles for wider adoption [6–8]. TAMIS on the other hand is rapidly gaining popularity owing to its low cost, simple setup, and the use of traditional laparoscopic equipment [9]. TAMIS is a versatile platform, which offers several applications beyond local excision [10]. One of the most important applications for TAMIS beyond local excision is to be able to perform a total mesorectal excision transanally called TAMIS-TME [11, 12]. This is a promising new approach to facilitate distal rectal mobilization and thus represents a new era in rectal cancer surgery. The TAMIS platform has also been used in conjunction with a robotic platform to perform local excision of rectal neoplasms as well as radical proctectomy for rectal cancer [13–16]. This chapter will review the technique of TAMIS and differences to the TEM platform described in the previous chapter.

Background

The TAMIS platform can be used for benign rectal neoplasms and for well-selected T1 cancers with histologically favorable features, where the risk of nodal metastasis is low. The indication for TAMIS may also be broadened to cT0 lesions in patients with rectal cancer after neoadjuvant therapy for the purpose of confirming mural complete pathologic response (ypT0). As indicated in the introduction, TAMIS platform has been used in several nonneoplastic conditions like recto-urethral fistulas, removal of foreign bodies, and completion proctectomy [10]. The use of TAMIS in the bottom-up technique as TAMIS-TME for radical rectal resection is currently investigational.

Patient Preparation

All patients undergoing a TAMIS procedure should undergo adequate preoperative evaluation beginning with colonoscopy to rule out synchronous lesions of the colon. For malignant lesions, complete staging work-up should be performed. Careful office proctoscopy should also be performed to

Electronic supplementary material Supplementary material is available in the online version of this chapter at 10.1007/978-1-4899-7531-7_27. Videos can also be accessed at http://www.springerimages.com/videos/978-1-4899-7530-0.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
DOI 10.1007/978-1-4899-7531-7_27, © Springer Science+Business Media New York 2015

confirm tumor height and exact orientation. Inability to view the lesion in the office owing to more proximal location than thought should prompt one to consider alternative approaches. Patient selection is key for the technical success of this procedure. A lesion that is too proximal can be a higher risk for peritoneal entry with the increased difficulty of a secure closure. Conversely, a lesion that is too low can create technical difficulty during resection by limiting the triangulation of the instruments. This can be avoided by preoperative clinical examination of the lesion by the operating surgeon. Full mechanical bowel preparation and parenteral antibiotics are recommended.

Room Setup and Positioning

High Dorsal Lithotomy

The surgeon and assistant sit and view the monitor in between the patient's legs over the abdomen. The advantages of this positioning are to have access to the abdomen if the surgeon needs to perform a hybrid procedure, easy access to the patient's airway, and easy setup. The majority of lesions, if not all, can be approached this way (see Fig. 27.1).

Prone Jackknife

The surgeon and assistant stand on either side of the patient. Some surgeons favor this position for anterior lesions. One of the major drawbacks of the prone position is the difficulty managing the airway. This also means intubating the patient on the stretcher and then transferring the patient onto the operating room table, which translates into more operating room personnel and longer operating room setup time (see Fig. 27.2).

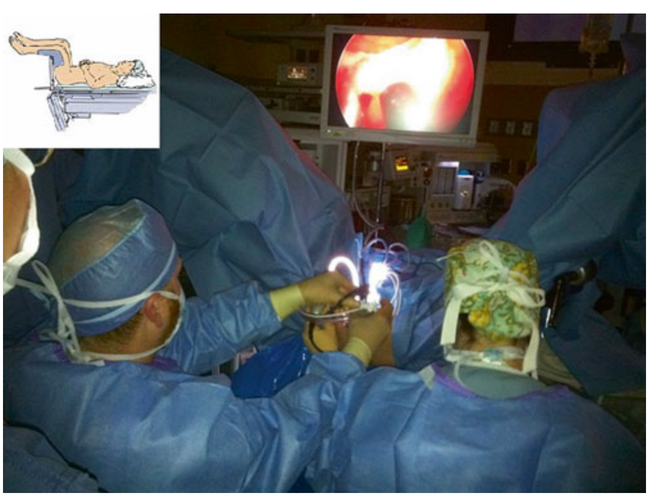

Fig. 27.1 High dorsal lithotomy position with surgeon and assistant sitting and viewing monitor in between the patient's legs

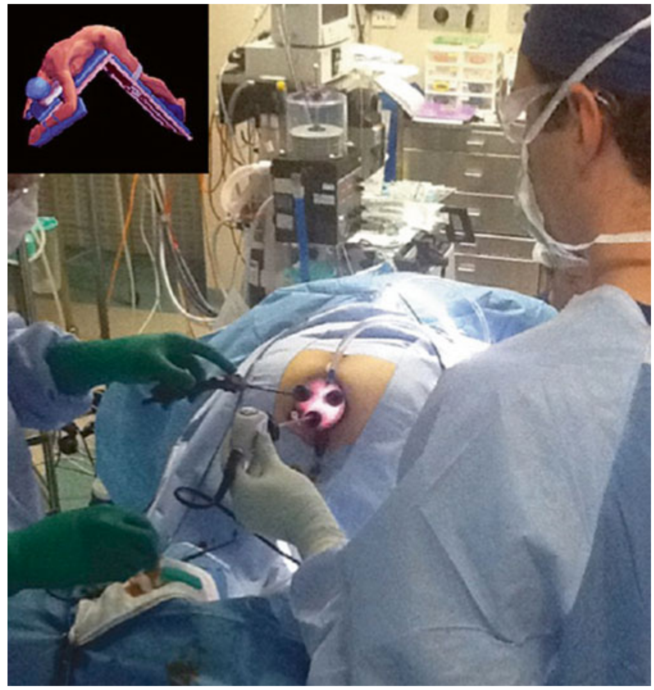

Fig. 27.2 Prone jackknife position with surgeon and assistant standing on either side of the patient

Port Setup and Instrumentation

Port Systems

Platforms approved by the Federal Drug Administration (FDA) for transanal access are the GelPOINT® Path port (Applied Medical, Rancho Santa Margarita, CA) and the SILS™ Port (Covidien, Mansfield, MA). Other access platforms that have been used are TriPort™ (Olympus, Wicklow, Ireland) system, Single-Site Laparoscopy (SSL) Access System (Ethicon Endo-Surgery, Cincinnati, OH), and the poor man's glove port (see Figs. 27.3 and 27.4).

Three working ports are available in the GelPOINT® Path port, one for the camera and two as working ports. Any of the ports can be upsized to a 12 mm port if necessary. The advantage of this setup is that the surgeon has separation of the ports to allow for triangulation of the instruments. If necessary, a fourth port can be accommodated by piercing the gel cap directly.

Three working ports are also available in the SILS™ port. This port is particularly useful in patients with a narrow anal canal. The disadvantages of this platform are increased leakage of the pneumorectum and slippage of the port due to pliability of the used material. The access ports are positioned closer, which can make the triangulation more difficult.

The Olympus TriPort™ platform has three working ports. The top of the access platform can be exchanged to a 4-port

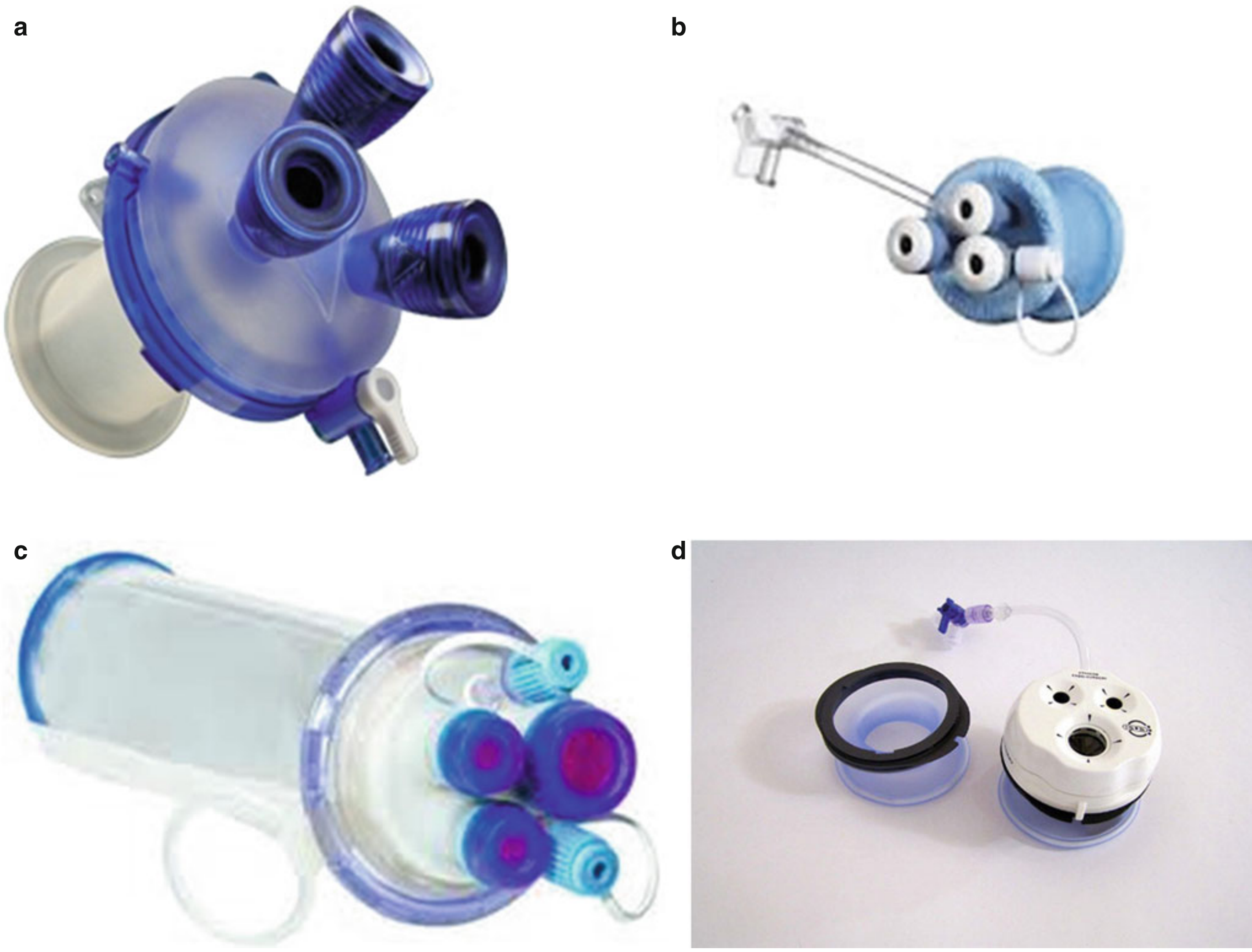

Fig. 27.3 Commercially available TAMIS platforms: SSL access system (**a**), SILS port (**b**), GelPOINT Path (**c**), TriPort (**d**)

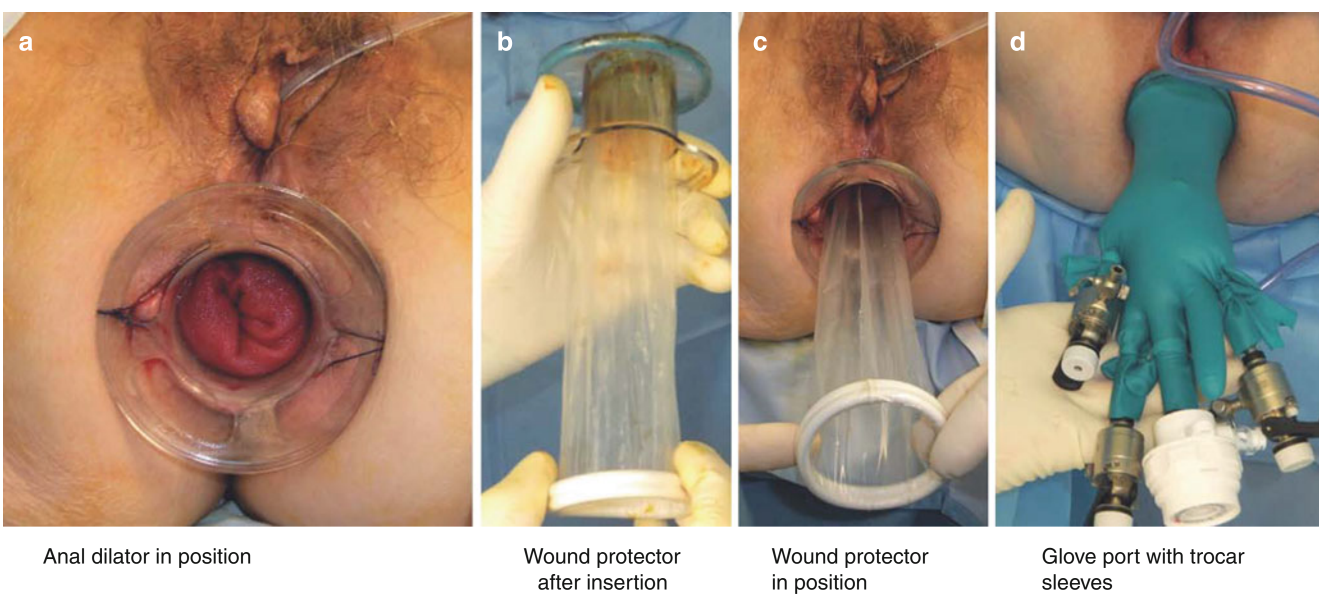

Fig. 27.4 Glove port (**a**), anal dilator in position, (**b**) wound protector after insertion, (**c**) wound protector in position, (**d**) glove port with trocar sleeves

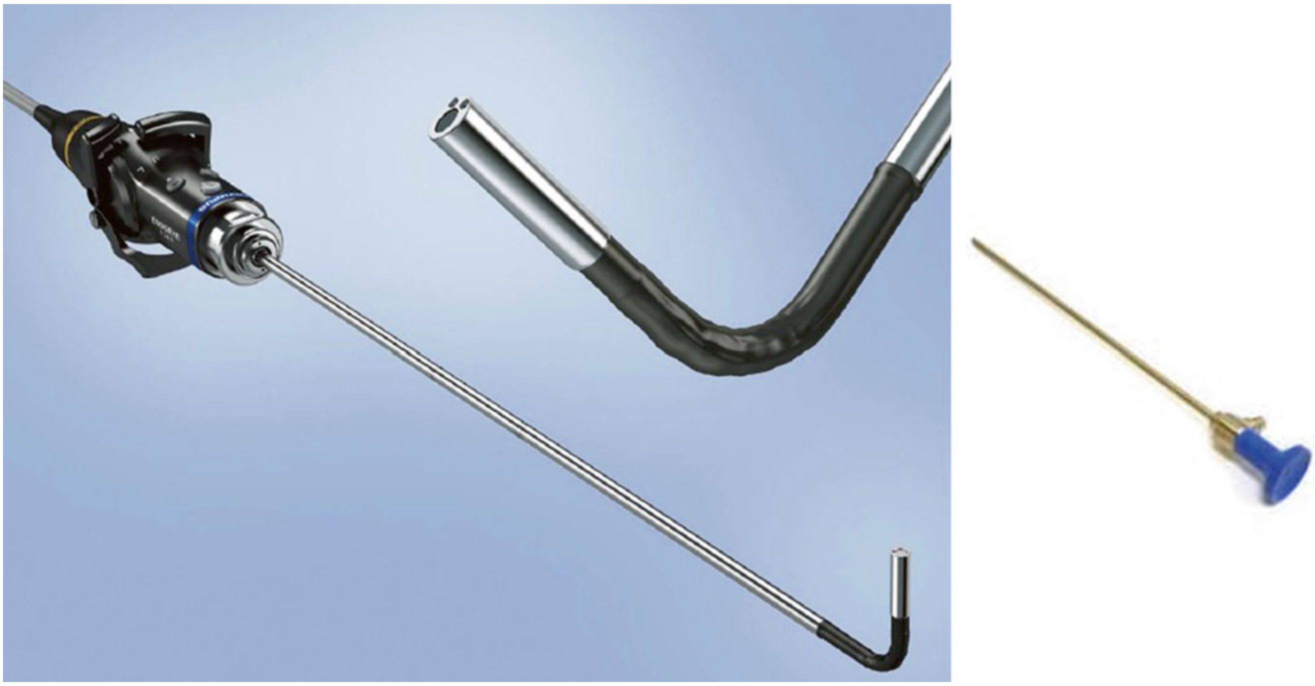

Fig. 27.5 Standard laparoscope and the Olympus EndoEYE

version if an additional port is necessary. The length of the port is adjustable and can be tailored to the length of the patient's anal canal offering a better fit and seal for the pneumorectum.

The Single-Site Laparoscopy (SSL) Access System accommodates two 5 mm instruments and one 15 mm instrument. The seal cap is designed such that the instruments can be directly inserted into the rectum without the need for trocars.

Several authors have successfully reported the poor man's glove technique [17, 18]. A disposable circular anal retractor is secured to the skin, a wound retractor is then placed into the anal retractor, and a surgical glove is placed airtight over the wound retractor. Trocars are inserted through the fingertips of the glove. This port offers a less expensive alternative to all the above platforms. Additional manual support is necessary during each insertion and extraction of instruments, making it a floating platform.

Operating Instruments

A 5 mm camera with an angled tip allows a 360-degree view of the entire circumference of the rectal wall. One of the disadvantages of using standard laparoscopes is that the light cord interferes with the working instruments. Alternatively, a 5 mm flexible tip video laparoscope, EndoEYE™ (Olympus, Wicklow, Ireland) can be used; this is a low-profile system that prevents instrument collision outside as well as inside the rectal lumen (see Fig. 27.5). A standard laparoscopic CO_2 insufflator is used to establish the pneumorectum with pressure set at 7–12 mm of Hg.

One of the working ports is used for a grasper and the other for an energy device. A 5 mm Maryland grasper is used as it provides a strong and precise grip of the specimen. The energy device can be an ultrasonic device and monopolar or bipolar cautery. Bipolar cautery and ultrasonic devices achieve excellent hemostasis but with added costs. Monopolar cautery can be used with a hook, spatula, scissors, or a needle tip, which can be bent. The advantage of using a monopolar cautery is that it can be used inside a 5 mm suction irrigator, which also aids in suctioning smoke. It also allows for a more precise plane of dissection.

Operative Steps (Table 27.1)

Table 27.1 Operative steps

Operative steps	Degree of technical difficulty (scale 1–10)
1. Establishing access and pneumorectum	2
2. Marking	2
3. Dissection and excision	5
4. Removal of specimen	2
5. Closure	7

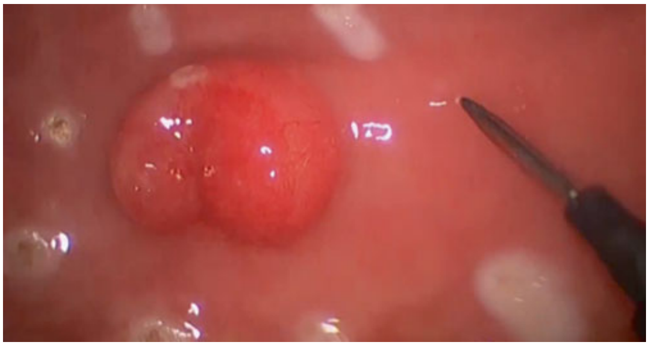

Fig. 27.6 Marking of the target lesion

Fig. 27.7 Defect in the rectum after full thickness excision including perirectal fat

Establishing Access and Pneumorectum

The anal canal should be well lubricated and dilated up to three fingers and the selected access platform should be inserted into the anal canal. The access platform should be then secured to the skin with a suture. Securing the port to the skin is an important step to provide an adequate seal for the pneumorectum and to prevent port slippage (see Video 27.1). The ports are inserted into the access channel. For the GelPOINT® Path port, the ports should be inserted into the Gel cap before securing the cap to the access channel. The handles of the instruments should be in horizontal position, away from each other to minimize instrument collision. Camera and instrument locations are dynamic throughout the procedure; they vary depending on the location of the lesion and area of dissection similar to laparoscopy. Pneumorectum is established using a standard laparoscopic CO_2 insufflator up to a pressure of 7–12 mmHg. This pressure can be increased up to 20 mmHg to achieve adequate distention. At this point, the patient should be under general anesthesia, fully paralyzed without any spontaneous breathing to prevent any bellowing of the rectum. Smoke can be evacuated with short bursts of suction to avoid loss of pneumorectum.

Marking

The lesion should be marked circumferentially using cautery to guide the margins of resection (see Video 27.2). No data currently exist regarding the benefits of 5 mm versus 1 cm margins (see Fig. 27.6).

Dissection and Excision

The preoperative assessment of the lesion will dictate the plane of dissection – submucosal, full thickness, or partial mesorectal excision (Videos 27.3 and 27.4). Handling of the tumor or polyp directly with graspers should be avoided at all costs to limit tumor fragmentation. Normal mucosa surrounding the lesion should be grasped for retraction. Dissection is started at the lower edge of the lesion and continued proximally. Anterior lesions in women should be handled with care to avoid vaginal entry. Excellent hemostasis should be achieved along the way to aid in visualizing the plane of dissection. In the event of bleeding, the camera should be kept in position with the bleeding point in view at all times, using minimal suction to dry up the blood. The surgeon should visualize the bleeding point, get control of the bleeding point using a grasper, and handle the bleeding appropriately.

Removal of Specimen

It is important to remove the specimen in one single piece with adequate margin for optimal oncologic outcomes. For benign lesions, submucosal excision is adequate, and for malignant lesions, in contrast to the historical description of a simple full-thickness incision into perirectal fat, a pyramidal volumetric excision containing an adequate specimen of perirectal fat is recommended as described by Lezoche et al. (see Fig. 27.7) [19].

Closure

If possible, primary closure of the resultant rectal wall defect should be done for all cases. Surgery in a radiated field can result in poor wound healing; surgeons should take this into consideration expecting a delay in wound healing. This can be the most difficult step of the entire procedure; hence, there are several options to accomplish the closure. Intracorporeal knot tying can be done by standard laparoscopic instruments but can be very challenging given the narrow lumen of the rectum (Video 27.5). Alternatively, an Endo Stitch™ device (Covidien, Mansfield, MA) can be used (Video 27.6). The

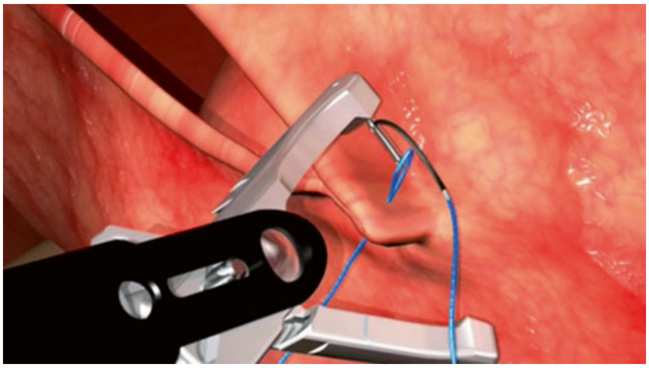

Fig. 27.8 Endo Stitch device with the v-LOCK suture

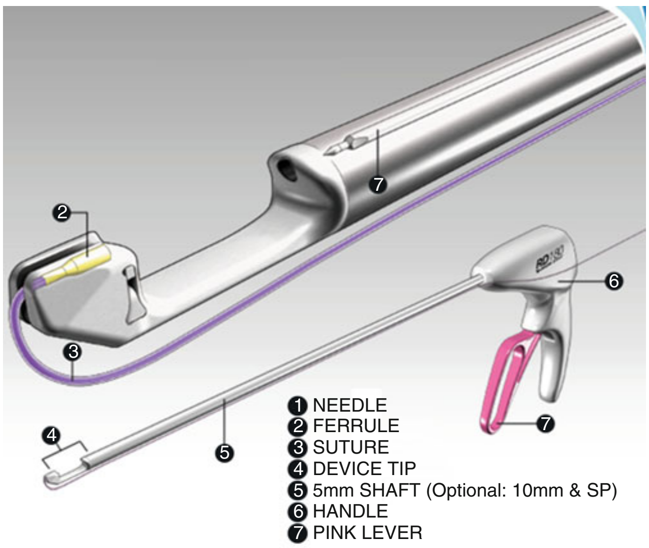

Fig. 27.9 LSI running device and knot pusher

sutures can be regular sutures, V-lock™ sutures or V-lock™ with barbed sutures (Covidien, Mansfield, MA). There is also a Running Device RD180™ (LSI Solutions, Victor, NY) that can be used through a 5 mm port to suture the defect (see Video 27.7). Extracorporeal knot tying and a knot pusher can be used in this scenario as a third option (see Figs. 27.8 and 27.9).

Summary

Dealing with any pathology in the rectum adds additional complexity because of the unique location of the rectum adjacent to vital structures and unique function of the rectum that cannot be replicated or substituted. With technology ever improving and indications ever expanding, familiarity with the TAMIS platform will be an invaluable tool in a surgeon's armamentarium.

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O. Bardakcioglu (ed.), *Advanced Techniques in Minimally Invasive and Robotic Colorectal Surgery*,
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