Techniques in Minimally Invasive Rectal Surgery

Alessio Pigazzi
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Contents

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Chapter 1
Training and Learning Curve in Minimally Invasive Rectal Surgery

Deborah S. Keller and Eric M. Haas

Introduction to Learning Curves in Minimally Invasive Surgery

The learning curve is a graphical demonstration of the number of cases a surgeon must perform to become proficient.

When learning a new procedure, performance is expected to improve with experience, and graphically plotting performance against experience produces a learning curve [1–3]. The concept of a learning curve, where inexperienced clinicians improve with increasing experience, is particularly fitting for minimally invasive surgery, which requires a high degree of special dexterity and technical skills, and learning has potentially dramatic implications [4, 5]. The learning curve is a graphic representation of the individual surgeon's experience performing a procedure versus outcome variables of clinical interest, such as operative time, postoperative complications, and conversion rates [6–9] (Fig. 1.1). A technically demanding technique, such as minimally invasive rectal resection, is often termed as having a "steep learning curve." This term has been described as a misnomer, as complex techniques are more likely to have gradual learning curves, with small improvements in outcome associated with each case, and expertise possible only after significant experience [4].

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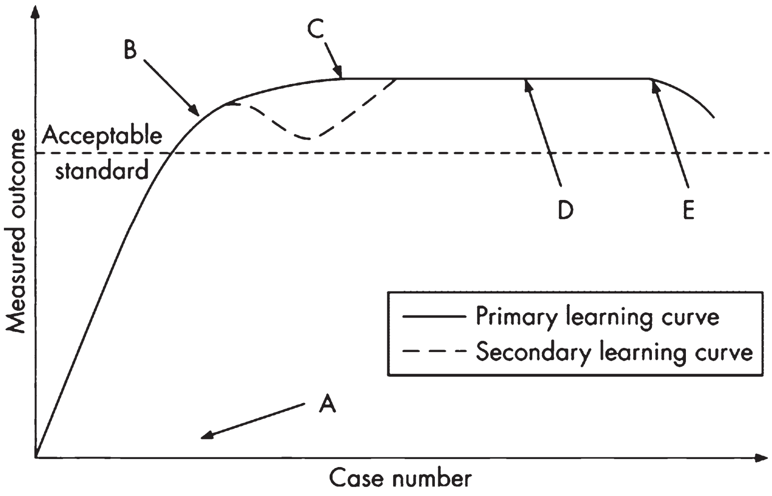

Fig. 1.1 Idealized learning curve

Defining a learning curve for minimally invasive surgery is complex but necessary to identify the number of cases for competence, facilitate more effective training, and integrate minimally invasive rectal surgery into practice [10]. Measuring the learning curve also has benefits for patient safety and surgical education, as teaching is centered on techniques and outcomes [11, 12]. Progress along the learning curve for surgical technique is measured by surgical process and patient outcomes [4]. In minimally invasive surgery, ascent up the learning curve is based on a decline in operating time, intraoperative complications, conversion rate, and length of stay [13]. An initial training period is required for all surgeons to become proficient in these complex procedures by continuous repetition of the tasks [5]. However, the learning curve is individualized and variable, as different biases and laparoscopic experiences of each surgeon limit the generalizability of comparable curves [14].

Creating a Learning Curve

The cumulative summation (CUSUM) method, a practical tool for creating a learning curve, plots a defined outcome variable against the surgeon's experience to define the point where proficiency and independence are reached.

As a surgeon learns a new technique, constructing a learning curve to measure outcomes and estimate their location on the curve is helpful. Most studies describing the learning curve in minimally invasive colorectal surgery fail to properly define the curve, have poor descriptions of mentorship/supervision, and have variable definitions of successfully attaining proficiency [15]. Several statistical methods can be used to create a learning curve, including simple graphs, splitting the data chronologically, and performing a *t* test or chi-squared test, curve fitting, or other model fitting [1, 15, 16]. For continuous variables, such as operative time, the moving average method is useful. For binary outcomes, which may or may not happen, such as conversion and complications, the cumulative summation (CUSUM) method is the most practical tool [14]. CUSUM uses sequential analysis technique to allow a surgeon to judge whether the variation observed in performance is acceptable or outside outcomes expected from random variation [17]. More simply, CUSUM is the running total of differences between the individual data points for a defined outcome variable and the sum of all data points [18]. To plot the CUSUM curve, the outcome of interest is selected and the cases are listed chronologically. Then, CUSUM (SN) is calculated as $SN = \sum (X_i - X_0)$, where X_i is the individual case's value and X_0 is the mean for all cases. After each case, the variable is sequentially added to the cumulative scores for that variable and then plotted graphically [10]. The CUSUM variable is plotted on the *y*-axis against the procedure attempt on the *x*-axis [19]. At acceptable levels of performance, the CUSUM curve is flat, while at unacceptable levels of performance, the curve slopes upward and eventually crosses a decision interval [16]. The surgeon's proficiency can be extrapolated from the graph by the peak or plateau for that outcome variable. This graphical representation allows an individual surgeon training to determine when they can efficiently and effectively perform a certain procedure, as well as facilitating more effective training, and integrating the technique into practice [10].

Differences in Minimally Invasive Colon and Rectal Surgery

The learning curves for minimally invasive colon resections are well defined, as the safety and efficacy was proven in early controlled trials, giving surgeons greater experience than with rectal resections.

Minimally invasive colorectal surgery was introduced in the early 1990s and remains an evolving technique. The safety and feasibility of minimally invasive surgery for colon cancer was proven in early controlled trials [20–26]. With widespread acceptance and utilization, the learning curve for laparoscopic colon resections has been well defined. Previous studies suggested laparoscopic colon resections require approximately 50 cases to gain proficiency, with reports ranging from 30 to 150 cases for independence and improved surgical process and patient outcomes [27–32]. Procedure-specific learning curves are estimated at 70–80 cases for sigmoid colectomy [2], 55 cases for right colectomy, and 62 cases for left colectomy [5].

The comparative effectiveness of laparoscopy for rectal cancer was less clear, as early controlled trials concentrated on the oncologic safety of *colon* cancer [22, 24, 33, 34]. Initial high-level rectal cancer data stemmed from the UK MRC-CLASICC trial, which raised concerns of adequate total mesorectal excision (TME), positive circumferential resection margins, increased rates of erectile dysfunction, and worse overall outcomes in converted patients [24–26, 35]. These concerns hindered general acceptance [36]. Since the initial studies, long-term outcomes from the COLOR II and CLASICC randomized controlled trials supported use of laparoscopic surgery for rectal cancer [37, 38]. The Comparison of Open versus laparoscopic surgery for mid- and low REctal cancer After Neoadjuvant chemoradiotherapy (COREAN) trial furthered these findings, demonstrating laparoscopic rectal resection after preoperative chemoradiotherapy was safe, oncologically equivalent to open surgery, and offered improved short-term outcomes [39]. Multiple additional studies and meta-analyses have found affirmed the equivalent oncologic outcomes and superior patient outcomes of laparoscopic rectal resection, even in converted cases [24, 39–53].

The Learning Curve for Specific Minimally Invasive Rectal Surgery Techniques

Laparoscopic Rectal Resection

While pelvic surgery is technically difficult, proficiency can be reached after performing 16–75 multiport laparoscopic cases. Fewer cases are required for experienced laparoscopic surgeons to reach competence.

With safety and oncologic equivalency proven, studies sought to define the specific learning curve for laparoscopic rectal resection. Laparoscopic surgery for rectal cancer is more technically demanding than laparoscopic colectomy [54]. The narrow confines of the bony pelvis, standard practice of autonomic nerve-sparing TME, and limitation of available stapling devices make laparoscopic surgery even more challenging [55]. Further, the inherent differences in case complexity warrant a specific analysis of the laparoscopic rectal resection learning curve [56]. The long curve has been cited as a major factor limiting growth [57–60].

Despite the inherent difficulties, studies on the learning curve for laparoscopic rectal resections found lower case numbers were needed for proficiency than with colon resections. Schlachta et al. reviewed a prospective database over 8 years at a single center, finding the learning curve for performing colorectal resections was approximately 30 cases; after that point, the "experienced" surgeons performed significantly more rectal resections, had significantly shorter operative time (180 vs. 160 min, $p<0.001$) and length of stay (6.5 vs. 5 days, $p<0.001$), and trended toward lower intraoperative complications and conversion rates [30]. Li et al. had similar results, finding the learning curve of laparoscopic rectal resections was approximately 35 cases; further, surgeons without previous basic laparoscopic experience could ascend the learning curve at the same rate by performing 2.1 laparoscopic rectal resections per month [61]. Kayano et al. evaluated 250 consecutive laparoscopic low anterior resections, split into 5 groups of 50, to determine the learning curve with the moving average method [54]. They found the learning curve stabilized at 50 cases, the conversion rate decreased significantly by group 4 (151–200 cases), and postoperative complication rate decreased significantly by group 5 (201–250 cases). Additionally, they found the risk factors affecting the learning curve were T stage and male sex [54]. Liang et al. cited the lowest number needed for proficiency [62]. In evaluating 160 laparoscopic-assisted rectal cancer resections based on lymph node harvest, length of distal margin, blood loss, complications, conversion rate, and length of stay over 2 years, Liang et al. found a surgeon may be proficient after performing only 16–20 rectal cancer cases [62]. Conversely, Son et al. cited the highest number of cases needed for proficiency in the current literature [56]. They retrospectively evaluated 431 patients over a 12-year period for conversion to laparotomy, complications, reoperations, operative time, and intraoperative transfusion using the CUSUM method, moving average method, and analysis of variance (ANOVA) tests. The authors found the learning curve was at case 61 for conversion, case 79 for complications, and cases 61–75 for operative time and intraoperative transfusion. Overall, the authors concluded the learning curve for laparoscopic rectal surgery was approximately 60–80 procedures [56]. Experience in laparoscopic colon resections has facilitated ascension up the learning curve for rectal resection. A prospective, single-center observational study by Bottger et al. reported a surgeon experienced in open colorectal surgery, with basic laparoscopic experience, needs to perform 35laparoscopic rectal resections within 200laparoscopic colon resections before operating time and complication rates plateau [63]. While these studies give a range of cases needed to ascend up the learning curve, all reports were based on single-center, non-randomized studies.

Park et al. added another dimension to the learning curve, evaluating economic outcomes along the curve between laparoscopic and open management of rectosigmoid cancer [64]. The authors analyzed operating room (OR) costs, OR-related hospital profit, total hospital charge, and patient payment during early (initial 37 laparoscopic cases) and experienced (subsequent 79 laparoscopic cases) learning periods. OR costs remained significantly higher with laparoscopy during the two periods, but by the experienced period, the OR-related hospital deficit improved (−$1072 to −$840), total hospital charges were similar ($7983/patient versus $7045/patient, $p > 0.05$), and patients paid a lower surcharge for laparoscopy ($1885–$1118) [64]. Given the current financial pressures, defining and shortening the learning curve is critical for making minimally invasive rectal surgery cost-effective and viable in today's healthcare environment (Table 1.1).

Table 1.1 Data on the learning curve for multiport laparoscopic rectal resections

Year	Author	*n*	Learning curve
2001	Schlachta et al.	461	30 cases
2006	Li et al.	105	35 cases
2010	Son et al.	431	60–80 cases
2011	Kayano et al.	250	50 cases
2011	Liang et al.	160	16–20 cases
2011	Bottger et al.	200	35 cases

Single-Incision Laparoscopic Surgery

The learning curve for single-incision laparoscopic surgery (SILS) in rectal resections is yet to be defined. With the unique skill sets and ergonomic demands, defining the SILS learning curve could benefit training and implementation.

With emerging technology in colorectal surgery, studies on the learning curve addressed new minimally invasive techniques. Single-incision laparoscopic surgery (SILS) has proven benefits over multiport laparoscopy, reducing the number of incisions, tissue trauma, perioperative pain, postoperative narcotics, port-site-related complications, and, in some studies, length of stay [65–69]. SILS has been shown safe and feasible specifically in rectal resections [70]. Small single-institution studies found SILS safe in slim patients with small tumors [65]. However, use is recommended only for skilled laparoscopic surgeons. While safety and feasibility have been established, all learning curve and training studies to date have focused on colectomy [71, 72]. Thus, studies evaluating the learning curve for SILS rectal resections are needed and, from the current literature, can be performed without increasing risk to the patient. Knowing the unique skill sets and ergonomic demands of SILS, the implementation of an evidence- and competency-based SILS training curriculum could facilitate efficient and effective training of SILS surgeons [73].

Hand-Assisted Laparoscopic Surgery

Hand-assisted laparoscopic surgery (HALS) is a bridge between open and laparoscopic surgery, allowing more complex procedures to be performed with minimally invasive benefits. Limited research in HALS rectal resection have conflicting outcomes, ranging from no distinct learning curve to higher case volumes for proficiency compared to multiport laparoscopy, Thus, further study is needed.

Hand-assisted laparoscopic surgery (HALS) was developed to bridge the learning curve between open and laparoscopic surgery. HALS retains the benefits of minimally invasive surgery while allowing surgeons to perform more complex procedures that would have otherwise been performed open or with great difficulty laparoscopically [74]. HALS has been reported especially advantageous for rectal resections and patients with higher BMI and comorbidity profiles [75]. Outcomes for HALS are comparable to multiport laparoscopy [74, 76–78]. Further, HALS has similar patient outcomes between colon *and* rectal surgery. In a 5-year review of a prospective database at the Mayo Clinic in Minnesota, short-term outcomes of 323 patients undergoing HALS for colon (194) or rectal cancer (129) were evaluated. Operative time was significantly less for colon than rectal cases (157 vs. 204 min; $p<0.0001$), but conversion to laparotomy (14 % vs. 10 %; $p=0.38$), lymph node yield (18 vs. 18; $p=0.45$), and postoperative complications were similar (28 % vs. 30 %; $p=0.72$) [79]. Proponents of HALS claim the tool can restore the tactile sensation lacking in laparoscopic procedures, improve hand-eye coordination, allow the hand to be used for blunt dissection or retraction, and rapidly control unexpected bleeding [80–84]. These features can significantly reduce operative time, a major variable on the minimally invasive surgery learning curve [83]. A virtual reality training simulator comparing HALS with multiport laparoscopy for sigmoid colectomy confirmed HALS accelerated the mobilization and anastomosis steps [85]. Advocates of HALS claim it is also easier to learn than multiport laparoscopy; however, there is limited published literature on the learning curve for HALS in rectal resections [81]. Ozturk et al. sought to define the learning curve for HALS procedures including total proctocolectomy [86]. A retrospective review of a single surgeon's operative time, conversion rate, complications, length of stay, reoperations, and readmissions was compared for 2 consecutive cohorts of 25 HALS procedures. They found no changes in outcomes or the operative time for proctocolectomy as experience was gained, concluding there was no learning curve for HALS [86]. When evaluating rectal resections exclusively, higher case volumes were reported for proficiency with HALS compared to multiport laparoscopy. Pendlimar et al. used CUSUM analysis to determine the cases required to attain technical proficiency and effect improvement in operative time with HALS [87]. The change point occurred between 105 and 108 total cases, with decrease in mean operative time for low anterior resection at 70 min ($p < 0.001$), coloanal anastomosis at 52 min ($p = 0.003$), and total proctocolectomy with ileal reservoir at 80 min ($p < 0.001$) [87]. With increasing use of HALS, more studies focused on rectal resections are needed to objectively define the learning curve using this technology.

Robotic-Assisted Laparoscopic Surgery

Robotic-assisted laparoscopic surgery (RALS) for rectal surgery has a multiphasic learning curve, with initial proficiency, integration of more challenging cases, and mastery of the technique between 25 and 72 cases. With the addition of more complex cases with increasing experience, operative time is not the optimal measure of proficiency.

Of the new technologies, the most robust learning curve data for minimally invasive rectal surgery is with RALS. Bokhari et al. evaluated the learning curve for RALS using the CUSUM method in 50 consecutive rectal resections [9]. They found the learning curve had three unique phases: (1) the initial learning curve (15 cases), (2) the plateau with increased competence (10 cases), and (3) mastery with more challenging cases (after 25 cases). For RALS rectal surgery, the authors concluded the learning curve occurred at 25 cases [9]. Sng et al. also found a multiphase learning curve for RALS rectal cases [88]. The authors performed a retrospective review of operative times in 197 consecutive patients over a 4-year period to define the learning curve using the CUSUM technique; they note the curve described an experienced laparoscopic colorectal surgeon [88]. Sng et al. found docking time had a learning curve of 35 cases, while the learning curves for total operative, robot, and console had three phases: (1) the initial learning curve (35 patients), (2) more

Table 1.2 Data on the learning curve for robotic-assisted rectal resections

Year	Author	*n*	Initial competence	Mastery
2011	Bokhari et al.	50	15 cases	25 cases
2012	Jimenez-Rodriguez et al.	43	9–11 cases	21–23 cases
2013	Sng et al.	197	35 cases	69 cases
2014	Kim et al.	167	32 cases	72 cases

challenging cases (93 patients), and (3) the concluding phase (69 patients). In addition, increased case complexity and subsequent longer hospital lengths of stay were seen in the latter two phases [88].

The three distinct phases were again seen when looking specifically at RALS for rectal cancer. Jimenez-Rodriguez et al. used CUSUM methodology to analyze the learning curve in 43 consecutive rectal cancer resections over a 2-year period [89]. The authors created two curves, operating time and success, and both had three well-differentiated phases: (1) initial learning (9–11 cases); (2) consolidation of skills, with increased competence (12 cases); and (3) mastery with more complex cases (after 21–23 cases). The authors found significantly reduced docking time ($p<0.001$) but increased operative time ($p=0.007$) in phase 3 [89]. Thus, the estimated learning curve for RALS in rectal cancer is achieved after 21–23 cases. To analyze the learning process in robotic TME, Kim et al. performed a retrospective review of 167 patients who underwent robotic TME for rectal cancer over a 5-year period [90]. The moving average and CUSUM methods were used to create learning curves based on operative time, conversion, complications, and circumferential margin. The authors found the learning curve for all outcomes was reached after 32 cases, while operative time had 2 plateaus: after 32 cases and then again after 72 cases. More complicated cases were performed in later phases, but complications remained constant throughout the series ($p=0.82$). Therefore, the learning process for robotic TME is most prominent after the initial 32 cases [90]. While present evidence on RALS shows comparable feasibility, safety, and patient outcomes to multiport laparoscopic surgery, operative time and total cost are greater; surgeons should keep this in mind when considering embarking on a new learning curve for RALS [91] (Table 1.2).

Future Direction

Transanal Approaches

While the learning curve for proficiency in TEM is brief, other factors have limited widespread use. New methods for transanal excision of rectal lesions, such as TAMIS and NOTES, are emerging, but further research is needed to develop formal learning curves with these techniques.

Transanal endoscopic microsurgery (TEM), a minimally invasive technique for a full-thickness resection of rectal tumors with highly specialized instruments, was originally described by Gerhard Buess in the early 1980s [92, 93]. TEM was the initial progression of local excision for benign and well-selected malignant rectal tumors [94]. TEM offered the benefits of minimally invasive local excision with access higher in the rectum, offering comparable oncologic outcomes, greater exposure than transanal excision, and less morbidity than transabdominal approaches [95–97]. TEM alone was sufficient for "favorable" T1 tumors, while unfavorable T1 or T2 tumors required adjuvant treatment, and use in T3 or greater was only for palliation [96]. Studies demonstrated reductions in operation time, length of stay, and complication rates with increasing experience [98]. Barendse et al. evaluated outcomes of 4 colorectal surgeons performing 555 TEM resections, finding a learning curve affected conversion rates, procedure time, and complication rates but not recurrence rates [99]. Maya et al. evaluated the learning curve in 23 patients over a 3-year period using the CUSUM method [92]. The authors found two phases: initial stabilization of the learning curve after the first four cases and then an additional rising and leveling after the first ten cases [100]. While proficiency may be achieved after four cases, widespread acceptance of TEM has remained slow for several reasons, including technical demands, costly equipment, cumbersome setup, limited indications, and perceived difficulty [97, 100, 101].

Transanal minimally invasive surgery (TAMIS) is a popular, emerging tool for resection of benign and carefully selected, early-stage malignancies of the mid- and distal rectum [102]. TAMIS is a feasible alternative to local excision and transanal endoscopic microsurgery, providing its benefits at a fraction of the cost [103–105]. TAMIS has expanded the bounds of local excision, making transanal resection of upper rectal/rectosigmoid lesions possible [106]. Continued expansion of this technique, including using the robotic platform for transanal access surgery, is underway [107–109]. The TAMIS technique has also evolved to a full TME. Transanal mini-laparoscopy-assisted natural orifice transluminal endoscopic surgery (NOTES) or TAMIS-TME is a new approach to performing minimally invasive rectal resection. For locally advanced mid- and distal-rectal cancer with curative intent, it is a rapidly expanding approach with significant promise. The "bottom-up" approach to en bloc rectal cancer resection is especially advantageous in obese male patients with a narrow pelvis [110]. Short-term outcomes have shown oncologic adequacy [110–112]. While promising, careful patient selection, a specialized team, and long-term outcome evaluation are required before widespread use of this technique [112]. While the popularity and applications of TAMIS continue to grow, larger case series and controlled trials are needed to develop formal learning curves with this platform.

Training in Minimally Invasive Rectal Surgery

During the learning process, patient safety and outcome are not adversely affected. Virtual reality simulators and colorectal fellowship training may help surgeons ascend learning curve.

The generalizability of current learning curve studies is limited from inconsistent data quality and individual variations [32]. One consistent finding across all studies is that training patient safety and oncological outcomes are not adversely affected during training in minimally invasive rectal surgery [27, 71, 113–115]. The techniques are reliable and efficient during the learning curve [116]. Furthermore, with increasing experience, more technically demanding procedures can be performed with reduced operating times, conversion rates, and supervision, still without increasing patient morbidity or mortality [27, 114, 117]. These findings have important implications for incorporating new techniques into practice under supervision of an experienced surgeon.

Given the safety and feasibility of learning minimally invasive rectal surgery, emphasis should therefore be placed on technical training [113]. Colorectal surgery fellowship training may provide sufficient experience so that learning curve issues are redundant in early practice [13]. Waters et al. retrospectively reviewed the first 100 laparoscopic colon (83 %) and rectal (13 %) resections performed by a colorectal fellowship trained surgeon, finding no difference in mortality or morbidity between early and late cases and decreased operative time with experience [118]. The authors concluded that laparoscopic training during fellowship surpasses the learning curve for safety and outcomes, while operative time continued to improve during the first year of practice [118]. A virtual reality training curriculum may also improve the learning process. Previous work has found proficiency-based virtual reality training shortens the learning curve and creates a more cost- and time-effective approach to learning laparoscopic colectomy [119]. Integrating simulator-based practice into rectal surgery training may be of similar benefit.

Conclusions

Minimally invasive rectal surgery is distinct from colon surgery, and a separate learning curve is necessary for establishing clear progression with all minimally invasive platforms. As best practices are developed for managing rectal cancer, future work should focus on standardizing training, defined quality outcome variables, and consistent methodology for constructing learning curves guiding the safe and effective growth of minimally invasive rectal surgery techniques.

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Chapter 2
Transanal Approaches: Transanal Endoscopic Surgery

Traci L. Hedrick and Joshua Bleier

Introduction

To a large degree, the development of transanal endoscopic microsurgery (TEM) was catalyzed by the revolution started by the widespread adoption of minimally invasive surgery and laparoscopic cholecystectomy. The technology was developed by Professor Gerhard Buess in Tubingen, Germany, as a response to limitations in the ability of transanal surgery to manage more proximal rectal lesions. Professor Buess developed a tool, which provided substantial advantages to standard transanal excision (TAE). In 1983, following successful animal trials [1], Buess published a report using his innovative TEM proctoscope to remove a rectal adenoma. The cannula was a 40 mm proctoscope, available in two different lengths: 12 and 20 cm. An attached faceplate allowed the continuous insufflation of air to create a pneumorectum and allowed three ports, one for suction and two for laparoscopic-type dissecting instruments. A fourth portal in the faceplate accommodated a camera with binocular optics allowing for a dramatically clear and three-dimensional image (Fig. 2.1). After the initial proof of principle, Professor Buess used this technique for the excision of early rectal cancers, with a 0 % mortality rate [2]. The use of this

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Fig. 2.1 Transanal endoscopic microsurgery. Includes image of working proctoscope with working ports and self-guided optics held in position with a stationary arm

technique expanded in the USA with Drs. Theodore Saclarides and Bruce Orkin publishing several larger series [3]. The technology for TEM has evolved, now with the original design being augmented with a laparoscopic attachment for overhead viewing. In addition, as detailed later in this chapter, several other evolutions of this technique have now been described. These include a platform similar to Buess' original design from Storz (TEO platform) and ingenious new modifications, utilizing single-incision laparoscopic devices, in the form of the TAMIS (transanal minimally invasive surgery) platform as developed by Atallah, Albert, and Larach [4]. Taken together these various techniques are collectively referred to as transanal endoscopic surgery (TES). This chapter will serve to outline the technique, indications, outcomes, and pitfalls of the various TES techniques for the management of rectal surgery. Finally, we will discuss some newer innovative and thought-provoking uses of the TES platform.

Indications and Contraindications

Benign Indications

Buess originally used TEM for resection of an endoscopically unresectable rectal polyp in 1983 [2]. It is ideally suited for resection of large, sessile, or recurrent adenomas. Although there are no randomized controlled trials comparing TES to standard transanal excision for rectal polyps, there is a plethora of retrospective data suggesting that TES is a superior technique. Moore et al. compared 89 patients that

Table 2.1 Recurrence rate following TES for rectal adenoma

Series	Year	Platform	*N*	Recurrence (%)	Follow-up, mean
Buess [11]	1987	TEM	75	1.3	–
Chiavellati [12]	1994	TEM	24	0	19
Said [19]	1995	TEM	286	7.0	38
Endreseth [14]	2004	TEM	64	13.0	24
Ganai [15]	2006	TEM	82	14.6	44
Bretagnol [10]	2007	TEM	148	7.6	33
Moore [5]	2008	TEM	49	4.0	20
Ramirez [18]	2009	TEM	149	6.0	43
De Graaf [13]	2009	TEM	353	9.1	27
Jeong [17]	2009	TEM	13	7.7	37
Guerrieri [16]	2010	TEM	402	4.0	84
Tsai [21]	2010	TEM	120	5.0	24.5
Steinhagen [20]	2011	TEM	46	2.0	20.4
De Graaf [6]	2011	TEM	216	6.1	32
Albert [9]	2013	TAMIS	25	3.6	20

underwent traditional TAE with 82 patients that underwent TEM. TEM was associated with a higher yield of negative margins (90 % vs. 71 %) and less fragmentation (94 % vs. 65 %) ($p<0.001$) [5]. Similar findings were reported by De Graaf [6] and Christoforidis [7] when comparing TEM and standard TAE. In each of these studies, the positive margin and fragmentation rate is lower with TEM [5–7], equating to a lower rate of recurrence [8].

The recurrence rates following TES for benign polyps range from 2 to 16 % but on average are less than 10 % throughout the literature [6, 9–21] (Table 2.1). Predictors of recurrence following local excision with TES include positive margins, size, and histology [8, 13, 16]. The recurrence rate following excision with negative margins is 6.1 % vs. 25 % following excision with positive margins in a large series of TEM for rectal adenomas [13]. McCloud found that tumors less than 5 cm are associated with a less than 10 % recurrence rate, while those large than 5 cm are associated with a 25 % recurrence rate likely related to the inability to achieve negative margins [8]. Recurrence has also been associated with the presence of high-grade dysplasia by Ganai et al. [15] who found that the five-year recurrence rates were 11 % for benign adenomas and 35 % for adenomas with high-grade dysplasia.

Advanced endoscopic resection techniques including endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD) are techniques that facilitate more sophisticated endoscopic resection than standard snare polypectomy. EMR was retrospectively compared to TEM for large rectal adenomas in eight hospitals in the Netherlands [22]. Although the morbidity was lower in the EMR group (13 % vs. 24 %, $p<0.05$), the early recurrence rate was significantly higher with EMR at 10 % vs. 31 % ($p<0.001$). With repeated procedures for these early recurrences, the late recurrence rates were more similar at 9.6 % (TEM) and 13.8 %

(EMR). The TREND-study is an ongoing multicenter randomized trial among 15 hospitals in the Netherlands comparing TEM and EMR for resection of large rectal polyps [23].

TES has also been described for the use of various other innovative benign indications such as excision of anastomotic strictures, endometriomas, repair of recto-vaginal and rectourethral fistulae, drainage of pelvic abscesses, and rectal stump excision following proctectomy although descriptions of each of these novel indications is limited to case reports [24–27].

Malignant Indications

T1 Rectal Cancer

A radical resection with a total mesorectal excision (TME) is the standard of care for all patients with rectal cancer including T1 cancers where overall survival is greater than 80 % with a local recurrence rate less than 10 % [28, 29]. However, despite advances in minimally invasive technology over the last decade, this is not without morbidity. In many series, there is a 2–3 % risk of death with up to a 40 % risk of complication with proctectomy [30]. There is often a need for a temporary or permanent stoma [31]. There is a significant risk of poor bowel function with a low anastomosis, poor healing with perineal wounds, sexual and bladder dysfunction, and depression. This is in drastic comparison to TEM, which has been shown to have minimal effect on fecal incontinence with an excellent quality of life following surgery [32]. For patients with early-stage tumors, the oncologic goals must be balanced against the effect on quality of life.

As such, surgeons have employed local excision for these distal early cancers for decades. Early reports in the 1990s were quite promising. Data from the CALGB 8984 trial, which evaluated the efficacy of local excision (TAE) in the treatment of T1 and T2 rectal cancers, revealed a local recurrence rate of 8 % with a distant metastasis rate of 5 % in 59 patients undergoing local excision for T1 tumors [33]. This was associated with an overall survival of 84 %. The recurrence rate for T2 tumors was higher at 18 % with a 12 % distant recurrence rate corresponding to a 66 % overall survival rate. However, reports began to surface demonstrating significantly higher rates of recurrence. Garcia-Aguilar published the University of Minnesota group's experience demonstrating an 18 % recurrence rate in 55 T1 lesions with a 98 % survival with a mean of 54 months of follow-up. The recurrence rate for T2 lesions was 37 % [34]. Data from Memorial Sloan-Kettering was similar with a 17 % 10-year local recurrence rate and 74 % 10-year disease-free survival in 74 patients with T1 cancers. In this study, 50 % of recurrences were local recurrences only, suggesting inadequate resection as the cause of treatment failure [35]. A nationwide cohort study from the National Cancer Database demonstrated a dramatic increase in the use of local excision for T1 rectal cancers from 27 to 43 % between 1989 and 2003 with an associated increase in local recurrence (12.5 % vs. 6.9 %

for T1 and 22.1 % vs. 15.1 % for T2, $p < 0.05$) and decline in overall survival as compared to standard resection for T2 tumors (77.4 % vs. 81.7 % for T1, $p = 0.09$, and 67.6 % and 76.5 % for T2, $p < 0.05$) [28]. Findings of higher recurrence and lower overall survival were also demonstrated in several other observational studies comparing traditional TAE to radical resection as well [14, 36]. This led to scrutiny for the increasing rate of local excision for Stage I rectal cancer and thus methods to improve TAE.

Transanal excision fails secondary to inadequate removal of the primary tumor, unrecognized nodal disease, or systemic spread. Luminal recurrences account for the majority of the local recurrences following TAE [37]. Therefore, inadequate removal of the primary tumor and tumor implantation by poor surgical technique likely contributes substantially to the significant recurrence rates seen in the prior studies utilizing standard TAE. It stands to reason that improved surgical technique could equate to improved oncologic outcomes.

As previously mentioned, TES is a superior technique to standard TAE with improved rates of negative margins and less fragmentation. Table 2.2 demonstrates the case control studies to date with reported outcomes following TES (majority with TEM) for T1 rectal cancer. The recurrence rates are seemingly lower than earlier reports with standard TAE although certainly there is risk for publication bias in these series. To date there are no randomized controlled trials comparing standard TAE to TES, only small retrospective studies with the expected limitations. Moore et al. [5] in Vermont compared 28 patients undergoing TEM for malignancy to 89 patients undergoing traditional TAE. The recurrence rate for TEM was only 3 % compared to 26 % after TAE. However, the follow-up for standard TAE was more than double that for TEM (53 ± 44 months vs. 20 ± 16 months, $p > 0.05$), thereby influencing the results. Christoforidis et al. [7] reported on 37 TEM procedures for malignancy performed by one surgeon compared to 117 TAE performed by 21 different surgeons and found the recurrence to be 12 % vs. 22 %

Table 2.2 Recurrence rate following TES for T1 rectal cancer

Series	Year	Platform	*N*	Recurrence (%)	Follow-up (months)
Wind [72]	1996	TEM	24	4.2	41
Ganai [15]	2006	TEM	21	19	44
Bretagnol [10]	2007	TEM	31	9.7	33
Jeong [17]	2009	TEM	17	0	37
Allaix [73]	2009	TEM	38	0	60
De Graaf [38]	2009	TEM	80	24	42
Palma [74]	2009	TEM	34	5.9	86.5
Tsai [21]	2010	TEM	51	9.8	54
Doornebosch [75]	2010	TEM	88	20.5	84
Steinhagen [20]	2011	TEM	12	0	33
Ramirez [52]	2011	TEM	54	7.4	71
Lezoche [58]	2011	TEM	51	0	97
Stipa [53]	2012	TEM	86	11.6	85

for T1 tumors and 25 % vs. 33 % for T2 ($p > 0.05$). The follow-up was more similar in these two groups at 60 months (10–125 months) for TEM compared to 45 months (7–133 months) for TAE.

Although not randomized, De Graff et al. [38] reported their experience with TEM as a recruitment center for the Dutch TME trial and referral center for TEM. Compared to 75 patients with T1 tumors that underwent TME, there was a significantly higher rate of recurrence in 80 patients that underwent TEM at 25 % compared to 0 % with similar DFS at 87 and 90 %. There was no mention of pathologic risk stratification for T1 tumors in the Dutch trial, which is known to influence nodal metastasis and thus recurrence. This recurrence rate is the highest of the series in Table 2.2 and highlights the difficulty in interpreting the data when there are such wide variances between groups.

T2 Rectal Cancer

Studies including patients with T2 rectal cancer are outlined in Table 2.3. Local excision alone for T2 tumors is insufficient with recurrence rates up to 40 %, mirroring the known incidence of nodal metastases in these patients. It remains to be seen whether local excision combined with chemoradiation therapy (CRT) will prove to be an acceptable form of treatment. However, the initial results of the American College of Surgeons Oncology Group (ACOSOG) Z6041 trial are promising [39]. The ACOSOG Z6041 trial is a prospective, multicenter, single-arm Phase II trial to assess the efficacy and safety of neoadjuvant CRT and local excision for T2N0 rectal cancer. Ninety patients were accrued and 79 patients completed therapy. There was a 44 % complete pathologic response rate and a 39 % CRT-related toxicity, mainly rectal pain following surgery [39]. The oncologic outcomes were reported at the American Society of Colon and Rectal Surgeons annual meeting in Hollywood, FL. After a mean follow-up of 4.2 years, there was a 3 % local recurrence rate and 7 % distant recurrence rate with an 87 % 3-year DFS [40]. However, given that 44 % of patients had a complete pathologic response to CRT, it remains unclear what clinical effect the addition of local excision had in these patients. A trial of nonoperative treatment in these patients is currently underway by the same group.

Other studies evaluating the feasibility of TES in T2N0 tumors combined with CRT have been reported. The Urbino trial was an Italian randomized controlled trial

Table 2.3 Recurrence rate following TES for T2 rectal cancer

Series	Year	Platform	*N*	Chemoradiation	Recurrence (%)	Follow-up (months)
Endreseth [14]	2004	TEM	5	None	20.0	24
Ganai [15]	2006	TEM	4	Adjuvant	50.0	44
Jeong [17]	2009	TEM	6	Adjuvant	16.7	37
Tsai [21]	2010	TEM	17	Selective	23.5	42.8
Lezoche [58]	2011	TEM	84	Neoadjuvant	4.7	97

that randomized 70 patients with T2N0 lesions who underwent neoadjuvant CRT to either TEM or laparoscopic low anterior resection or abdominoperineal resection. Five-year follow-up demonstrated less than 10 % recurrence rates with a 94 % disease-free survival in each group [41]. The CARTS study is an ongoing multicenter feasibility study in 15 Dutch hospitals to evaluate whether chemoradiotherapy followed by TEM will provide effective oncologic outcomes. Data from this trial are not yet available [42].

Preoperative Nodal Staging

The Achilles heel of local excision of rectal cancers is inaccurate nodal staging with current technology. Up to 12 % of T1 tumors and 30 % of T2 tumors are associated with lymph node metastases (LNM) in rectal cancer specimens [43]. Preoperative staging for patients with rectal cancer involves either endorectal ultrasound (EUS) or magnetic resonance imaging (MRI) to evaluate the depth of tumor extension through the rectal wall and the presence of lymphadenopathy. Unfortunately, as Salinas et al. [44] demonstrated, preoperative imaging in Stage I cancers is inaccurate. In this study, 109 consecutive patients with preoperative imaging suggestive of T1N0 or T2N0 tumors underwent radical surgery with TME at Massachusetts General Hospital. Twenty-seven patients were found to have T3 disease (25 %) on final pathology, while 11 % of the T1 and 28 % of the T2 lesions were found to have LNMs [44]. Given that this is the exact proportion of LNMs that you would expect in T1 and T2 tumors based on historical data, this implies that nodal staging is inaccurate in these early-stage tumors. This was further demonstrated by Landmann et al. [45] who found the sensitivity of EUS for nodal staging to be linked to the size of the lymph node. Because T1 tumors are typically associated with small LNMs (median lymph node size of 3.3 mm compared to 8.0 mm for T3 tumors), EUS accuracy is less than 50 % in T1 rectal cancers compared to 84 % in T3 tumors [44, 45]. MRI has emerged as an important advance in preoperative staging of late-stage rectal cancer. It is highly accurate in predicting the circumferential radial margin and identifying invasion into surrounding structures. However, its use in patients with early Stage I rectal cancer is of questionable efficacy [46], and there are data to suggest that EUS is more accurate for staging in patients with early-stage rectal cancer [47].

Pathologic Risk Factors for Lymph Node Metastases

Success with local excision of early-stage cancers relies heavily on patient selection. There is significant variation in oncologic outcomes between groups as evident in Tables 2.2 and 2.3. It is difficult to explain the variances in outcomes between studies. Certainly technique plays a significant role. But patient selection as it pertains to predicting the risk of LNM is just as likely to influence outcomes between studies. In addition to T stage, there are other known factors for predicting LNM, including differentiation, lymphovascular invasion (LVI), SM classification, and tumor budding. Well to moderately differentiated tumors are associated with LNMs in 14 % of T1 or T2 tumors as opposed to 30 % with poorly differentiated tumors [48]. Similarly, the presence of LVI doubles the risk of LNMs from 14 to 33 % [48]. In the absence of any of these high-risk features, Blumberg et al. found the risk of LNMs to be 7 % for T1 lesions [48].

The SM classification further stratifies T1 tumors according to the degree of invasion into the submucosa, which correlates with LNMs. Nascimbeni et al. [49] stratified the degree of invasion into the submucosa into three levels and found significant correlation with nodal disease. SM1 tumors had a 3 % risk of nodal metastases, SM2 8 %, and SM3 23 %. Along with LVI and distance from the anal verge, SM classification was found to independently predict LNM. Finally, the presence of tumor budding is emerging as an increasingly important predictor of nodal metastases [50]. Tumor budding refers to the presence of individual or clusters of tumor cells at the invasive front of the tumor, representing an epithelial to mesenchymal transition (Fig. 2.2). In one study involving 55 patients with T1 rectal cancers undergoing radical resection, tumor budding had a sensitivity of 83.3 %, a specificity of 60.5 %, and a negative predictive value of 0.958 for LNM [51].

Patient selection, focused on these high-risk pathologic features, can improve oncologic outcomes. Ramirez stratified patients with T1 rectal cancer following TEM into low-risk and high-risk categories based on the presence of poor differentiation and LVI. High-risk patients were treated with adjuvant CRT. The recurrence rate (including both local and distant) was 7.4 % in the low-risk group and 12.5 % in the high-risk group for an overall recurrence (local and systemic) rate of 9 % [52].

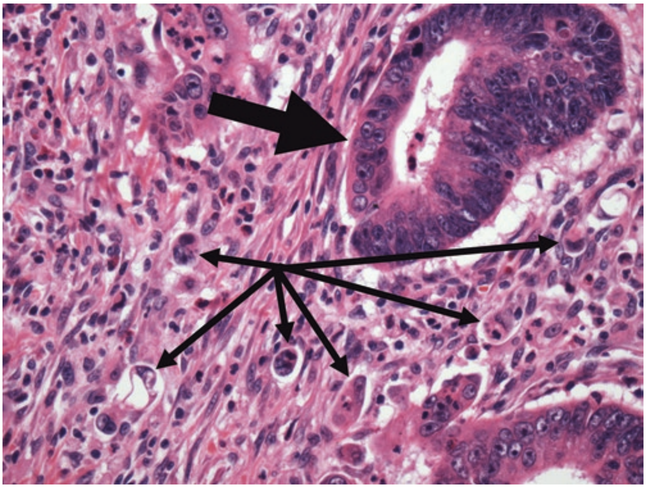

Fig. 2.2 Invasive rectal adenocarcinoma. The *large arrow* highlights a typical invasive gland. Numerous surrounding single cells and small nests (*small arrows*) surround the gland within the desmoplastic stroma (tumor budding)

Summary Statement for Treatment of Early-Stage Rectal Malignancy

As evident from the studies outlined above, the decision to perform local excision for early-staged rectal cancer cannot be entered into lightly. Given the recurrence rates for T2 lesions and the known risk of nodal metastases, TES alone is not appropriate for patients with T2 tumors unless the patient is otherwise unfit for an operation or is in a clinical trial. In this circumstance, local excision should be combined with CRT. Whether or not this should be given before or after local excision remains to be seen.

With regard to T1 rectal cancers, the NCCN guidelines list the following requirements for consideration of transanal excision:

- <30 % circumference of bowel
- <3 cm in size
- Margin clear (>3 mm)
- Mobile, non-fixed
- Within 8 cm of anal verge
- 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 pretreatment imaging

Treatment of Recurrences

Close surveillance following transanal excision of early-stage rectal cancer is imperative as an unrecognized recurrence is often incurable. Doornebosch followed 88 patients with T1 rectal cancer that were treated with TEM [53]. Eighteen patients recurred at a median of 10 months (4–50) following local excision. Two had metastatic disease at the time of presentation, while 16 underwent salvage surgery. An R0 resection was achieved in 15 of 16 patients. Median follow-up after surgery was 20 (2–112) months. Overall survival was 31 % at 3 years; cancer-related survival was 58 %. Stipa followed 86 patients with T1 rectal cancer that underwent TEM [53]. Ten patients recurred (11.6 %) and all but one underwent salvage surgery with an R0 resection. Overall 5-year disease-free survival was 92 % in all 86 patients [53]. Median time to recurrence was 11.5 months (1–62). Finally Weiser et al. reviewed 50 patients who underwent salvage surgery for curative intent following local recurrence after transanal excision (not necessarily TEM) at Memorial Sloan-Kettering. Fifty-five percent of these patients required a multi-visceral resection although this is likely biased by the referral pattern of the institution. Five-year disease-specific survival was 53 % [54].

TES for Palliation

There are certain patients that develop rectal cancer who are medically unfit to undergo radical resection following completion of neoadjuvant CRT for advanced-stage tumors. Each case must be considered on an individualized basis, and TEM for palliation is not indicated if the patient has had a complete clinic response following CRT. However, TEM may provide palliation for the patients with residual small volume disease following CRT in selected circumstances. In general, TEM following radiotherapy is well tolerated. Lezoche reported on 137 patients who underwent TEM after preoperative radiotherapy and found very few complications (2 % major complications) [55]. However, anecdotally the patients do have more pain than the non-radiated patients following TEM, and this was demonstrated further in the ACOSOG Z6041 trial [39]. Perez et al. [56] examined 27 patients with small residual tumors (<3 cm) that were pT2 or less following neoadjuvant CRT who underwent TEM. Local recurrence was 15 % after a median follow-up of 15 months. Certainly, this should not be considered in the medically fit patient but may be an effective form of palliation in the patient that would otherwise not tolerate a formal resection.

Carcinoid

The rectum is the second most common location of gastrointestinal carcinoid tumors following the small bowel. For small lesions less than 1 cm in size, the likelihood of lymph node metastases is very rare. However, carcinoid tumors greater than 2 cm in size are associated with lymph node or distant metastases in 70 % of cases. Invasion into the muscularis propria, the presence of LVI, and a high mitotic rate (≥2 per 50 hpf) increase the risk of lymph node metastases. A rectal carcinoid tumor less than 1.5 cm in size is an ideal indication for TEM with reported rates of recurrence of less than 1 % [21, 57]. Tumors greater than 2 cm in size are best treated with a radical resection.

Preoperative Workup

Every patient that presents for evaluation of TES must have a full history and physical exam. Special attention must be given to a history of any pelvic radiation or prior surgery such as prostatectomy, which may complicate transanal excision. The patients must be fit enough to withstand general anesthesia so a full review of their comorbidities is imperative. Patients on chronic anticoagulation for various conditions should have a plan in place for the perioperative period. The risk of a thromboembolic event must be weighed against the risk of postoperative hemorrhage.

A personal endoscopic exam is paramount for the surgeon to determine the patients' appropriateness for the procedure. Many surgeons perform rigid proctoscopy in the office to determine the location of the lesion in question. This can also be accomplished with flexible sigmoidoscopy. The distance from the anal verge must obviously be taken into account. However, this is highly dependent on the patient's body type and has poor inter-rater reliability. The authors find it more useful to assess the location of the lesion relative to the valves of Houston when assessing candidacy for TES. TES can be used to reach most any lesion distal to the third valve of Houston. It is difficult to reach a lesion proximal to the third valve of Houston with TEM given that the caliber of the sigmoid colon prevents advancement of the 4 cm proctoscope. In addition, it is difficult to see around the bend of the rectosigmoid junction with the rigid proctoscope. TAMIS may permit better visualization of these more proximal lesions. However, this remains to be seen. Any lesion at the second valve of Houston or above, particular in women or in the setting of an anterior tumor, may be above the peritoneal reflection. It is prudent to consent all these patients for laparoscopy just in case it is necessary to perform an air leak test or place sutures from the abdomen.

For TEM it is important to note the exact location of the lesion (anterior, posterior, right, or left) within the lumen as this determines positioning. This is readily apparent with rigid proctoscopy. With a flexible endoscope, this can be determined by irrigating the rectum with saline and rolling the patient to determine the location of the lesion relative to the meniscus of the fluid. This should be documented immediately while fresh in the surgeons mind and placed on the consent form to prevent confusion in the OR from malpositioning. An evaluation of continence should be performed with clinical history and evaluation of the sphincter complex. This can be aided by the use of one of the fecal incontinence scoring systems. Some surgeons use anal manometry preoperative but the authors do not find this particularly helpful.

A pathologist should review the pathology specimen carefully for characteristics that would mandate a radical resection prior to TES. The endoscopic specimen should be evaluated for histology, margins, presence of lymphovascular or perineural invasion, differentiation, and the presence of tumor budding. A multidisciplinary tumor board conference is an ideal venue to review the pathology and determine the most oncologically appropriate course of action for each individual patient.

As discussed previously, mesorectal evaluation is critical prior to consideration of TES in patients with early rectal cancer or high-risk rectal polyps. If there is any concern for the possibility that the polyp could represent a malignancy (gross appearance, high-grade dysplasia, etc.), an evaluation of the mesorectum should be undertaken. It is important to know the landscape at your institution, as expertise in staging modalities will vary. The authors find EUS to be more accurate in T stage determination but do obtain an MRI in all patients with suspected malignancy undergoing TES for nodal staging. Many of the patients are also followed with MRI and this preoperative MRI can serve as a baseline for comparison. In addition, a full workup as outlined in the NCCN guidelines is necessary including:

- Biopsy
- Pathology review
- Colonoscopy

– Proctoscopy
– CT scan of the chest/abdomen/pelvis
– CEA
– EUS or pelvic MRI

Operative Details

There are various platforms available. Until recently, the only equipment available was the original Richard Wolf TEM Instrument System (Richard Wolf, Knittlingen, Germany). The all-inclusive equipment involves two 4 cm-diameter working proctoscopes of varying lengths, a face plate with three working ports, a stationary high-definition camera, specifically modified laparoscopic equipment, and a combination pump/insufflator that maintains consistent distention of the rectum during suctioning. The instrumentation is custom-made and angled downward and inward to facilitate dissection within the confines of the rigid proctoscope. Advantages of this system are that it is all-inclusive, is stationary (obviating the need for an assistant), and provides insufflation that is resistant to changes in pressure from suctioning or entry into the peritoneal cavity. However, the cost of the equipment is prohibitive for many centers, particularly given the poor reimbursement for TEM procedures. Recently Karl Storz (Tuttlingen, Germany) released a competing product referred to as TEO® (transanal endoscopic operation). The equipment is similar to the Wolf system in that it consists of a rigid 4 cm proctoscope, a faceplate with three working channels, and a stationary arm that holds it in place. However, it can utilize conventional laparoscopic equipment. Finally, Atallah, Albert, and Larach were the first to adapt equipment for single-incision laparoscopic surgery (SILS), to perform transanal surgery, which they termed transanal minimally invasive surgery (TAMIS) [4]. This technique utilizes the SILS Port (Covidien, Applied Medical) within the anal canal and standard laparoscopic equipment. Advantages of this system include the reduced cost and ability to perform the procedure in lithotomy for the majority of patients. Disadvantages are that the technique requires an assistant to drive the camera and the SILS port obscures the distal rectum making it difficult to use for distal lesions.

Regardless of the platform utilized, the procedure starts with general anesthesia, which is helpful to ensure adequate insufflation although some TES can be performed under spinal or epidural anesthesia in high-risk patients. For TEM, positioning of the patient is paramount as the lesion must be in the dependent position. Therefore, patients must be placed prone for anterior lesions, lithotomy for posterior lesions, and on their respective side for lateral lesions. A split leg table is the key to success for this type of positioning (Fig. 2.3). For the other types of platforms, the patient is placed in lithotomy. The patient must be secured safely to the bed with chest rolls or a beanbag, but the abdomen must not be compressed to allow for adequate insufflation during the procedure.

Fig. 2.3 Patient in the lateral posiiton using a split leg table to provide adequate exposure

Once the patient is positioned and draped, gentle manual dilation is performed. The instrumentation (either the TEM proctoscope or the TAMIS port) is then inserted and secured. From this point forward, the technique is similar no matter what the platform (see Video 2.1 presentation). The procedural steps will depend on the type and size of the lesion being removed. Regardless, however, the circumference of the lesion is first marked out with electrocautery maintaining a 1 cm margin. Once the dissection begins, the margins are difficult to discern. Therefore, it is necessary to mark them at the beginning with electrocautery. For very proximal lesions, it may also be advantageous to place sequential stay sutures along the margins to assist with retraction later on during the dissection. Once the resection is planned, the dissection commences with a mucosal incision. Either electrocautery or a thermal device such as the Enseal® may be used. If it is a benign polyp, it may be advantageous to perform a submucosal dissection. Injection of saline or an epinephrine solution into this plane will aid in dissection. If the lesion is malignant, or there is a concern that it may be malignant, a full thickness incision is necessary. In this case, the mucosal incision is taken down to the glistening mesorectal fat. It is important during this dissection not to encroach or undermine the margin. The resection should be cylindrical to permit an adequate resection [58]. A thermal device can assist during this dissection. Bothersome bleeding may be encountered in the mesorectum, particularly with posterior lesions. Anteriorly, care must be taken to avoid the vagina or prostate. During this dissection, the peritoneal cavity may be encountered. It is usually obvious if the peritoneal cavity is entered. This may affect insufflation with some of the platforms although this is typically not an issue with the Wolf system. Care must be taken to avoid injuring the underlying viscera. Once the resection is complete, the specimen is removed. The margins are inspected and the specimen is pinned to foam. If there is any concern, the margin is re-excised and sent as a separate specimen. The resection cavity is then irrigated. Some surgeons use Betadine or water to sterilize the resection bed and theoretically reduce the risk of mucosal or tumor implants. If there is a defect in the peritoneal cavity, this is closed separately prior to mucosal repair. The authors use 3-0 polyglactin 910 suture for peritoneal closure and 3-0 polydioxanone (PDS) suture for the mucosa. Silver beads (Richard Wolf, Knittlingen, Germany) are used to secure the suture with TEM. Other options are barded suture or LAPRA-TY® (Ethicon). The TAMIS port facilitates the use of the Endo Stitch™ (Covidien).

Following completion of the procedure, it is important to assure the lumen is still patent. If there is any concern, the authors perform a flexible sigmoidoscopy following completion of the procedure. When there is entry into the peritoneal cavity, a laparoscope may be placed intra-abdominally to facilitate an air test of the suture repair. This is not always necessary for small peritoneal defects but should remain in the surgeon's armamentarium. The equipment is then withdrawn. Local anesthetic is given. The patient is then awoken and taken to recovery.

Postoperative Care

As opposed to traditionally rectal surgery, TES is very well tolerated and associated with very little morbidity [59]. Patients are either discharged the same day or kept overnight, as opposed to traditional low anterior resection, which requires a significant hospital stay and is associated with a six-week recovery time. The indication for admission depends on the size of the resection, entry into the peritoneal cavity, and patient comorbidities. Resections greater than 30 % of the circumference of the lumen, particularly if they are distal, can be associated with an SIRS-type reaction. As such, these patients are typically observed overnight. Admission is also warranted for patients who are anticoagulated and can be considered following entry into the peritoneal cavity.

Patients are typically left on a soft diet for the first 2 days following the procedure. Liberal use of stool softeners and laxatives to keep the stool soft is helpful. Postoperative antibiotics are not routinely required. The postoperative course is dependent on patient and procedure factors. Patients undergoing small resections (<30 % of the circumference of the lumen) proximal to the dentate line typically have limited pain or debilitation following surgery. However, patients with larger, more distal lesions that cross the dentate line can have significant perineal pain, similar to that seen with hemorrhoidectomy. Additionally, the patients heal faster if the suture line is intact. Suture line dehiscence, which is common in patients following neoadjuvant CRT, is associated with a feeling of rectal fullness, tenesmus, low-grade fever, rectal drainage, and bleeding. This may require prolonged admission or readmission. It is also imperative to tell the patients that they may pass some suture material or silver beads (in the case of TEM) as this will lead to unnecessary concern and confusion if the patient is not expecting this.

Possible Complications

TES is attractive given that the complication rate is quite low.

- *Urinary retention* is the most common complication, particularly in elderly men. A urinary catheter is routinely inserted prior to surgery. The catheter is maintained overnight in men with moderate to large resections to prevent urinary retention. But approximately 10–20 % of patients will require reinsertion of the urinary catheter.
- *Anal Fissure*: Some patients may suffer a traumatic anal fissure during the procedure, which may contribute to pain following surgery and can be treated conservatively. Taking care at the beginning of the procedure to perform gentle steady dilation can help prevent this from occurring.
- *Suture line dehiscence*, which is common in patients receiving neoadjuvant CRT, is associated with a feeling of rectal fullness, tenesmus, low-grade fever, rectal drainage, and bleeding. This occurs over 50 % of the time following radiation and may require readmission.
- *Fecal soilage* occurs 4 % of the time and is usually temporary. This can be improved with fiber therapy and constipating agents early in the postoperative course [32].
- *Rectal bleeding* can occur, particularly in patients on anticoagulation. This usually resolves spontaneously although may require reoperation. The authors have used TEM to control hemorrhage in a patient on therapeutic enoxaparin who bled following resection of a large recurrent polyp.
- Some patients may develop a *systemic inflammatory response syndrome*-type response. Patients with large distal lesions at the dentate line are most at risk [60]. This can be managed with resuscitation and IV antibiotics in the vast majority of cases and does not warrant exploration. This is relevant for patients that travel from long distances to have TES at a referral center and then subsequently present to their local emergency room with a septic complication. It is imperative that the patients are well informed so they know to communicate early and effectively with the surgeon who can guide management from afar and facilitate transfer back to the center where the procedure was performed.
- *Rectovaginal/urethral fistula*: Anterior lesions, particularly following radiation, are most at risk for the development of a fistula. The upmost care has to be taken to prevent injury to these structures during the procedure, as the sequela of such an injury is very difficult to manage.
- *Stricture* occurs most commonly with large circumferential lesions. These can be managed most often with dilation [61].
- Hypercarbia and emphysema are infrequent complications of the procedure that can be prevented in many cases by keeping the pressure insufflation below 18 mmHg [62].

Implications of Prior TEM on Radical Resection

As demonstrated by Salinas et al. [44], staging with early-stage tumors can be inaccurate. Thus, the need will ultimately arise for every surgeon that practices TES to perform a radical resection with TME following TES. What are the implications? Hompes et al. [63] examined 36 patients that underwent completion surgery following TEM. Postoperative complications occurred in 19 patients, and the procedures were technically challenging as evident by higher intraoperative blood loss and operating time. In addition, the quality of the resected specimen was moderate or poor in 13 of the 36 patients, which had a significant effect on 5-year disease-specific survival. Median follow-up was 49.2 (3–137) with a 16.7 % relapse rate and 5-year disease-specific survival of 100 % in patients with a good TME specimen and 51 % in those with an inferior TME specimen. Levic et al. [64] performed a case-matched study of 25 patients undergoing early salvage surgery following TEM with 25 patients who underwent primary TME, matched according to gender, age, stage, and operative procedure. There was no difference in operative time, blood loss, complications, circumferential margin status, or recurrence. The Dutch group published their series of 59 patients who underwent TME following TEM, comparing them to patients who underwent TME surgery during the Dutch TME trial [65]. Compared to a group of patients that underwent neoadjuvant radiation and radical resection up front, those that underwent a completion TME following TEM had higher rates of recurrence and resulted in more colostomies [65].

Follow-Up

The surveillance strategy is dependent on pathology and unfortunately there are no published guidelines. For benign polyps, the authors perform a flexible sigmoidoscopy at six-month intervals for 2 years and then annually for 3 years with a colonoscopy at 1 and 3 years. For small polyps in the absence of high-grade dysplasia, this surveillance schedule may be liberalized [66]. Small carcinoids (<1 cm) are very unlikely to recur and do not likely need additional follow-up [67].

Loss to follow-up in the patients with malignancy can be devastating as evident by the poor salvage outcomes reported earlier. Therefore, the follow-up for patients with rectal cancer must be clearly outlined to the patient up front, and they *must* be willing to enter into a regimented long-term surveillance program. There are no guidelines for surveillance following transanal excision of rectal malignancies. The following represent the authors' opinion based on NCCN guidelines for radical resection, expert opinion, and other surgeons' experience [39, 56].

- History and physical every 3–6 months for 2 years and then every 6 months for a total of 5 years.
- CEA every 3–6 months for 2 years and then every 6 months for a total of 5 years.
- Chest/abdomen/pelvis CT annually for up to 5 years.

– Colonoscopy at 1 year; if advanced adenoma, repeat in 1 year; if no advanced adenoma, repeat in 3 years and then every 5 years.
– Flexible sigmoidoscopy every 3 months for 2 years, then every 6 months for 3 years, and then annually.
– Assess for mesorectal recurrence with either MRI or EUS every 6 months for 2 years and then annually for 5 years.
– Some authors perform PET/CT for mesorectal and systemic surveillance.

Tips and Tricks

– Document location of the lesion immediately after examining the patient.
– If you are struggling to see or maintain insufflation during the procedure, it is often due to inadequate paralysis by the anesthesiologist even if "the patient doesn't have any twitches" on the twitch monitor. The authors have anecdotally found the intraluminal pressure of the rectum as perceived by the operating surgeon to be a much more sensitive indicator of the patients' paralysis level than the twitch monitor.
– For distal lesions, the authors will perform the proximal dissection with the TEM equipment and the distal portion with standard transanal retractors if necessary. Given the much-improved visualization, the authors go to great lengths to avoid having to use the traditional TAE.
– Consider the ramifications of having to perform a subsequent radical resection if the pathology is unfavorable as a prior TES procedure does likely interfere with the ability to perform a subsequent sphincter salvage operation particularly for the very distal lesions.

Future Directions

Realistically, any section describing future directions in the use of TEM is doomed to fall short since innovation is likely proceeding faster than publishing! However, the current vanguard of intrepid TES surgeons is pushing the technology to its limits in the form of transanal TME. As an offshoot of natural orifice surgery using the TES platforms, surgeons have been able to perform total transanal mesorectal excisions, often in combination with laparoscopic or robotic assistance. A query of PubMed yields almost 30 publications regarding this approach, with the earliest description being credit to Dr. Antonio Lacy in 2011 [68]. Sylla and colleagues further refined this technique in a cadaveric series published in 2013 [69], and TES pioneers Atallah and colleagues described this technique in humans in 2013 [70]. Drs. Lacy and Sylla published their multinational collaboration data on 20 cases in 2013 [71] with excellent success. Further modifications to TES technique are exploring the use of the robot for transanal surgery.

Time and human ingenuity will undoubtedly open up new avenues for the use of this platform. With the versatility, enhanced optics, and robustness of these systems, the possibilities for the application of TES continues to grow, and it is exciting to wait to see how continued further innovation will change the face of our minimally invasive approach to rectal malignancy.

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Chapter 3
Transanal Approaches: Transanal Minimally Invasive Surgery (TAMIS)

John P. Burke and Matthew R. Albert

Introduction

Following the popularization of colorectal cancer screening, the incidence of large rectal polyps and early-stage cancer is increasing [1]. Due to the suboptimal functional outcomes following proctectomy, an aging population, stoma aversion, and improving response rates following neoadjuvant chemoradiation, local excision of large polyp early-stage rectal cancer is increasingly being requested by patients and utilized in clinical practice [2]. The modalities available for the local excision of both large polyps and early-stage rectal cancers include traditional transanal excision (TAE), colonoscopic/endoscopic mucosal resection, and transanal endoscopic microsurgery (TEM).

TEM (or the more recently modified transanal endoscopic operation (TEO) was first described in 1984 by Gerhard Bues [3] and represents the intraluminal excision of a rectal lesion using a rigid resectoscope. TEM maintains a stable pneumorectum and allows either high-definition or binocular optical visualization of the target site, with precise instrumentation for tissue tensioning, dissection, resection, and mucosal re-apposition. Meta-analyses of TEM for benign and malignant tumors show significant advantages over other techniques. When compared to conventional TAE, TEM provides a superior quality resection, with higher rates of negative microscopic

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margins, reduced rates of specimen fragmentation, and lesion recurrence but with equivalent postoperative complications [4]. When compared to advanced colonoscopic techniques such as endoscopic mucosal resection and endoscopic submucosal dissection, TEM remains superior with respect to lesion recurrence [5, 6].

However, while TEM has been used for more than 30 years, it has been slow to become incorporated into routine colorectal practice due to a steep learning curve [7] and significant associated initial cost of the operating system [8]. The aforementioned requirement for safe, oncologically sound, and cost-effective access modalities for the local excision of rectal lesions has led to the evolution of transanal minimally invasive surgery (TAMIS).

Single-incision, multiport laparoscopic devices that have facilitated a wide spectrum of abdominal procedures [9, 10] and the evolution of single-site laparoscopic surgery provided colorectal surgeons with the devices and technical skill set necessary to perform complex surgery, under magnification, in a confined space, while operating along a single axis. As crossover exists by which instrumentation designed and skills attained for a unique application can be used for a different task, it was realized that the techniques applied to single-incision surgery could be used for transanal rectal surgery. This evolution in application was termed TAMIS. First described in 2010 in a series of six patients using a multichannel port positioned transanally, TAMIS was found to be a feasible alternative to TEM, providing its benefits at a fraction of the cost without specialized instrumentation [11].

Indications and Contraindications

The indications for TAMIS are similar to TEM or standard TAE. These include benign adenomas, neuroendocrine tumors less than 2 cm in diameter, and well-differentiated T1 invasive carcinoma less than 3 cm [12]. There exists no agreed limit to the size of rectal adenoma that can be resected, the primary concern being excess tissue removal leading to a narrowed lumen and rectal stenosis. We know however from the TEM literature that rectal stenosis following TEM excision is rare even for lesions greater than 5 cm provided the lesion is not circumferential [13].

The 2013 American Society of Colon and Rectal Surgeons' practice parameters for the management of rectal cancer state local excision is an appropriate treatment modality for carefully selected T1 rectal cancers without high-risk features [12]. This guidance has been bolstered by a recent analysis of Surveillance, Epidemiology, and End Results data, demonstrating the local excision of T1 rectal cancer does not affect cancer-specific survival when compared to radical surgery [14]. The concern naturally is the under treatment of T1 lesions that are node positive. In an analysis of 205 T1 rectal cancers from the Swedish Rectal Cancer Registry, the overall rate of nodal metastasis was 12 % [15]. However, if no adverse features (lymphovascular invasion or poor differentiation) were present, the rate was 6 % [15]. A recent meta-analysis of 4510 patients highlighted the risk factors for nodal metastasis in the setting of T1 rectal cancer to include submucosal invasion >1 mm (odds ratio (OR) 3.87), lymphovascular invasion (OR 4.81), poor differentiation (OR 5.60), and tumor budding (OR 7.74) [16]. If any of these risk factors are present on final pathology, it appears prudent to offer completion proctectomy. Similarly, for rectal carcinoids >20 mm or with adverse features, radical surgery with mesorectal clearance should be offered to suitable patients [17].

Due to unacceptable rates of local recurrence, patients with T2 lesions should be recommended to undergo radical mesenteric excision. Local excision following neoadjuvant therapy for rectal cancer may also be considered, preferably within a clinical trial, especially in the setting of a complete pathologic response [12, 18]. TAMIS local excision may be considered in this scenario, however, as a less invasive but oncologically inferior alternative to radical excision in those patients with excessive comorbidities, or who refuse radical surgery or a permanent colostomy. Finally, in patients with metastatic disease, TAMIS may be utilized for potential palliation and symptom control.

There are no notable absolute contraindications for TAMIS. For patients with very distal lesions (within 2 cm of the dentate line), obtaining an adequate seal with TEM is problematic. Most flexible transanal ports on the other hand are between 4 and 5 cm in length and "hook" into place on the anorectal ring, thus obscuring the dentate line and distal rectal mucosa. TAMIS surgeons have overcome this through development of a hybrid technique where the dissection is initiated using a traditional anorectal retractor for 1–2 cm above the dentate line, prior to inserting the port and completing the excision (Fig. 3.1). Despite the notion by some that traditional TAE can be employed in these cases, there are major advantages to perform

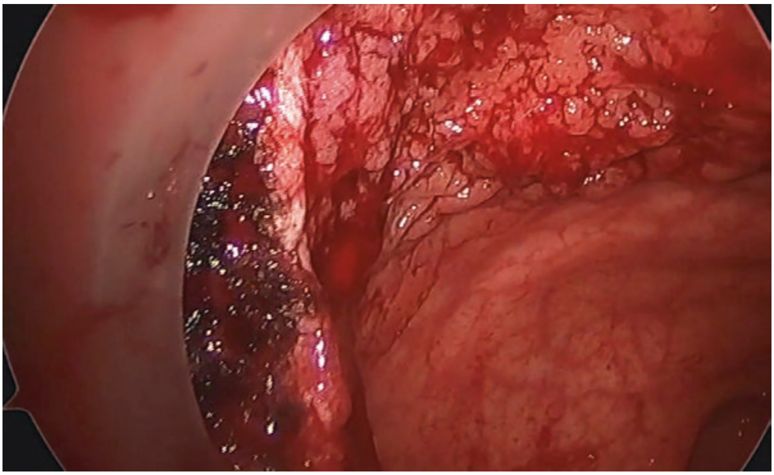

Fig. 3.1 Utilizing a hybrid technique allows the surgeon all of the benefits of TAMIS for even the most distal lesions. The photo demonstrates a large villous adenoma extending from the anterior midline half the luminal circumference to the posterior midline. The access channel is secured within the rectal lumen; however, the distal margin has already been created with a mucosal incision utilizing a standard anorectal retractor and dissecting proximally 1–2 cm

transanal endoscopic surgery in this scenario, specifically lesions that start low but extend far proximally, lesions that occupy more than a third of the lumen where frequent retractor changes are necessary, and lastly in large bulky adenomatous lesions where major specimen fracture is inevitable. Caution must also be exercised in upper third rectal lesions situated anteriorly, as the peritoneum may be entered during resection. While the majority of these peritoneal entries can be repaired using a transanal approach [19], laparoscopy may also be required for confirmation of closure or assisted repair and advanced practitioners may best manage these lesions [20]. Furthermore, lesions in the upper rectum and distal sigmoid colon can also be challenging to resect. TEM's superiority over TAMIS is demonstrated primarily in its ability to reach more proximally. The rigidity of the rectoscope permits the rectum to be stented open, with reports of excision as high as 25 cm. As a result, longer channel TAMIS ports have been constructed and already being utilized in clinical practice.

Regarding nontraditional indications, TAMIS has been used to repair rectourethral and complex Crohn's fistulas, revise strictured low rectal anastomosis, repair rectoceles, ligate bleeding vessels, and even extract foreign bodies [21]. Other reported novel applications include repairing a low rectal anastomosis after a failed leak test and suturing bleeding anastomoses. Furthermore, as transanal approaches to rectal surgery evolve, transanal TME (TaTME) has come to the forefront as a new and exciting approach to performing minimally invasive proctectomy with sphincter preservation. TAMIS is rapidly becoming the preferred access modality [22, 23]; indeed, the first completely transanal TME reported was performed using TAMIS [24].

Preoperative Workup

A thorough disease history should be obtained eliciting disease-specific symptoms, associated symptoms, and family history. Patients must also be assessed for their fitness to undergo surgery. Routine laboratory values, including carcinoembryonic antigen (CEA) levels, should also be evaluated in an attempt to identify an underlying focus of carcinoma. A full physical examination, including rigid proctoscopy, should be performed by the operating surgeon in conjunction with a digital rectal examination to determine the distance of the lesion from the anal verge and mobility and to assess its position in relation to the sphincter complex. All patients with a rectal lesion should undergo a full colonic evaluation with colonoscopy if possible before treatment to out rule any synchronous disease. Precise preoperative lesion localization is imperative for surgical planning, and the combination of physical examination with flexible and rigid proctoscopy will enable the determination of anterior or posterior location, relation to the valves of Houston, distance from the anal verge in centimeters, size, and distribution (% involvement of wall).

The majority of lesions planned for local excision will have a preoperative histological diagnosis that is benign, but up to 20 % of patients with a preoperative diagnosis of adenoma will have an invasive adenocarcinoma on final pathology. If concern exists regarding the appearance of the polyp or in certain patients with an invasive lesion that is being considered for local excision, radiological assessment is indicated.

The goal of the radiological preoperative evaluation is to identify lesions that are suitable for local excision by determining the radiological TNM stage, as defined by the American Joint Committee on Cancer based on the depth of local tumor invasion (T stage), the extent of regional lymph node involvement (N stage), and the presence of distant metastasis (M stage).

Endorectal ultrasound (ERUS) with rigid or flexible probes and MRI with either endorectal or increasingly phase array coils are the primary tumor-staging modalities of choice. It must be noted ERUS is more accurate in the determination of T stage for early lesions with over-staging of T1 tumors observed in 11 % of cases compared to 100 % of those staged with MRI [25]. Accurate detection of involved lymph nodes remains a diagnostic challenge for all imaging modalities, but is likely that MRI is superior in this setting. Thus ERUS and MRI should be considered complementary in the setting of early rectal cancer assessment. It must be noted that a biopsy or local excision of the target lesion prior to radiological assessment may lead to reactive lymphadenopathy, which may be confusing and lead to over-staging. If a preoperative diagnosis of invasive disease is made, all patients should have preoperative radiological staging to assess for metastatic disease with a CT scan of the chest, abdomen, and pelvis.

Operative Details

Mechanical bowel preparation should be administered preoperatively and prophylactic antibiotics given in accordance with departmental guidelines. Following informed consent, patients should be administered general endotracheal anesthesia with pharmacologic paralysis. The patient should be positioned for TAMIS in the high dorsal lithotomy position, which allows access to lesions in any location. Access to anterior lesions in fact can be extremely advantageous in lithotomy, which is facilitated by gravity (Fig. 3.2). This differs to TEM where the 30° camera is situated anteriorly within the lumen of the beveled resectoscope, necessitating the patient being positioned with the target lesion placed dependently. Following antiseptic skin preparation and appropriate draping, the transanal port is inserted and sutured in place (Fig. 3.3a, b). TAMIS devices are easy to set up and insert; the setup time for TAMIS is typically 1–3 min [11, 20]. Currently there exist five TAMIS platforms in common usage: GelPOINT Path™ (Applied Medical Inc, Rancho Santa Margarita, CA), SILS™ (Covidien, Mansfield, MA), SSL™ (Ethicon Endo-Surgery, Cincinnati, OH), TriPort™ (Olympus KeyMed, Southend, UK), and the improvised Gloveport. Currently, transanal platforms utilized for TAMIS are determined by individual surgeon preference. No comparative data in humans currently exists. It must be noted

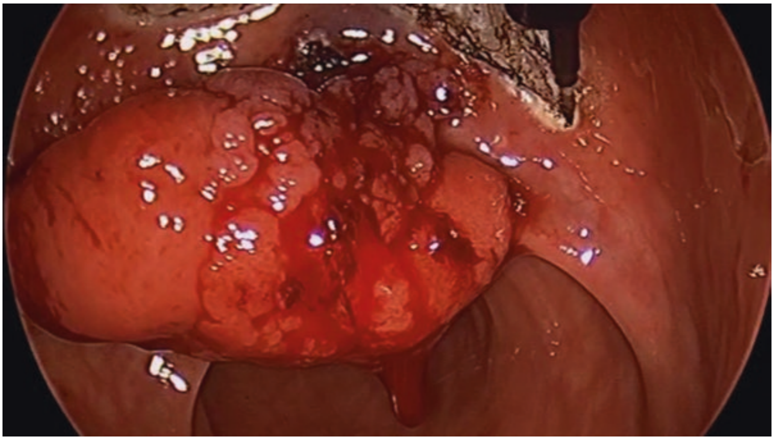

Fig. 3.2 Contrary to transanal endoscopic microsurgery (TEM), transanal minimally invasive surgery (TAMIS) can be performed for all patients in lithotomy position including anteriorly based lesions which permits operating in a direct horizontal access and is facilitated by gravity

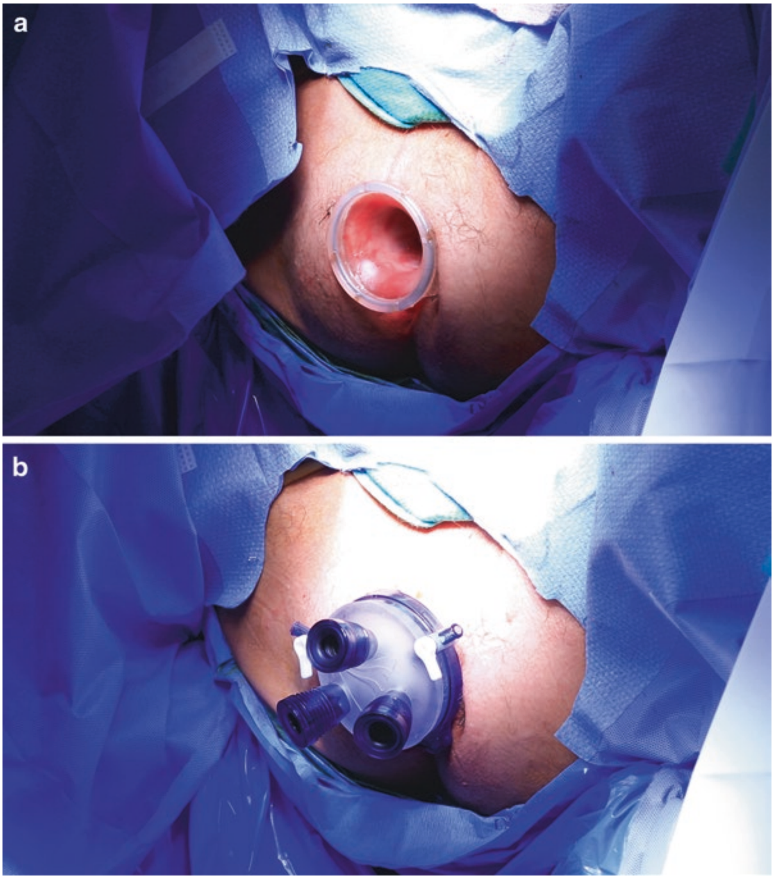

Fig. 3.3 (**a**) The GelPOINT Path (Applied Medical, Rancho Santa Margarita, CA), one of two ports FDA approved for use in TAMIS and transanal TME (TaTME), is shown first with the 40 mm access channel in place and properly secured in the anorectum. (**b**) Following connection of the GelSeal cap with trocars already placed in the appropriate location

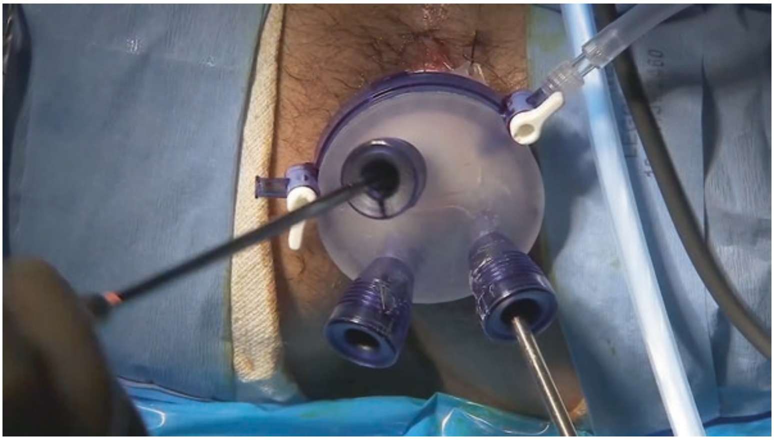

Fig. 3.4 A port used for TAMIS is demonstrated properly secured within the anorectum and shown with attached insufflator, 5 mm 45° camera, and two working instruments

that the *GelPOINT Path*™ is the only access system to date custom designed for the purpose of transanal surgery and, along with Covidien SILS port, FDA approved for transanal use.

The pneumorectum is then established by using standard CO_2 insufflation with an initial pressure set at 15 mmHg and flow set at 40 mmHg per minute. Recently, new insufflators have been developed (Surgiquest Airseal, CT) which provide improved stability of pneumorectum at lower pressures in addition to dramatically reducing intraluminal smoke. A high-definition laparoscopic camera is inserted then to visualize the target lesion through any of the working ports (Fig. 3.4). A 30° or 45° camera lens is preferable for assessment of the lateral and proximal margins. Furthermore, a 5 mm camera provides more working space in the tight confines of the rectum than a 10 mm camera. Roticulating laparoscopes and even three-dimensional laparoscopic images (Olympus) can provide further enhanced visualization with less collision. Image stabilization and sufficient visualization of the working space are dependent on an experienced assistant surgeon.

A premium should be placed on the surgical technique and quality of resection; a non-fragmented specimen with negative margins has repeatedly demonstrated the lowest risk of recurrence. The lesion margin is first scored out on the mucosa using electrocautery with a 5–10 mm margin in order to maintain orientation and proper margins of resection (Fig. 3.5). Excision can be performed using standard monopolar electrocautery. Use of a spatula, pinpoint, or L-hook cautery allows precise dissection of the tumor and is cheap and reusable. The majority of practitioners utilize standard, straight laparoscopic instruments to perform excision, rather than roticulating instruments (Fig. 3.6). Energy devices can also be used with the principal advantage being hemostasis, albeit with increased costs. Handling of the tumor or polyp with graspers should be avoided and reduced to the surrounding mucosa to limit tumor fragmentation. On all lesions known to be malignant preoperatively, a full-thickness excision must be performed with the objective of obtaining a 1 cm

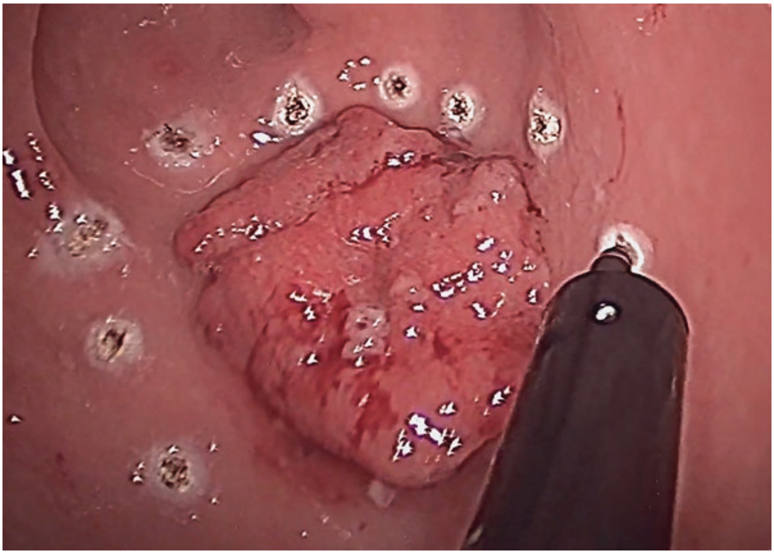

Fig. 3.5 Mid-rectal early rectal cancer (T1) at 9 cm posterior circumferentially marked out circumferentially with monopolar cautery

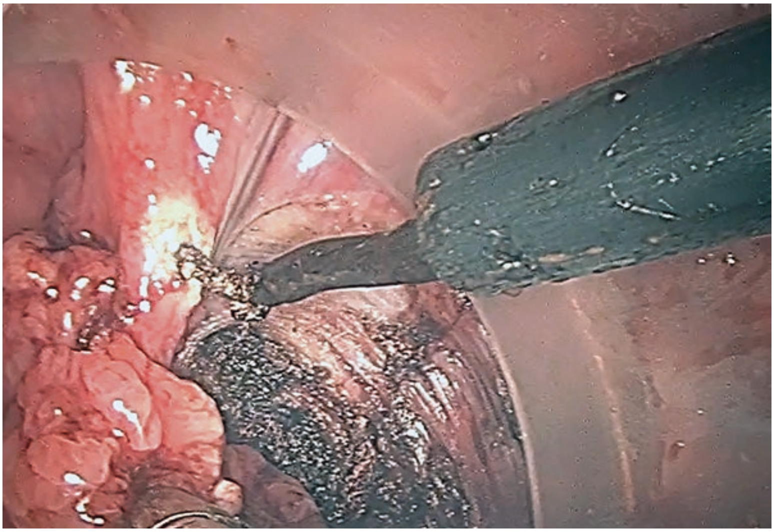

Fig. 3.6 A simple grasper, in this case a curved dissector, is used in conjunction with an L-hook monopolar cautery tip through two working trocars. Optimally, the mucosa adjacent to the tumor should be grasped to avoid specimen fracture. Energy devices can be used as an alternative to monopolar cautery

Fig. 3.7 Full-thickness excisions for malignancy located posterior in the rectum can be excised with a portion of mesorectal fat without breaching the mesorectal fascia. Defects such as this in the extraperitoneal rectum technically do not require closure

minimum negative margin (Fig. 3.7). In contrast to the historical description of a simple full-thickness incision into perirectal fat, we support a pyramidal, volumetric excision containing an adequate specimen of perirectal fat as described by Lezoche. This assures an adequate resection with negative margins, in addition to possibly retrieving surrounding lymph nodes for pathologic sampling. Aggressive mesorectal excision, as described, should not breach the mesorectal fascia for concern of increasing the difficulty of total mesorectal excision should it become necessary.

For lesions believed to be benign, a partial-thickness or submucosal excision may be performed at the discretion of the operating surgeon. Submucosal excision is often not possible in patients with multiple prior attempts at endoscopic polypectomy given the obliteration of planes from inflammation and fibrosis. Proponents of this technique maintain that the possible increased risks of morbidity with deeper defects, as well as the low risk of significant malignancy in a clinically benign lesion, make this the preferred technique. In addition, submucosal excision leaves minimal inflammation and distortion should total mesorectal excision be required. However, lesions excised in a submucosal fashion are at risk of fragmentation during specimen extraction, and due to the high risk of a focus of invasion in large rectal adenomas, some authors advocate a full-thickness excision in all cases.

Specimen extraction should be performed at completion of resection and prior to closure to maintain specimen integrity and avoid accidental proximal migration. The majority of platforms accommodate this by allowing removal of the faceplate; however, some ports require removal of the entire device with reinsertion for closure. Irrigation of the excision bed with dilute Betadine, presumably for its tumoricidal

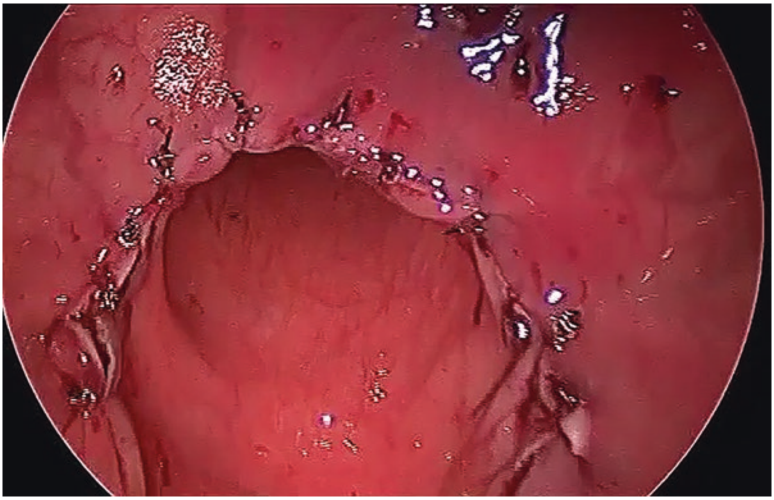

Fig. 3.8 A completed defect closure following excision of a large villous adenoma. Closure is performed with interrupted figure of eight sutures and secured with a knot-tying device and silver clips (LSI Solutions RD 180, TK (Ti-Knot), Victor, NY)

and bactericidal effects, is a common practice; however, no evidence-based literature exists to support this technique.

Rectal wall or mucosal defects are then closed in a full-thickness manner completely with absorbable suture material. A running suture beginning in the lateral portion of the incision can be performed but is technically more challenging. The use of a V-Loc™ suture (Covidien, Mansfield, MA) can facilitate continuous closure by maintaining tension and negating the need for knot tying. Conversely, closure can be performed in an interrupted fashion with knot tying facilitated by laparoscopic knot pushers. The use of modern suturing devices can significantly shorten the learning curve at the expense of increased procedural costs. Specialized silver beads with applicators were initially designed for use with the TEM system; however, several other simpler laparoscopic knot-tying devices and methods have since become available (Fig. 3.8).

Postoperative Care

Patients can safely undergo discharge on the same day of surgery. All patients must be counseled on the signs of early and late postoperative hemorrhage and pelvic sepsis. Selective postoperative overnight admission can be considered in the context of patient comorbidity. Should the peritoneal cavity be entered, the surgeon may consider contrast examination the following postoperative day prior to discharge. A prolonged postoperative stay or prolongation of preoperatively administered antibiotics is generally not necessary.

Complications

The reported complications of TAMIS to date have been relatively minor. The most common is post-procedural hemorrhage, which can occur early in the postoperative period or can be delayed in presentation [20, 26–28]. Cases of post-procedural hemorrhage that do not stop spontaneously have in all cases been managed successfully either colonoscopically or with examination under anesthesia and under sewing. Scrotal emphysema has been reported [20], which resolves spontaneously. Transient pyrexia has been reported following TAMIS which resolved with oral antibiotic treatment [26] and urine retention has occurred which was treated with urethral catheterization [27].

Intraperitoneal entry is one of the primary intraoperative complications of which practitioners must be aware [20]. This tends to occur during the resection of larger lesions, with an anterior location, with an uppermost level over 10 cm from the anal verge [29]. In the largest TAMIS series published to date, the incidence of peritoneal entry was 2 % [20]. In the TEM literature, the incidence is reported as 6–8.6 % [19, 29]. The intra- and postoperative management of this complication must be individualized to the size of the defect and the patient. The defect can be repaired either transanally or with a combined laparoscopic approach. The decision to fashion a diverting ostomy must also be individualized to the patient and their ability to tolerate an anastomotic leak with reported incidence of diverting ostomy in the setting of TEM being 0–14 % [19, 29]. A prolonged course of antibiotic coverage should also be considered.

Analysis of anorectal function following TEM has shown at 3 months following excision, the mean Wexner continence score deteriorates, with associated symptoms of fecal urgency, but returns to baseline within 5 years [30]. Postoperative manometry values at 3 months are significantly lower than at baseline, but return to preoperative values at 1 year [30, 31]. A recent series of 25 patients undergoing TAMIS with a SILS™ port assessed at 3 months following surgery with endoanal ultrasonography and a fecal incontinence severity index (FISI) score did not show anal sphincter injury or fecal incontinence-related symptoms, respectively. A further series of 37 patients undergoing TAMIS with SILS™ or SSL™ ports revealed an improvement in FISI score for patients with impaired preoperative continence [32]. Thus, there has been no demonstration to date that the performance of TAMIS adversely affects patient continence.

Follow-Up

The follow-up of patients following TAMIS should be individualized as to whether the lesion is benign or malignant and if the excision was complete. For patients following the excision of malignant lesions, in accordance with the National Comprehensive Cancer Network (NCCN) guidelines, a history, physical examination, rigid proctoscopy, and serum CEA level should be performed every 3 months for 2 years, then every 6 months for a total of 5 years. A full colonoscopy at 1 and 3 years following resection should be performed and every 5 years thereafter to identify metachronous lesions. It is the authors' practice to further perform an MRI pelvis to identify suspicious lymph nodes every 6 months for the first 2 years following resection of early T1 cancers. Following the complete excision of benign lesions, practitioners should follow societal guidelines [33], but if the excision has a positive margin, an early surveillance endoscopy at 3 months is prudent.

Tips and Tricks

At the commencement of TAMIS practice, one should carefully select suitable patients, posterior, <3 cm, mid-rectal lesions often being the best candidates. Absolute rectal cleansing is essential for safe dissection. Positioning the patient in the high lithotomy position optimizes ergonomics and ensures surgeon comfort during the learning phase. Endotracheal intubation and complete patient paralysis are essential in reducing abdominal wall contraction, rectal collapse, and loss of pneumorectum, with it a safe view for dissection. In certain cases the insertion of the TAMIS port can be challenging. Gentle finger dilation and the use of topical anal glyceryl trinitrate (GTN) can aid in sphincter relaxation [34] or the application of a Lone Star Retractor System™ (Cooper Surgical) will help in anal effacement. TAMIS uses traditional laparoscopic insufflators, which produce flow up to the preset pressure, briefly pause, and then recycle and reinitiate insufflation. New insufflators such as the Surgiquest Airseal™ provide improved stability of pneumorectum at lower pressures in addition to dramatically reducing intraluminal smoke. Marking a 1 cm circumferential margin before the commencement of dissection and performing a full-thickness excision are essential in reducing margin positivity. The nature of TAMIS is dynamic; thus the camera angle can be changed as can the configuration of the ports to facilitate dissection. Dissection should proceed from distal to proximal, and when complete, care must be taken not to lose specimen orientation during extraction. Intracorporeal suturing within the narrow confines of the rectum to close the resultant defect can be extremely challenging. Automated suturing and knot-forming devices can aid significantly with the more technically demanding aspect of wound closure.

Conclusions

Based on current available clinical data, TAMIS in experienced hands results in the high-quality local excision of rectal lesions with low histological margin positivity in an efficient manner with an excellent morbidity profile. TAMIS has enabled the performance of high-quality local excision of rectal lesions by many colorectal surgeons, integrating it into mainstream practice, not just the motivated few practitioners with an interest in and access to TEM equipment. Currently surgeon preference and device availability govern which platform is selected for use. As this technique becomes further popularized, however, the acquisition of appropriate training must be ensured and the continued assessment and assurance of oncological outcome must be maintained.

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Chapter 4
Laparoscopic Procedures: Laparoscopic Low Anterior Resection

Skandan Shanmugan and Bradley J. Champagne

Introduction

Laparoscopic colectomy has been proven to be equivalent to conventional open surgery and is now generally agreed to offer patients a reduced length of stay, shorter recovery times, and improved long-term outcomes [1–4]. In contrast, acceptance of minimally invasive rectal surgery has been delayed and the enthusiasm of early studies has met considerable skepticism. The feasibility of laparoscopic low anterior resection (LAR) in expert hands has been demonstrated, but randomized controlled trials comparing it to the open technique are lacking. The short-term results of the phase III COLOR II trial showed that in selected patients with rectal cancer treated by skilled surgeons, laparoscopic surgery resulted in similar safety, resection margins and completeness of resection to that of open surgery [5]. In a recent query of the National Cancer Data Base, 18,765 patients were identified to either open or laparoscopic LAR (34.3 % LLAR, 65.7 % OLAR) [6]. Complete resection was more common in patients undergoing LLAR (91.6 vs. 88.9 %, $p<0.001$), and statistically significant benefits were observed for gross, microscopic, and circumferential (>1 mm) margins (all $p<0.001$). There was no difference in median number of lymph nodes obtained (15 vs. 15). Patients undergoing laparoscopic LAR had shorter lengths of stay (5 vs. 6 days, $p<0.001$) without a corresponding increase in

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30-day readmission rates (6 vs. 7%, $p=0.02$). The American College of Surgeons Oncology Group is currently conducting a randomized controlled trial (ACSOG-Z6051) evaluating the superiority of both techniques. However, results from this study will not become available for some time, and in the interim, it is important to better define the oncologic equivalence of laparoscopic LAR, especially given the increasing use of laparoscopy in colorectal surgery.

The marginal quality and limited volume of evidence for laparoscopic rectal surgery can be attributed to the prolonged learning curve and poorly defined indications and contraindications for resection. In the pelvis, the restrictive bony landmarks heighten the learning curve and skill level required to perform a proper laparoscopic resection. Despite these challenges, laparoscopic rectal surgery can often enhance the pelvic dissection because of better visualization and magnification. Inevitably, advances in instrumentation, combined with greater experience and better training, will in time allow surgeons to perform laparoscopic rectal surgery and achieve unequivocally excellent results.

There are currently a variety of operative approaches used for laparoscopic low anterior resections. Therefore, it is important to define what truly constitutes a minimally invasive low anterior resection. Most surgeons use a left lower quadrant or periumbilical incision to extract the specimen for any left-sided colorectal resection. This is well tolerated by patients and typically requires recreation of the pneumoperitoneum to perform the anastomosis laparoscopically. Some surgeons perform the pelvic dissection and retraction through a Pfannenstiel incision and also utilize this incision to transect the rectum. Most purists feel that this hybrid technique reduces the benefits of laparoscopy. We feel strongly that the dissection of the rectum in the pelvis must be laparoscopic because ultimately we are trying to understand and realize the benefits of this approach. This can be performed by straight or hand-assisted techniques depending on the prior experience of the operator. In cases where the pelvic dissection is performed by open techniques through a Pfannenstiel or lower midline incision, the cases should be classified as open for the purposes of both billing and the assessment of outcomes.

Indications and Contraindications

The indications for performing a laparoscopic low anterior resection with either a handsewn or stapled colorectal or coloanal anastomosis are as follows:

High (11–15 cm from anal verge) rectal tumors that require takedown of the anterior peritoneal reflection to achieve a 5-cm distal margin as most of these lesions in the proximal rectum are treated like colon cancer.

Middle (6–10 cm from anal verge) to low (4–5 cm from anal verge) rectal tumors with ≥1-cm distal margins. A double stapled coloanal anastomosis will require an additional 1–2-cm margin.

The *absolute* contraindications for performing a laparoscopic low anterior resection include patients with hemodynamic instability or fecal peritonitis. The *relative* contraindications depend on the experience of the surgeon and patient characteristics that may prohibit safe laparoscopy. Such characteristics include:

Morbid obesity
Severe cardiac and pulmonary disease prohibiting a long operation
Pregnancy
Previous adhesions and scarring
Bulky lesions that invade the surrounding organs such as the prostate or trigone of the bladder and require a full pelvic exenteration

Preoperative Workup

As with every preoperative plan, an informed consent, and frank discussion with the patient in regard to the risks and benefits, potential complications and alternatives to the procedure provide a realistic gauge of the patient's expectations. A very detailed discussion about expectations regarding postoperative function and fecal incontinence is also essential. Many patients may technically be able to have reconstruction but "should" not because of their occupation or lifestyle. Some procedures may also warrant a preoperative multidisciplinary approach with the urologist, gynecologist, oncologist, and radiologist. Therefore all parties involved should evaluate the patient appropriately. The possibility of conversion to open surgery should always be discussed as well as the need for additional procedures including an intraoperative colonoscopy or a rigid proctoscopy.

Preoperative evaluation of the patient's overall fitness and determination of operative risk includes:

Medical and/or cardiology clearance
Preadmission testing or evaluation by anesthesiologist
Complete blood count (CBC), comprehensive metabolic panel (CMP), tumor markers, coagulation panel, type and screen, and evaluation of nutritional status with albumin or prealbumin
Preoperative counseling for stoma care, education, and marking
Evaluation of preoperative fecal incontinence and possible anal manometry for elderly patients
Preoperative mechanical bowel preparation with oral antibiotics
Consideration to placement of preoperative bilateral ureteral stents if necessary

Preoperative evaluation specific to rectal cancer includes:

Digital rectal exam and/or flexible sigmoidoscopy/rigid proctoscopy
Biopsy-proven diagnosis
Colonoscopy to exclude synchronous lesions

Endorectal ultrasound and/or pelvic MRI for T and N staging
Computed tomography (CT) or positron emission tomography (PET) to evaluate distant or local metastasis

Operative Details

Equipment

The essential laparoscopic tools for performing a successful laparoscopic low anterior resection include a 5- and 10-mm 30° camera, a thermos with warm sterile water, atraumatic laparoscopic bowel graspers, laparoscopic scissors with electrocautery capability, a bipolar energy device, and laparoscopic staplers. It is our practice to use a 10-mm Hasson balloon port with multiple 5-mm working ports. A 12-mm working port should also be available to upsize a 5-mm port for introduction of the stapler.

Patient Positioning and Preparation

The patient is placed supine on the operating table on a beanbag with both arms or one arm (with more comorbidities) tucked. Appropriate and timely preoperative antibiotics, beta blockers, and DVT prophylaxis are administered per SCIP guidelines. After induction of general anesthesia and insertion of an orogastric tube and Foley catheter, the legs are placed in yellow fin stirrups.

The beanbag is aspirated to help fix the patients' arms by their sides and prevent them from sliding on the table during steep Trendelenburg position. The patients' extremities should be well padded to avoid any trauma at bony prominences.

It is also important to ensure adequate exposure of the perineal area off the edge of the operating table to allow easy passage of the circular stapler or placement of a Lone Star retractor in the case of a handsewn coloanal anastomosis. The previously marked stoma site should now be tagged with a needle tip to prevent losing the mark during preparation.

It is our practice to administer rectal irrigation with Betadine solution. The abdomen is prepped and draped in the usual sterile fashion at both anterior axillary lines and across the xiphoid and pubis. It is preferable to laparoscopic draping with built-in pockets to secure cords, tubing, and instruments.

Instrument Positioning and Port Insertion

The primary monitor is placed on the left side of the patient at approximately the level of the hip. The secondary monitor is placed on the right side of the patient at the same level and is primarily for the assistant during the early phase of the operation and during port insertion. The operating instrument table is placed between the patient's legs. There should be sufficient space to allow the operator to move from either side of the patient or between the patient's legs for mobilization of the splenic flexure, if necessary. The primary operating surgeon stands on the right side of the patient with the assistant standing on the patient's left. The assistant moves to the right side, caudad to the surgeon once ports have been inserted. A 30° camera lens is generally used. The umbilical port is inserted using a modified Hassan approach, with a vertical 1-cm subumbilical incision. A 10-mm balloon port is inserted through this port site allowing the abdomen to be insufflated with CO_2 to a pressure of 15 mmHg. After initial laparoscopy, a 5-mm port is inserted in the right lower quadrant 2–3 cm medial and superior to the anterior superior iliac spine. If a low rectal transaction is anticipated, this port may be placed 1 or 2 cm further medially. A 5-mm port is then inserted in the right upper quadrant at least a hands-breadth above the lower quadrant port. A left mid-quadrant 5-mm port is inserted. All of these remaining ports are kept lateral to the epigastric vessels. For a low rectal transection, a 12-mm port can be inserted through the planned ileostomy site.

Approach to and Division of the Inferior Mesenteric Vessels

After port insertion, the assistant moves to the patient's left side, standing caudad to the surgeon. The patient is then placed into the steep Trendelenburg position and tilted to the right side. This helps move the small bowel away from the operative field. The surgeon then inserts two atraumatic bowel graspers through the two right-sided abdominal ports. To begin laparoscopic surgery, normal anatomy must first be restored whereby previous adhesions to the anterior abdominal wall are lysed sharply with great care. The greater omentum is then reflected over the transverse colon so that it comes to lie on the stomach, which should be decompressed with an orogastric tube. The small bowel is moved to the patient's right side allowing visualization of the medial aspect of the rectosigmoid mesentery (Fig. 4.1). An atraumatic bowel grasper is placed on the rectosigmoid mesentery at the level of the sacral promontory, approximately halfway between the bowel wall and the promontory itself, drawing it anteriorly. In most cases, this demonstrates a groove between the right and or medial side of the inferior mesenteric pedicle and the retroperitoneum (Fig. 4.2). The assistant uses the left mid-quadrant port to provide this exposure and the surgeon then works through the two right-sided ports with a grasper and cautery scissors. Cautery is used to open the peritoneum along this line, opening the plane cranially up to the origin of the inferior mesenteric artery and caudally past the sacral promontory (Fig. 4.3). Blunt dissection is then used to lift the vessels away from the retroperitoneum and presacral autonomic nerves. The ureter is then demonstrated anterior and lateral to the left common iliac artery (Fig. 4.4). If the ureter cannot be seen, and the dissection is in the correct plane, the ureter should be just deep to the parietal peritoneum and just medial to the gonadal vessels. The dissection is continued up to the origin of the inferior mesenteric artery which is

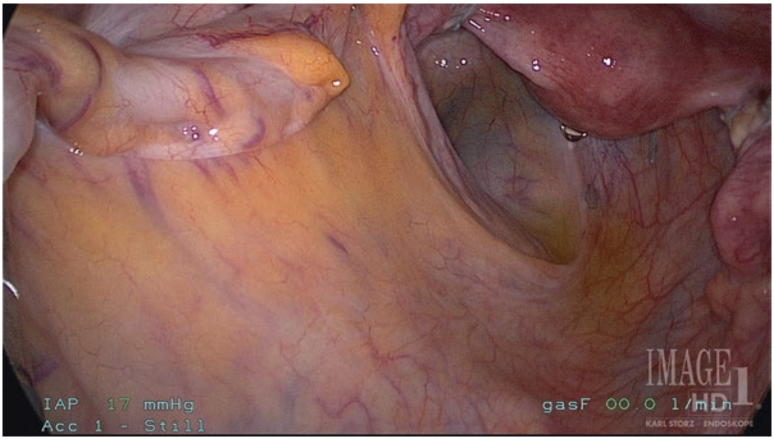

Fig. 4.1 Medial aspect of the rectosigmoid mesentery

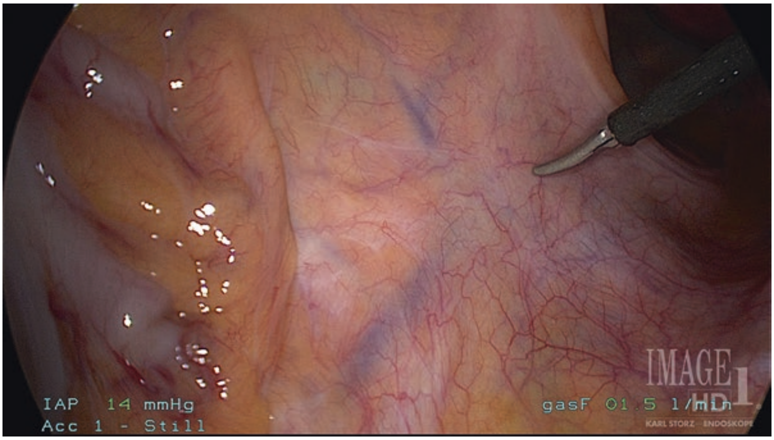

Fig. 4.2 Atraumatic bowel grasper is placed on the rectosigmoid mesentery at the level of the sacral promontory

carefully defined and divided using a high ligation, proximal to the left colic artery (Fig. 4.5). Having divided the vessels at the origin of the artery, the plane between the descending colon mesentery and the retroperitoneum is developed laterally, out toward the lateral attachment of the colon and superiorly dissecting the bowel off the anterior surface of Gerota's fascia up to the splenic flexure (Fig. 4.6). This makes the inferior mesenteric vein quite obvious, and this vessel can be divided two times (after the IMA) and again when it is seen just inferior to the pancreas. This allows increased reach for a coloanal anastomosis.

Fig. 4.3 Cautery used to open the peritoneum, opening the plane cranially up to the origin of the inferior mesenteric artery

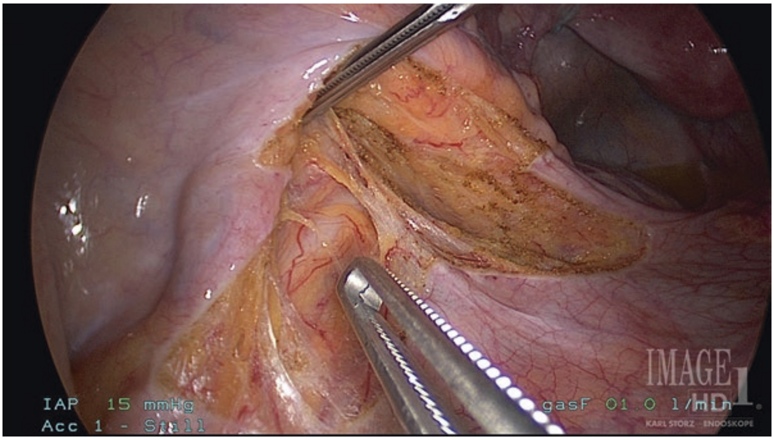

Fig. 4.4 The ureter anterior and lateral to the left common iliac artery

Mobilization of the Lateral Attachments of the Rectosigmoid and Descending Colon

The surgeon now grasps the rectosigmoid junction with his left-hand instrument and draws it to the patient's right side. This allows the lateral attachments of the sigmoid colon to be seen and divided using cautery. Bruising can usually be seen in this area from the previous retroperitoneal mobilization of the colon from the medial to lateral dissection. Dissection now continues 1 mm medial to the white line of Toldt,

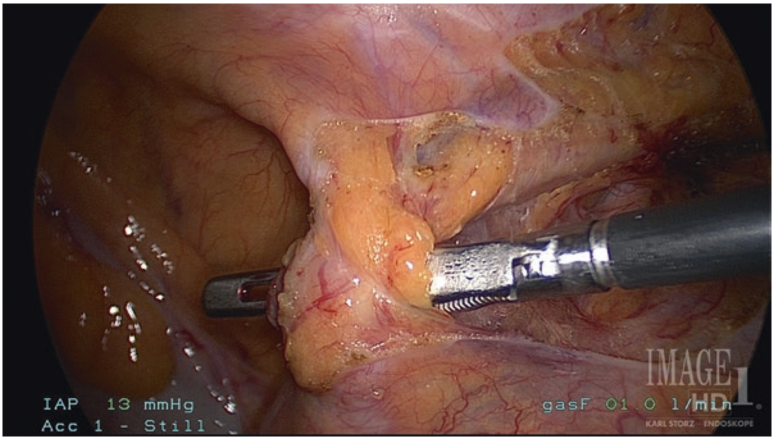

Fig. 4.5 The inferior mesenteric artery, carefully defined and divided using a high ligation, proximal to the left colic artery

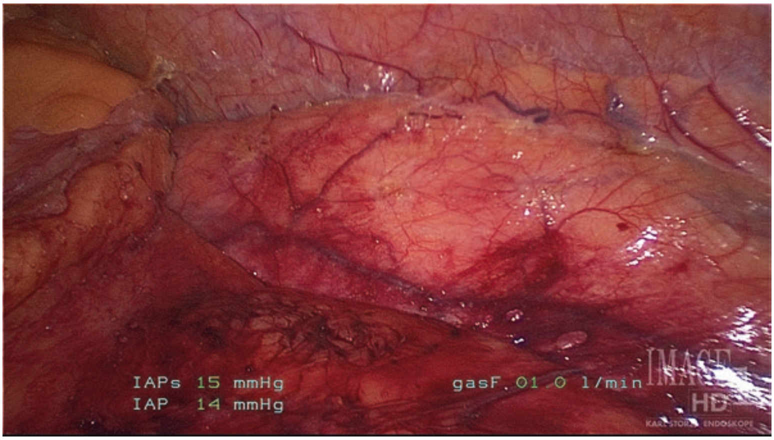

Fig. 4.6 The plane between the descending colon mesentery and the retroperitoneum is developed laterally, out toward the lateral attachment of the colon and, superiorly, dissecting the bowel off the anterior surface of Gerota's fascia up to the splenic flexure

toward the splenic flexure. As the dissection continues, the surgeon's left-hand instrument needs to be gradually moved up along the descending colon to keep the lateral attachments under tension (Fig. 4.7). In this way, the lateral and any remaining posterior attachments are freed, making the left colon and sigmoid into a midline structure (Fig. 4.8). Elevating the descending colon and drawing it medially is useful, as this keeps small bowel loops out of the way of the dissecting instrument and facilitates the dissection. In some patients, particularly very obese or otherwise large patients, it is difficult to reach high enough through the right lower quadrant

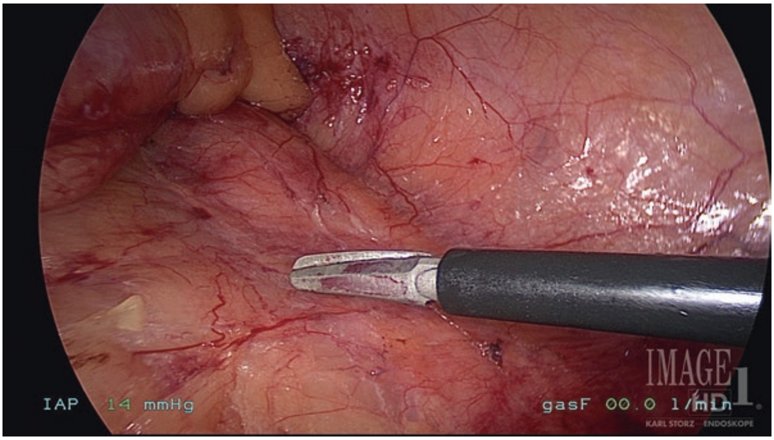

Fig. 4.7 The left-hand instrument gradually moved up along the descending colon to keep the lateral attachments under tension

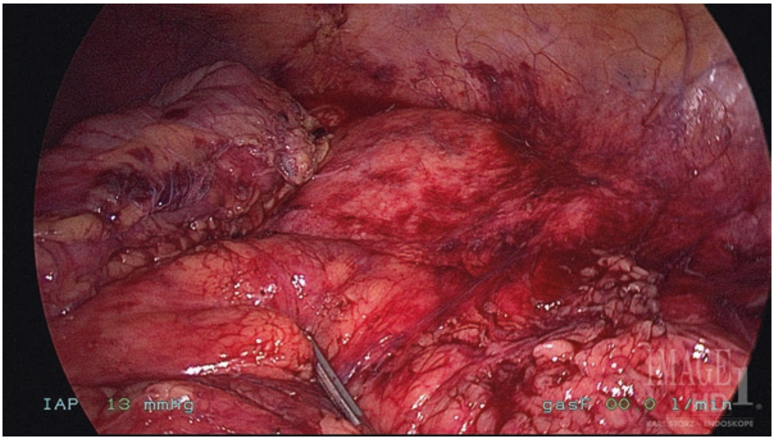

Fig. 4.8 Lateral and any remaining posterior attachments are freed, making the left colon and sigmoid into a midline structure

port. For this reason, the surgeon positions himself/herself between the patient's legs and the surgeon's right-hand instrument is moved to the left mid-quadrant port site. This permits greater reach along the descending colon.

Mobilization of the Splenic Flexure

Complete lateral mobilization of the left colon up to the splenic flexure is performed as the initial step. The descending colon is pulled medially using an atraumatic bowel grasper in the right lower quadrant port and the scissors are placed in the left

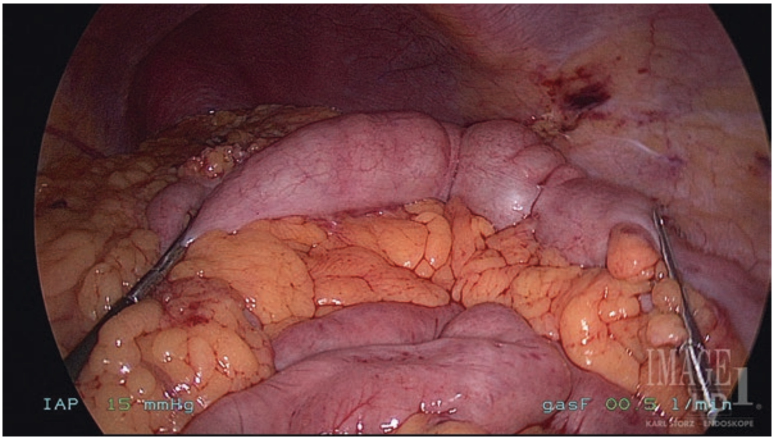

Fig. 4.9 Dissection continued toward the splenic flexure

mid-quadrant port. A 5-mm left upper quadrant port may be necessary, particularly in those with a very high splenic flexure or very tall or obese individuals. Having freed the lateral attachments of the colon, it is necessary to move medially and enter the lesser sac. Some surgeons prefer to perform this as an initial step before lateral mobilization. To enter the lesser sac, the patient is tilted to a slight reverse Trendelenburg position. The assistant holds up the greater omentum, toward its left side, like a cape. The surgeon grasps the transverse colon toward the left side using a grasper in the right lower quadrant port to aid identification of the avascular plane between the greater omentum and the transverse mesocolon. Electrocautery scissors are used via the left mid-quadrant port to dissect this plane and enter the lesser sac. The surgeon may move to stand between the patient's legs for this part of the procedure. This dissection is continued toward the splenic flexure. Following separation of the omentum off the left side of the transverse colon, connecting this dissection to the lateral dissection allows the splenic flexure to be fully mobilized (Figs. 4.9 and 4.10). The colon at the flexure is retracted caudally and medially and any residual restraining attachments divided, bringing the entire left colon to the midline.

Rectal Mobilization

The patient is returned to Trendelenburg position and the small bowel reflected cranially. The rectosigmoid junction is elevated away from the sacral promontory by the assistant in the left mid-quadrant port, to enable entry into the presacral space. An open atraumatic grasper is used through the right upper quadrant port as if mimicking the role of the St. Mark's retractor in an open pelvic dissection (Fig. 4.11). The posterior aspect of the mesorectum is identified and the mesorectal

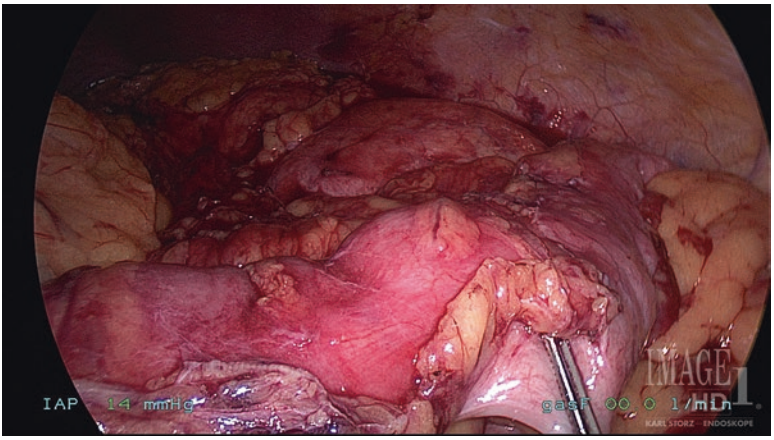

Fig. 4.10 Following separation of the omentum off the left side of the transverse colon, connecting this dissection to the lateral dissection allows the splenic flexure to be fully mobilized

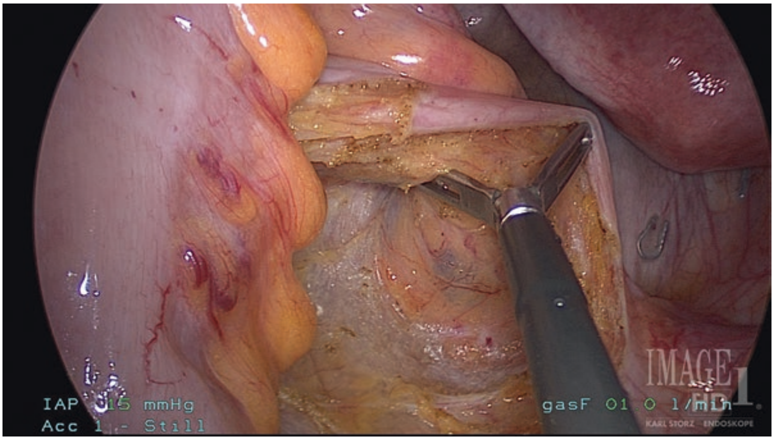

Fig. 4.11 An open atraumatic grasper is used through the right upper quadrant port

plane dissected with cautery scissors, preserving the hypogastric nerves as they pass down into the pelvis anterior to the sacrum. Dissection continues down the presacral space in this avascular, loose areolar plane toward the pelvic floor (Fig. 4.12). Attention is now switched to the peritoneum on the right side of the rectum. This is divided to the level of the seminal vesicles or rectovaginal septum. This is repeated on the peritoneum on the left side of the rectum. This facilitates further posterior dissection along the back of the mesorectum down to the anal canal. For a low anterior resection, it is necessary to perform a total mesorectal excision, and hence the rectum must be dissected down to the muscle tube of the rectum below the inferior

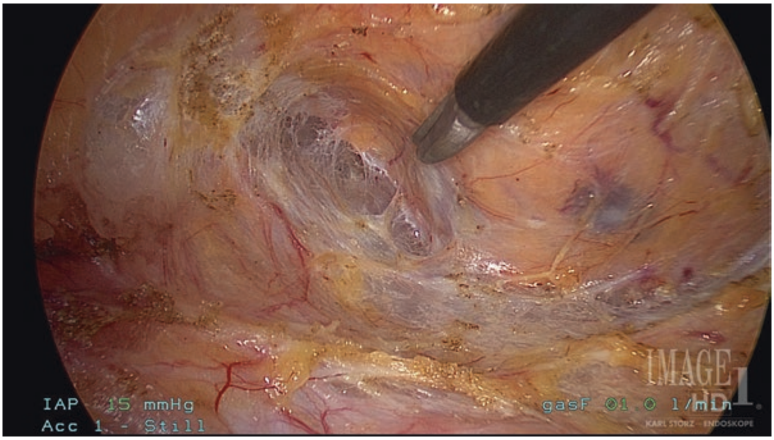

Fig. 4.12 Dissection continues down the presacral space in this avascular, loose areolar plane toward the pelvic floor

extent of the mesorectum. In many cases, particularly those who are obese, or men with a narrow pelvis, some or all of the anterior and lateral dissection must be completed to get adequate visualization to complete the posterior dissection. An atraumatic bowel grasper via the left mid-quadrant port is used to retract the peritoneum anterior to the rectum forward. The peritoneal dissection is continued from the free edge of the lateral peritoneal dissection anteriorly. Lateral dissection is continued on both sides of the rectum and is extended anterior to the rectum, posterior to Denonvilliers' fascia in most cases, separating the posterior vaginal wall from the anterior wall of the rectum or down behind the prostate in a male patient. The difficulty of dissection will vary depending on the body habitus of the patient, the diameter of the pelvis, and the size and level of the tumor. Rectal mobilization can be very difficult to perform laparoscopically under specific circumstances. Low bulky rectal tumors in the anterior position, morbidly obese men, or tumors adherent to the posterior wall of the vagina may need to be completed in an open fashion via a lower midline or a Pfannenstiel incision. In fact, many surgeons perform much of the pelvic dissection in an open fashion using a hybrid or hand-assisted approach.

Rectal Division

Prior to rectal transection, the surgeon must ensure that their distal margin is adequate. Ideally a 2-cm margin is obtained, but recent data suggests that 1-cm or negative distal margin may be acceptable in tumors without high-risk features [7]. A 12-mm port can be inserted through the planned ileostomy site for a very low

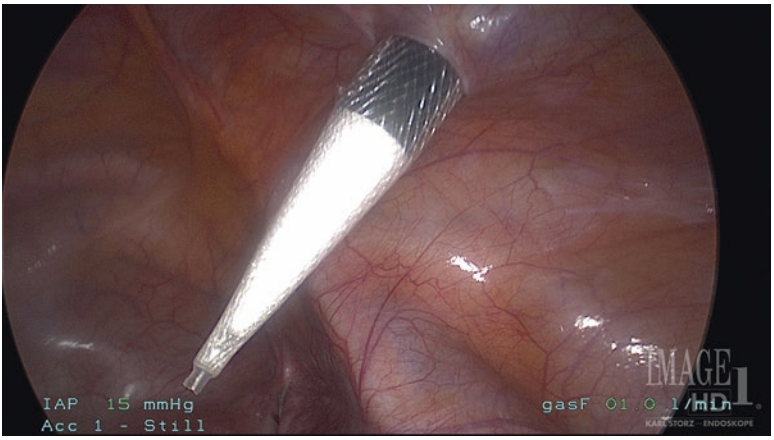

Fig. 4.13 A 12-mm port can be inserted through the planned ileostomy site for a very low tumor or the 5-mm right lower port can be increased to a 12 mm for a proximal lesion

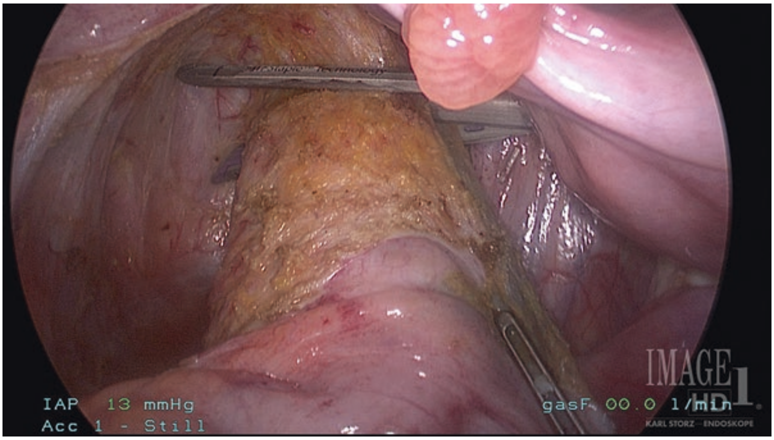

Fig. 4.14 The reticulating stapler inserted through the 12-mm port

tumor or the 5-mm right lower port can be increased to a 12 mm for a proximal lesion (Fig. 4.13). The lower rectum may be divided with a stapler either laparoscopically or via an open approach depending on ease of access related to the size of the pelvis. The reticulating stapler is inserted through the 12-mm port, and two to three firings of the stapler are usually required to divide the rectum (Fig. 4.14). A thick tissue and short load are required to fit low in the pelvis (Fig. 4.15). There is no residual mesorectum to divide at this level (Fig. 4.16). Digital examination is performed to confirm the location of the distal staple line, and if there is any doubt

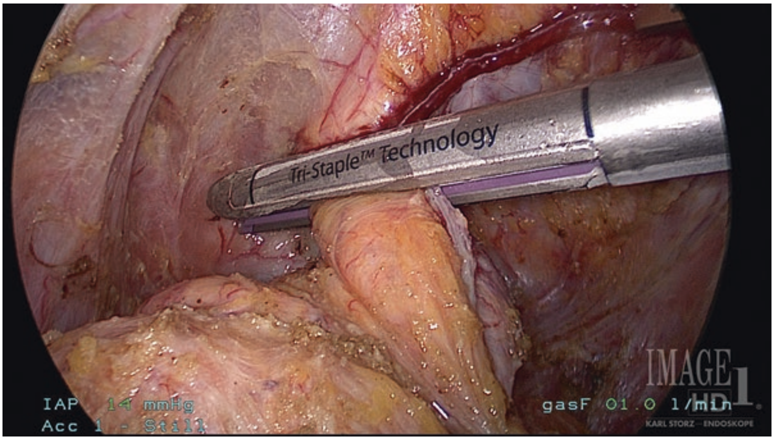

Fig. 4.15 A thick tissue and short load are required to fit low in the pelvis

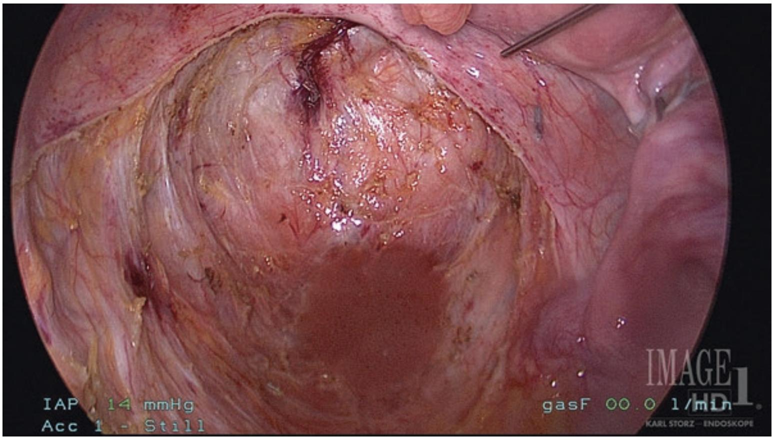

Fig. 4.16 There is no residual mesorectum to divide at this level

about adequacy of the distal margin, a rigid proctoscopy is performed. It is sometimes impossible to divide the rectum laparoscopically as the angulation of the endovascular stapler is limited to 45°, necessitating open division of the rectum or multiple firings. In some patients getting an assistant to push-up on the perineum with their hand may lift the pelvic floor enough to get the first cartridge of the stapler low enough. In some cases placing a suprapubic port allows easier access with the stapler to allow division of the rectum from a top-down approach, perpendicular to the rectal tube.

Specimen Extraction and Anastomosis

The specimen can be extracted either through a Pfannenstiel, periumbilical incision, or through a left iliac fossa incision using a wound protector (Fig. 4.17). The left colon mesentery is divided with cautery. The left colon is divided and the specimen removed. Pulsatile mesenteric bleeding is confirmed and the vessels ligated with 0-Vicryl ties. Depending on the preference of the operating surgeon, a colonic pouch may be fashioned. A purse string is inserted into the distal end of the left colon or pouch, the anvil of a circular stapling gun is inserted, and the purse string is tied tightly. If a Pfannenstiel incision has been made, the coloanal anastomosis can be performed under direct vision and open manipulation following insertion of a circular stapling gun into the rectal stump. However, this visualization is often more challenging than an intracorporeal approach. If a left iliac fossa or periumbilical incision has been used, the colon is returned to the abdomen and the incision closed, the pneumoperitoneum recreated, and the anastomosis formed laparoscopically (Fig. 4.18). The anastomosis can be leak tested by filling the pelvis with saline and inflating the neorectum using a proctoscope or bulb syringe (Fig. 4.19).

Port Site Closure and Ileostomy

The right iliac fossa 12-mm port site is closed laparoscopically and the umbilical port site is closed using the previously inserted purse-string suture. An ileostomy may be made at a preoperatively marked site in the right lower quadrant, if required.

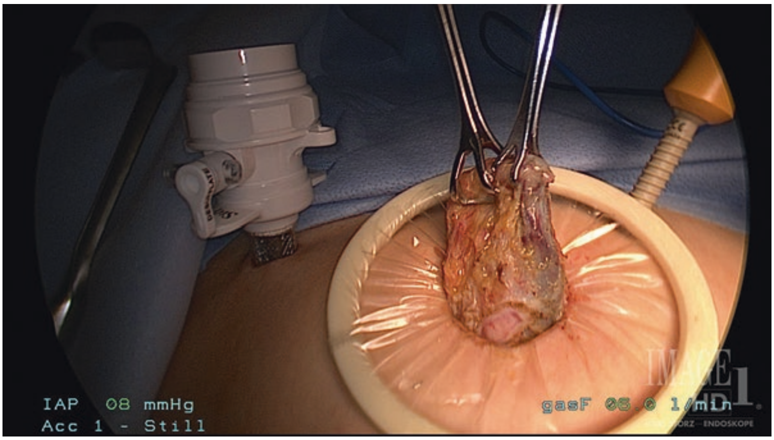

Fig. 4.17 Specimen extracted either through a left iliac fossa incision using a wound protector

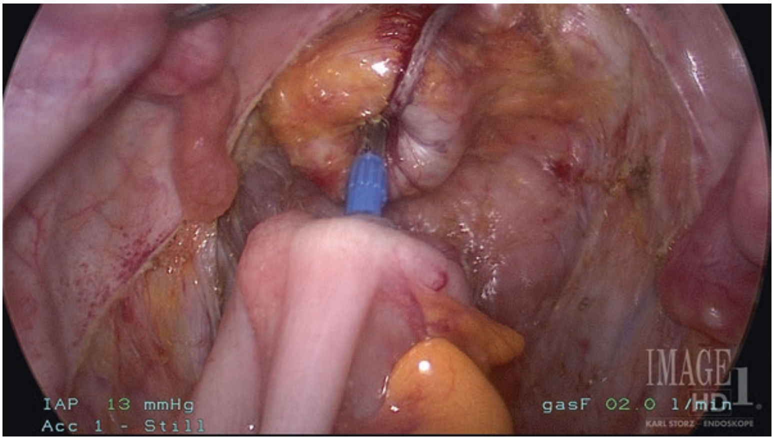

Fig. 4.18 If a left iliac fossa or periumbilical incision has been used, the colon is returned to the abdomen and the incision closed, the pneumoperitoneum recreated, and the anastomosis formed laparoscopically

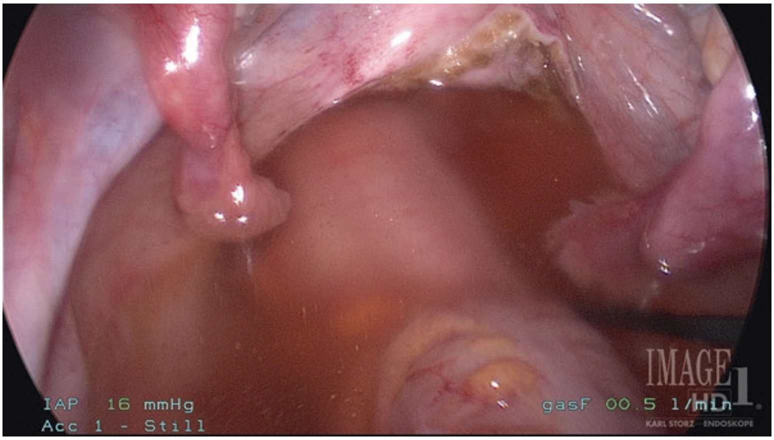

Fig. 4.19 Anastomosis leak tested by filling the pelvis with saline and inflating the neorectum using a proctoscope or bulb syringe

Postoperative Care

It is our practice that patients undergoing a laparoscopic low anterior resection with a diverting loop ileostomy should be enrolled in a pathway for enhanced recovery after surgery (ERAS). Other synonyms include fast-track or enhanced recovery protocols (ERP). These protocols have been well documented to minimize postoperative ileus and pain levels while reducing cardiopulmonary, thromboembolic, and infectious complications [8]. The components of our protocol include:

Appropriate patient selection
Preoperative feeding and carbohydrate loading

Perioperative fluid restriction
Minimally invasive surgery
Multimodal analgesia
Early postoperative mobilization
Early postoperative feeding
Avoidance of systemic opioids

Clear liquids and oral analgesia are started on postoperative day 1. Patients should undergo postoperative enterostomal teaching for care of ostomy and ostomy rods are removed after approximately 2–3 days. Discharge criteria should be established preoperatively and include safe mobility, tolerance of diet, multimodal pain control, and bowel function. The few patients with high ileostomy output are managed with antimotility agents.

Complications

Similar to other abdominal surgeries, possible complications include bleeding, infection, and postoperative ileus. Patients undergoing a laparoscopic low anterior resection with low pelvic anastomosis are at increased risk for anastomotic leakage and sexual and bladder dysfunction, when compared to those undergoing a right colectomy.

The incidence of anastomotic leak varies depending on the level of anastomosis. The risk of anastomotic leak after low anterior resection of the rectum is inversely related to the distance of the anastomosis from the anal verge and ranges from 7 to 20 % for low pelvic anastomoses [9]. Neoadjuvant therapy may increase the risk of anastomotic leak following laparoscopic surgery for rectal cancer. The creation of a diverting stoma proximal to a high-risk anastomosis minimizes the severe consequences of a leak but does not reduce the incidence of leak itself [10].

Ureter injuries in colorectal surgery can occur during laparoscopic low anterior resections during high ligation of the inferior mesenteric artery, during mobilization of the upper mesorectum at the level of the sacral promontory, and during the deepest portion of the pelvic phase of proctectomy. The key to avoiding a major complication is the intraoperative recognition and repair of a ureteral injury, sometimes facilitated by the use of preoperative ureteral stents. Repair of ureteral injuries is best performed by a urologist if available.

Bladder injuries can also occur, especially in the setting of an adherent rectosigmoid tumor or diverticular phlegmon. When the bladder wall is either resected or opened, the resulting defect can be closed in two layers with a Foley catheter left in place for 7–10 days postoperatively. A cystogram is often obtained prior to removal of the catheter to confirm healing. Interposition of the omentum between any bladder repair and a bowel anastomosis is advised to prevent fistulization.

Sexual dysfunction occurs in 15–50 % of male patients undergoing proctectomy for rectal cancer. The rate is influenced by factors such as patient age, preoperative libido, and neoadjuvant radiation therapy. Damage to the superior hypogastric (sympathetic) plexus most commonly results in retrograde ejaculation [11]. This is the most common type of sexual dysfunction seen in male patients after proctectomy and is also the type most likely to resolve with time. Damage to the pelvic plexus on the pelvic sidewall or the nervi erigentes or cavernous nerves (parasympathetic) anteriorly may result in erectile dysfunction. Preservation of the Denonvillier's fascia, if possible, may reduce the risk of injury to these nerves [12]. Female sexual dysfunction is less well described, but they may also have difficulty with pain, sensation, and sexual dysfunction postoperatively.

Approximately 15 % of patients experience some temporary bladder dysfunction postoperatively but less than 5 % will suffer from permanent dysfunction. The rate of postoperative urinary retention can approach possibly 30 % and can be mediated with replacement and temporary Foley leg bag.

Follow-Up

At long-term follow-up, 10 % of patients may experience low anterior resection syndrome which is classified as increased urgency, frequency, and soilage. Studies also describe 2–4 bowel movements per day on average without to 25 % of patients suffering some degree of incontinence. Most of these symptoms are managed with dietary and behavior modifications.

Creation of a colonic J-pouch has been proposed to decrease frequency and urgency but recent studies have demonstrated probable long-term outcomes in comparison to coloanal or straight colorectal anastomoses [13].

Patients undergoing a laparoscopic low anterior resection for rectal cancer are at 2–25 % risk of local or pelvic recurrence. Overall 5-year survival is stage dependent with rates ranging from 70 to 85 % for resections performed with a curative intent. In experienced hands, laparoscopic rectal surgery for cancer does not appear to increase rates of local recurrence when compared to open pelvic surgery. Cancer patients should be enrolled in the appropriate postoperative surveillance program as dictated by the NCCN guidelines.

Tips and Tricks

The most challenging cases to complete with a minimally invasive approach are male morbidly obese patients with a very narrow pelvis and bulky anterior lesions. In these cases, exposure can be challenging and the stapler also cannot be passed low enough at times. It is also prudent to measure waist hip circumference rations rather than BMI to determine the difficulty of the low pelvis. This may help you appropriately gauge your risk of conversion. During these difficult dissections, a surgeon may opt to perform a transanal intersphincteric dissection, remove the specimen, and then perform a handsewn coloanal anastomosis. This may allow you to complete the process with a laparoscopic approach but the overall function is compromised compared to a stapled approach. Another option is to perform a short Pfannenstiel incision, which allows a linear 30-mm stapler to be positioned and the rectum divided. This is frequently discussed at meetings and by opinion leaders but is much more challenging in practice than described. The greatest limitation in performing laparoscopic surgery for low rectal tumors is the limitations of the instruments, the steep learning curve, and the variety of different approaches introduced to residents/fellows during training.

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Chapter 5
Laparoscopic Procedures: Single-Incision Laparoscopic Colorectal Surgery

Daniel P. Geisler and Deborah S. Keller

Background

Laparoscopy was the greatest technological advance in colorectal surgery in the last quarter century. The first laparoscopic colon resection in the United States was performed in 1991. Since that time, the benefits of a minimally invasive approach for colorectal surgery have been well documented, including earlier return of bowel function, decreased analgesic requirement, faster recovery, superior cosmesis, and shorter length of stay without increasing readmission rates [1–10]. Despite proven benefits, there has been a limited adoption of traditional multiport laparoscopic colorectal surgery. Currently, the use of laparoscopic colorectal surgery is estimated in half of applicable elective cases [11] and even fewer colorectal cancer cases [12]. Reasons cited for limited use include the additional learning curve and added technical and ergonomic complexities of the surgery. Multiple minimally invasive variations have been devised to help increase adoption and penetrance, including hand-assisted and robot-assisted laparoscopic platforms. However, the paradigm of high-quality, high-satisfaction surgery has continued to progress toward less invasive modalities, such as reduced port and single-incision laparoscopic surgery (SILS).

Reduced port colorectal surgery, using a three-trocar approach, was developed and popularized by Cristiano Huscher in Italy and Dr. John Marks in the United States. These innovators of minimally invasive colorectal surgery devised the

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simplified setup with hopes of both standardizing the operation and minimizing the costs. The number of ports was reduced further when Dr. Paul Curcillo performed the first single-incision laparoscopic colon resection in Philadelphia in 2007. Since the initial case, the safety and efficacy of SILS have been well documented for benign and malignant colorectal disease [13–19]. Outcomes have been reported comparable between SILS and other laparoscopic platforms, with additional benefits of SILS in cosmesis, postoperative pain, port-site-related complications, and hospital length of stay [13–19].

After mastering the traditional three-trocar multiport technique, the transition to a single-incision access approach can be quite simple. As with the transition from open to laparoscopic surgery, the progression from multiport to SILS requires attention to proper surgical technique and oncologic outcomes. The steps of the operation are identical to the multiport approach, so the learning curve for SILS should concentrate on technical efficiency, proper ergonomics, and position of the operator and assistant. With the limited surface area for access, it is important to minimize wasted movements of the camera and of the instruments.

Access Platforms and Equipment

There are a few commercially produced SILS ports, such as the SILS™ Port (Covidien, Mansfield, Massachusetts, USA), the GelPOINT® platform (Applied Medical, Rancho Santa Margarita, California, USA), and the Tri/QuadPort (Olympus Medical, Center Valley, Pennsylvania, USA) (Fig. 5.1). Each port has distinct pros and cons, but all are similar in placing three to four ports through a single access platform introduced through a single incision. Novel instruments were created specifically for SILS. The

Fig. 5.1 SILS port in use (GelPOINT® platform, Applied Medical, Rancho Santa Margarita, California, USA)

instruments come in straight, curved, and articulating configurations and are available in standard (34–35 cm) and extra-long (44–45 cm) shaft lengths. A limitation of straight instruments working in parallel through the confined space is "sword fighting" between the working ports and camera. While experience can help surgeons learn to adapt and overcome with issue, articulating instruments were designed to overcome the lack triangulation encountered with straight instruments through a SILS port. These tools rotate 360° around the axis of the instrument, increasing internal triangulation around the working area. However, there is reduced rigidity and tactile feedback. Thus, most surgeons have returned to using the conventional instruments originally designed for multiport laparoscopic resection procedures. Laparoscopic camera for SILS comes in both 5 and 10 mm widths, conventional 0° and 30° tips, and an articulating 100° tip (EndoEYE™, Olympus Medical, Center Valley, Pennsylvania, USA). The articulating tip allows for the spatial separation between the camera holding assistant's hands and the operating surgeon's hands and can eliminate the clashing of parallel instruments while maintaining a direct view. The use of a posterior cable can also allow rotation of the camera without conflicting with the instruments.

Technical Pearls

In the standardized approach, instruments are labeled as one, two, or three. The camera (#1) is preferably a 5 mm articulating scope and is always given preference, as visualization is paramount to safely performing any surgical procedure. The camera is placed through the apical port and focused on the pathology prior to introducing any other surgical instruments. An atraumatic tissue grasper (#2) is then introduced for gentle traction on the tissue. Our preference is to take a solid bite of tissue and reposition the grasper as little as possible to avoid unnecessary trauma. Due to the fulcrum effect of the small skin aperture, it is also often useful to grasp tissue a few centimeters away from where one would in a conventional laparoscopic approach. Ideally, gravity is used as the source of countertraction. The heat source/vessel sealer (#3) is then introduced and used as the primary source of tissue dissection. Emphasis should be placed on minimizing wasted movements. The movement of all three instruments at that same time can disrupt the natural progression of the operation. With the small fulcrum of movement that the single-site platform offers, the movement of multiple instruments at once can impede the motion desired. Therefore, move the camera first to optimize visualization over the manipulation of the other instruments. Next, the tissue grasper always takes precedence over the heat source when approaching the anatomy.

Patient Positioning

Patient positioning, preferably with the patient safely secured on a split-leg table, room setup, is identical to conventional multiport surgery. One caveat to this is that having the camera operator positioned on the left side of the patient often facilitates the performance of a left-sided dissection. Fortunately, this does not add any degree of difficulty in operating the articulating camera.

Conduct of the Operation

The performance of a single-incision laparoscopic colorectal resective procedure can be greatly facilitated with a simple systematic approach. The steps of a right colectomy, left colectomy, total abdominal colectomy, low anterior resection, and restorative proctocolectomy have been well described and are the same when utilizing a single-incision approach as they are in multiport surgery. As laparoscopy increases for rectal cancer dissection, the steps of a total mesorectal excision (TME) warrant specific mention. A TME is the gold standard for proper oncologic resection of rectal cancer regardless of approach, with the completion of the TME predicting local recurrence and survival [20–23]. Technically, a TME is a nerve-sparing resection that increases sphincter preservation and decreases permanent stoma rates from APR. The steps of a total mesorectal excision (TME) using a single-incision approach warrant standardization.

SILS TME

The optimal location of the SILS port for visualization and dissection in pelvic cases is 20 cm cranial to the pubic symphysis. Depending on the patient's anatomy, the port can be placed at the umbilicus/ supraumbilical, through a Pfannenstiel incision or—in a patient with a predetermined diverting ileostomy—through the stoma site. After exploration of the abdomen, the splenic flexure is taken down in a medial to lateral fashion. A medial to lateral retroperitoneal dissection of the colon is performed, and the inferior mesenteric vein and artery are ligated. The ureter and gonadal vessel are identified and preserved during the retroperitoneal dissection. The pelvic dissection is started just above the sacral promontory, opening the retroperitoneum to the right of the superior rectal artery and inferior mesenteric pedicle, assuring the preaortic nerves and superior hypogastric plexus are left down and undisturbed. The pelvic dissection is executed in a circumferential fashion, starting posteriorly down to the pelvic floor, moving to the right lateral and left lateral sidewalls, then anteriorly. The posterior dissection is performed in the areolar plane between the visceral mesorectal fascia and the parietal endopelvic fascia; anterior traction on the rectum facilitates this step (Fig. 5.2). The rectosacral fascia is sharply opened, allowing pneumodissection to aid the sharp dissection and separate the posterior mesorectum from the endopelvic parietal fascia. The dissection proceeds inferiorly down to the levators in a plane anterior to the nerves. The dissection down to the pelvic floor facilitates the subsequent anterolateral dissection. For the lateral and anterior segments, the rectum is re-grasped with tension directed caudally and

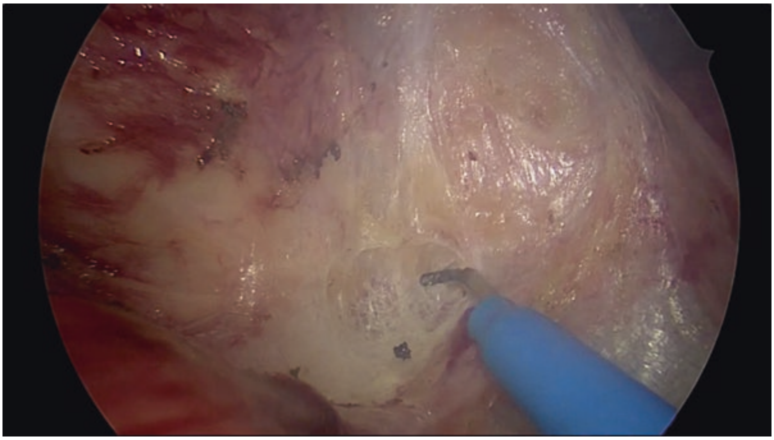

Fig. 5.2 Posterior TME dissection

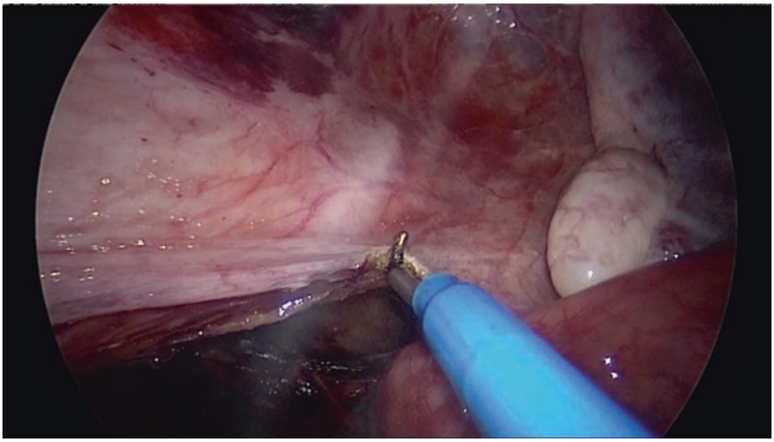

Fig. 5.3 Lateral TME dissection

fluidly moved contralaterally or posteriorly to aid the dissection. The lateral dissection begins on the right side, moving in a posterior to anterior direction, assuring the lateral mesorectal fascia is intact (Fig. 5.3). The cul-de-sac peritoneum is opened, and dissection continues between Denonvilliers' fascia and the anterior mesorectum before sharply dividing the lateral stalks at the lateral border of the mesorectal fascia. The retraction is then shifted to the right, and the lateral dissection is repeated on the left. After completing the posterior dissection and dividing the lateral stalks, the levators and Waldeyer's fascia are visible. Waldeyer's is incised posteriorly and laterally at the anorectal junction to expose the rectal tube past the puborectalis and

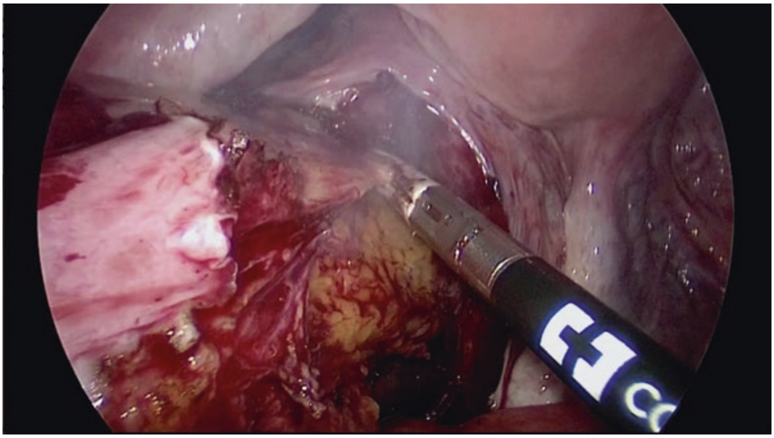

Fig. 5.4 Anterior TME dissection

posterior mesorectum. The anterior dissection commences with meticulous, sharp dissection to separate the rectoprostatic or rectovaginal plane from the anterior mesorectal fascia (Fig. 5.4). The dissection continues past the anterior mesorectum to expose the rectal tube at the anorectal junction. With the rectal tube circumferentially mobilized down to the anorectal ring, the distal rectum is divided. The proximal bowel is exteriorized through a wound protector, the specimen transected with appropriate margins in viable tissue, and the anvil of the intraluminal stapler placed and secured. The bowel is returned intra-abdominally and an anastomosis created with the transanal stapler.

Port Placement

With SILS, the abdominal cavity is accessed similar to the Hassan technique, with a 2–3 cm skin incision and a direct cutdown into the abdominal cavity. This incision is commonly placed at the umbilicus. For pelvic or multi-quadrant cases, a Pfannenstiel incision may be considered. When a diverting stoma is anticipated, the platform can be furthered from "single-incision" to "incisionless" surgery, as the stoma site itself serves as an excellent site for the port, further minimizing abdominal wall trauma (Fig. 5.5). The fascial incision can be extended as needed for port placement without extension of the overlying skin. Specimen extraction can also be performed at this site, eliminating the need for an additional incision. The use of a wound protector device or a port that has a wound protector sleeve, such as the GelPort or Tri/QuadPort, can facilitate specimen extraction.

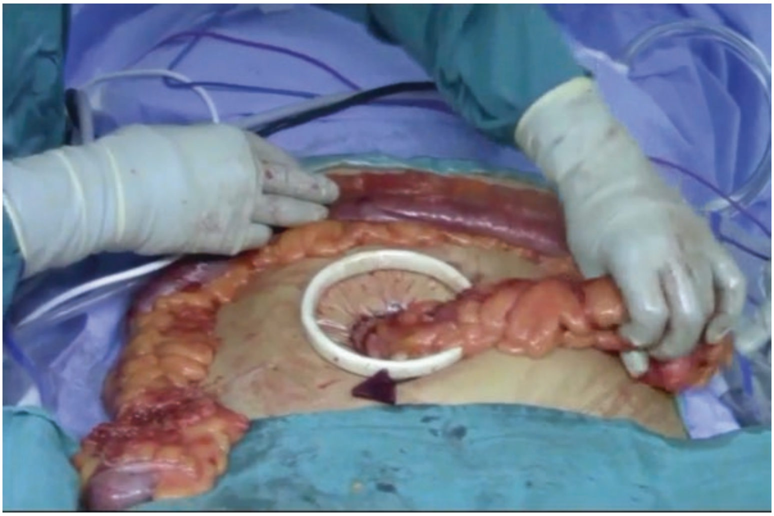

Fig. 5.5 “Incisionless” surgery with specimen extraction through the SILS port

Discussion

Single-incision laparoscopic access for colorectal resective procedures is safe and feasible. The further minimization of abdominal wall trauma seen with a single-incision technique shows promise in both optimizing patient outcome and minimizing complications. As we move toward less and less invasive procedures while dealing with more and more complex patients and disease processes, a single-incision technique will hopefully help serve as a bridge to incisionless surgery.

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Chapter 6
Laparoscopic Procedures: Laparoscopic Abdominoperineal Resection

Jake D. Foster and Nader K. Francis

Introduction

The Evolution of APR

The development of Abdominoperineal Resection (APR) in 1908 by W. Ernest Miles, Surgeon to St. Mark's Hospital London, signified a major breakthrough in the treatment of rectal cancer [1]. Before this, attempts at resection of rectal cancer were usually approached through the perineum, and local tumor recurrence was almost inevitable. The "Miles procedure" represented a more oncologically sound operation, with an abdominal incision used to mobilize the rectum together with its blood supply and lymphatic drainage, followed by a perineal procedure to remove the anus *en bloc*. While a combination of technical and technological developments in recent years have enabled a greater proportion of cancers to be treated by sphincter-preserving surgery [2], there still remains a substantial cohort of patients for whom APR remains necessary, in particular those with tumors of the lower third of the rectum.

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Fig. 6.1 Photograph of distal part of "traditional" APR specimen with "waisting" in the region of the levator muscle

Extra-levator APR

Higher rates of circumferential resection margin (CRM) involvement [3] and tumor perforation [4] have been reported after APR compared with anterior resection. This may be attributed in part to surgeons not following Miles' original description of APR—in which wide division of the levator muscles was emphasized to "include the lateral zone of spread" [1]. This can result in a narrow "waist" to the specimen at precisely the level where the tumor is located (Fig. 6.1).

In response to such reports, Miles' original description has recently been revisited. Such a resection with division of the levator ani muscles at their origins, rebranded as "extra-levator" APR (ELAPR) or "cylindrical" APR, has been proposed [5] (Fig. 6.2); meta-analysis of data from initial reports of adoption of this technique has suggested it to be superior for achieving a negative CRM [6]. The resection specimen has been described as "cylindrical" with a wrap of levator muscle around the tapering distal aspect of the mesorectal resection specimen (Fig. 6.3).

Until robust evidence is available comparing oncological outcomes, it is the opinion of the authors that ELAPR can facilitate optimal oncological outcomes from this surgery.

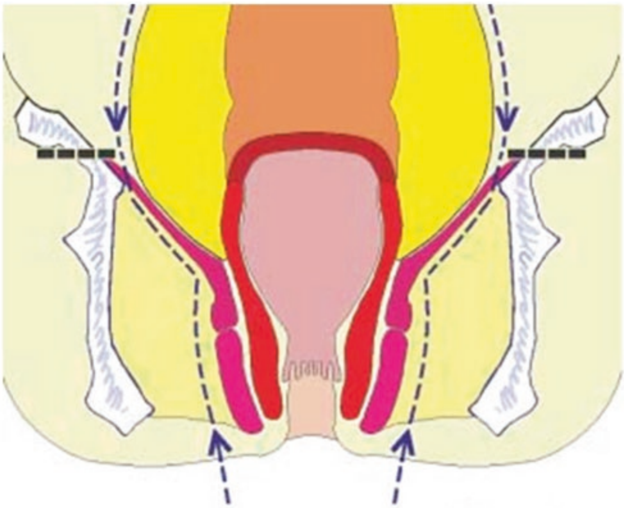

Fig. 6.2 Photograph of ELAPR specimen with "cylindrical" shape to distal part due to wrap of levator muscle

Laparoscopic APR

The first reports detailing laparoscopic APR originate from the early 1990s [7–9]; however, long-term oncological outcome data from large multicenter randomized controlled trials (RCTs) is still awaited. Utilizing laparoscopy for APR may deliver benefits to patients in terms of improved postoperative recovery and reduced pain. With the specimen evacuated through the perineum there is no large abdominal retrieval wound making a laparoscopic approach ideally suited to this operation.

The earliest RCT investigating laparoscopic APR was published over a decade ago [10]. While this study involved just 28 patients, it confirmed laparoscopic APR to be safe and technically feasible in a prospectively enrolled cohort of patients. More recently, a single-center RCT trial from Hong Kong involving 99 patients with low rectal cancer demonstrated earlier return of bowel function ($p<0.001$) and mobilization ($p=0.005$), and less analgesic requirements ($p=0.007$) when a laparoscopic approach was used ([11]). Although length of stay is not significantly different between laparoscopic and open cohorts in this study, it is noted that enhanced recovery postoperative care principles, which have since become routine in many colorectal departments, were not used for this study.

Short-term outcomes from the European multicenter COLOR II trial report an exciting, and statistically significant, reduction in of circumferential resection margin (CRM) involvement rate among patients who underwent laparoscopic APR surgery (8 %) compared with those undergoing open APR (25 %, $p=0.03$) [12]. Similarly, among patients who had APR in the COREAN trial, positive resection margins were reported in 5 % in the laparoscopic surgery group compared with 8 %

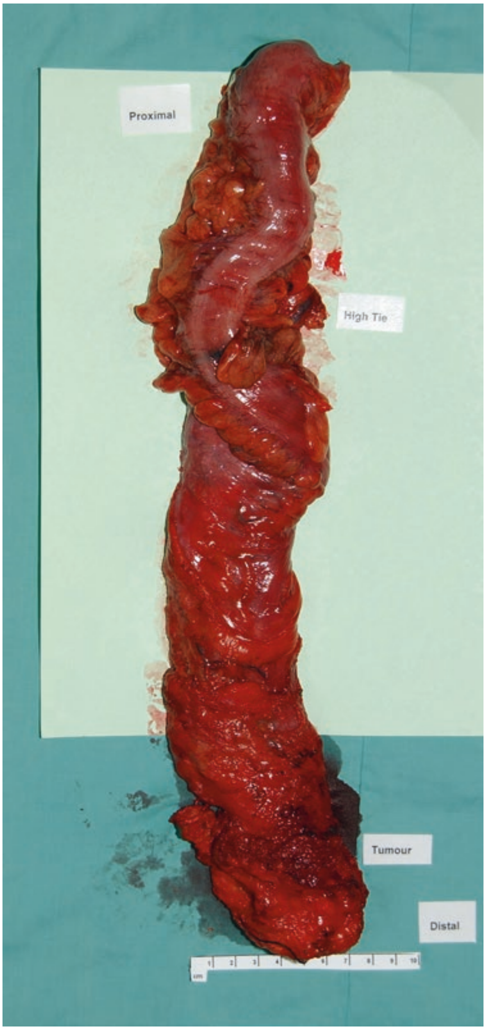

Fig. 6.3 Diagram showing the plane of dissection used for laparoscopic and perineal parts of ELAPR

in the open surgery group [13]. Given that the majority of the dissection at the level of the tumor is performed during the perineal dissection during these operations, these results might suggest that the enhanced views in the deep pelvis offered by laparoscopy enable surgeons to more accurately determine where and when to stop the mesorectal dissection from above. It will be interesting to see whether this will confer a survival benefit to patients in the laparoscopic cohort when long-term results from these trials and the American ACOSOG-Z6051 trial [14] become available.

Laparoscopic ELAPR

The oncological advantages of an extra-levator approach to APR should not be hindered by the application of a laparoscopic approach. A few centers have reported small series of a laparoscopic abdominal approach to ELAPR, with similar rates of CRM involvement and oncological outcomes reported as for series of open ELAPR [15–17][32]. In a single-center comparison between open and laparoscopic ELAPR, a significantly shorter length of stay was seen with laparoscopic compared to open ELAPR (7 days vs. 15 days) [15]. Initial experience from our own unit has demonstrated the oncological and operative safety of laparoscopic ELAPR including favorable rates of local recurrence, low rates of postoperative complications, and a short length of postoperative stay [16].

Indications and Contraindications

Indications

The major pathological indication for APR is adenocarcinoma of the lower rectum, especially where the tumor invades into the anal sphincter complex or levator muscles of the pelvic floor. However, other indications include malignant and benign conditions affecting the perianal region (Box 6.1).

Low rectal cancer requires careful clinical and radiological assessment, followed by discussion among a multidisciplinary team (MDT). The decision for APR rather than a sphincter-preserving procedure should be an outcome of this MDT process and ideally planned prior to surgery. Rectal cancer with a distal extent greater than

Box 6.1 Indications for Laparoscopic APR

- Curative surgery for low rectal adenocarcinoma (within 6 cm of the anal verge)
  - Involving the anal sphincter complex
  - Involving levator ani muscle
  - Unsuitable for sphincter-preserving surgery
- Other malignant conditions

  Salvage surgery after chemoradiotherapy for anal Squamous Cell Carcinoma
  Melanoma
  Leiomyosarcoma
- Benign conditions (rare)—e.g., fistulating Crohn's disease

around 6 cm from the anal verge can generally be treated with sphincter-preserving surgery, regardless of whether or not the surgeon elects to perform an anastomosis. For tumors sited at around 5 cm from the anal verge, careful consideration is needed of the most appropriate surgical procedure. While sphincter-preserving ultra-low anterior resection may be feasible for a low cancer, the potential for poor function following such surgery (especially where neoadjuvant radiotherapy has been used) means that patient selection is essential. For more locally advanced tumors that lie close to the tapering mesorectal surface in this region, and for very distal tumors at the level of the sphincter complex, APR is usually indicated. Where the pathology extends to involve the perianal skin, for instance, local fistulation or suppuration, a more extensive ischio-anal excision may be required during the perineal phase of the procedure; however, the resection is otherwise the same as for APR.

The choice of a laparoscopic approach requires consideration of the surgeon's technical capabilities in addition to patient and tumor factors. Laparoscopic APR should be performed by surgeons who routinely perform laparoscopic total mesorectal excision (TME). While it is acknowledged that all laparoscopic rectal resection surgery is technically challenging with a longer learning curve compared with laparoscopic colonic resection [18], centers with extensive experience in these techniques can achieve operating times for laparoscopic that are similar to those for open APR [19].

Contraindications

APR is a major surgical undertaking, and careful case selection is essential. Contraindications to APR may relate to situations where alternative surgery is more appropriate (Box 6.2). Where other organs, such as the prostate, are involved in the disease process more extensive surgery may need to be considered to ensure that a clear resection margin can be achieved. There are also instances where any resection may be inappropriate, for instance, where significant comorbidity or poor quality of life are encountered.

Due to the technical complexity of laparoscopic APR surgery, relative contraindications include morbid obesity and multiple previous abdominal surgeries. In these situations, an open approach may be considered more appropriate, although

Box 6.2 Contraindications to Laparoscopic APR

- Patients not fit for surgery
- Patients not suitable for APR

  Patient is suitable for local excision surgery
  Patient is suitable for sphincter-preserving surgery (TME)
  APR likely to result in involved resection margins, e.g., exenteration required

with increasing technical experience of the surgeon these relative factors may be less pertinent.

Preoperative Workup

Standard preoperative localization and staging of rectal cancer is required in all cases, including visualization of the entire colon where possible to exclude a synchronous tumor; whole-body computer tomography (CT) scanning to exclude metastatic disease; and local staging with clinical examination and Magnetic Resonance Imaging (MRI) scanning, with or without endo-anal ultrasound scanning. Careful consideration should be given to the need for neoadjuvant therapy, and such decisions should be made by a multidisciplinary team including oncology, radiology, and surgical experts once with the results of all staging investigations are available.

Abdominoperineal resection is one of the most complex commonly performed surgical procedures and can be associated with significant morbidity. Consideration and careful preoperative optimization of any major comorbidity is required. Specialist medical and anesthetic input may be needed for higher risk patients.

Prior to surgery, patients should be introduced to the Enhanced Recovery pathway, including counseling and encouraging patient ownership of their recovery. The discussion at this stage will also explore all the steps of recovery, including methods of pain control, the importance of postoperative mobilization, and resumption of oral intake after surgery.

A stoma therapist should meet the patient prior to surgery to educate the patient and to mark the optimal localization for the end colostomy. As the stoma will be permanent, it is essential for long-term quality of life that the patient's stoma is tailored to their body habitus, clothing, and lifestyle.

While mechanical bowel preparation is not necessary, phosphate enemas are recommended to ensure that the rectum has been fully emptied prior to the surgery. Perioperative low molecular weight heparin should be given for prophylaxis against deep venous thrombosis.

Operative Details

Setup

Given the potential complexity of this surgery, general anesthesia with neuromuscular blockade should be performed by an experienced anesthesiologist. The role of epidural anesthesia for postoperative pain relief has been questioned for laparoscopic colorectal procedures [20]; however, the perineal wound following APR can be very painful, and this remains the one laparoscopic colorectal procedure for which we would still advocate routine epidural anesthesia. Additional regional block for the perineum may be beneficial for reducing perineal pain. The physiological stress of the operation should be minimized through the intraoperative use of short-acting anesthetics and goal-directed fluid therapy. Antibiotic prophylaxis is administered at the time of induction.

Abdominal Phase

The patient should be carefully positioned supine on the operating table, supported to allow safe head-down angulation of the table during a potentially long procedure. The legs are elevated in a Lloyd-Davies position. Careful attention should be paid to reducing the risk of nerve injury both from pressure on the legs and also on the brachial plexus.

Given the importance of the location for the permanent stoma, efforts should be taken to ensure that the site marked so carefully by the ostomy therapist prior to surgery is not wiped away when the surgical antimicrobial solution is applied at the start of the procedure. Methods employed include remarking the site immediately following cleansing, placing a suture or staple at the marked site, or covering the ink marking with a sterile transparent dressing prior to preparing the abdomen.

The abdominal phase of laparoscopic APR uses the same approaches as laparoscopic anterior resection. The laparoscopy stack is best placed toward the patient's feet on their left side. Pneumoperitoneum is established using a standard open technique, and trocars are inserted under direct visualization. Four access ports are generally required. Whenever possible the marked stoma site should be used for the left lower quadrant port, as the precise location of this port will not significantly impact upon the procedure. We tend to alternate the laparoscopic camera between a midline and a right lateral port to optimize visualization during the procedure. Additionally, a right iliac fossa port is used, which will be the one used for the dissecting instrument for the mesorectal dissection. Before the procedure can be commenced, adhesions to the abdominal wall should be divided and diagnostic laparoscopy performed to evaluate for occult peritoneal or hepatic metastases.

We adopt a medial-to-lateral approach, with identification and high ligation of the inferior mesenteric artery pedicle. The inferior mesenteric vein is ligated at this level also, as more proximal ligation is rarely required for APR.

The left ureter is usually identified prior to medial-to-lateral mobilization of the descending colon mesentery as per laparoscopic TME. Splenic flexure mobilization is not usually required in APR.

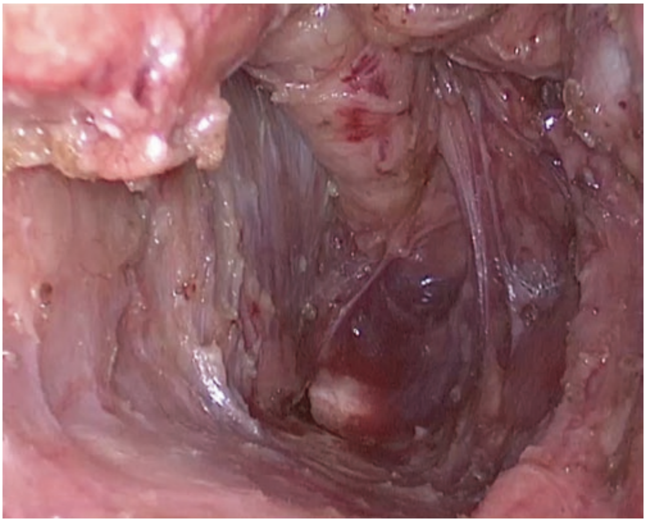

Fig. 6.4 Photograph of posterior mesorectal dissection. The coccyx is visible in the midline and the insertion of the levator muscle onto the pelvis is visible on the left side of this image

Laparoscopic Pelvic Dissection

Entry into TME "Holy plane" [21] is usually performed in posterior midline after defining the mesorectal fascia and loose areolar tissue plane. Dissection then proceeds on a broad front to develop this plane posteriorly with care taken to avoid injury of the hypogastric nerves.

Once the posterior dissection is completed (at the level of the coccyx), the anterior peritoneal reflection is divided at approximately 1 cm anterior to the apex of the fold. The lateral plane is then approached to join the anterior and posterior dissection planes.

Laparoscopic APR dissection should stop at:

- Posteriorly, the upper border of the coccyx (Fig. 6.4).
- Laterally, the level of the origin of the levator ani muscles, defined by the neurovascular bundle (Fig. 6.5).
- Anteriorly, just below seminal vesicles in male (Fig. 6.6) and at upper vagina in female.

Dissection may need to be tailored depending upon the tumor location. The abdominal phase completed with division of mesentery and descending colon at an appropriate level and formation of an end colostomy at the marked stoma site.

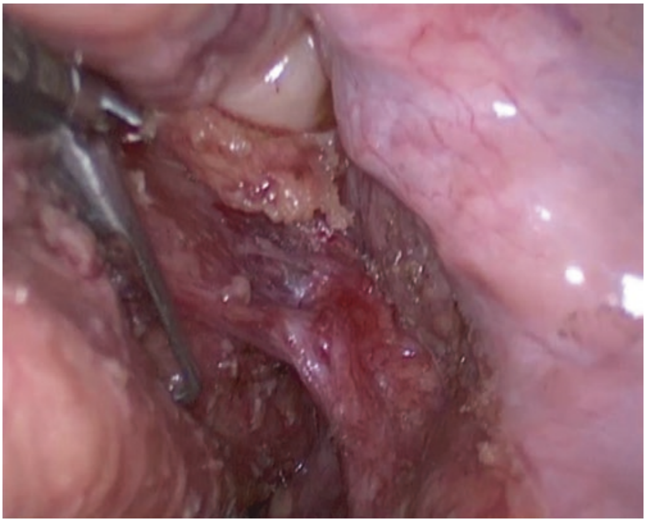

Fig. 6.5 Photograph of lateral mesorectal dissection. The inferior hypogastric nerve plexus is visible on the pelvic sidewall. The lateral mesorectal dissection should continue to just below this level

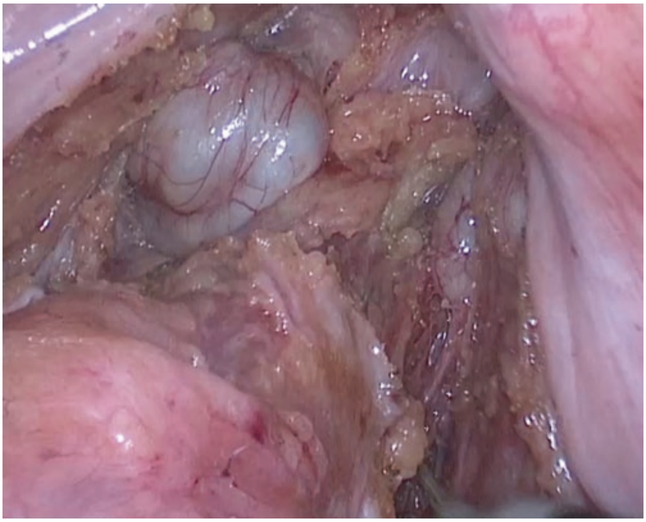

Fig. 6.6 Photograph of anterior mesorectal dissection. The left seminal vesicle and ductus defers can be seen in the top left of this image, indicating the landmark for cessation of the anterior dissection

Fig. 6.7 Photograph of "teardrop" shaped skin incision used for the perineal entry for ELAPR

Perineal Phase

Although some authors report that cylindrical specimens can be successfully achieved with patients in the lithotomy position [22], the authors favor the excellent views of the anterior plane that are achieved with the patient in the prone "jackknife" position. Careful positioning of the patient on the table is needed, with attention to the head, endotracheal tube, and to the limbs to protect areas of pressure and maintain access to intravenous lines and catheters.

For access to the perineum, the buttocks can be separated using an adhesive tape attached to the sides of the operating table. The anus should be sutured closed using a silk suture. A teardrop-shaped skin incision is performed from the tip of coccyx to perineal body, preserving the perianal skin (Fig. 6.7).

The dissection then follows the margin of the sphincter complex, preserving the ischiorectal fat. In the case of anal cancer, a wider resection will be required here. This plane takes the dissection onto the inferior surface of the levator muscles which are followed to their origins on the pelvic sidewall.

The coccyx is often removed in continuity with the main specimen to facilitate direct visualization and access into the pelvis. This also can reduce the risk of perforation of the specimen during extraction especially in bulky mesorectum and narrow pelvis. Waldeyer's fascia is then divided to enter the mesorectal dissection plane that has been developed from above. The levator muscles are divided laterally at their origins and the specimen is then gently brought out through the perineal incision (Fig. 6.8). The specimen can then be dissected from the back of the prostate or vagina anteriorly under direct visualization. In case of anterior tumor, a cuff of the vagina wall/ prostate capsule can be removed to ensure negative CRM.

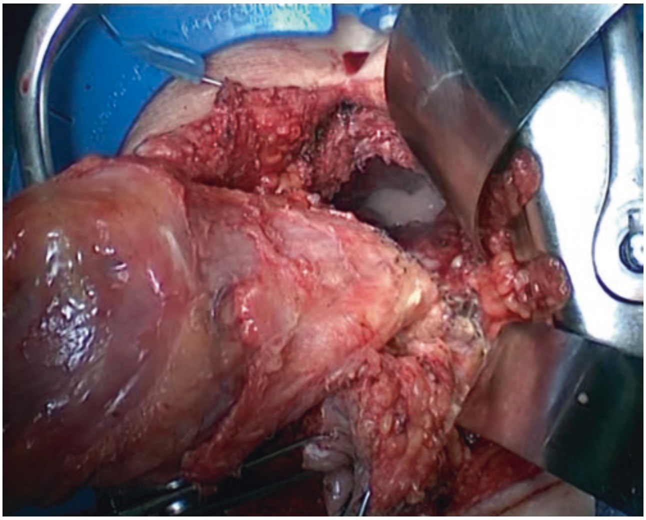

Fig. 6.8 The specimen is extracted through the perineal wound to enable anterior dissection to be performed under direct vision

Reconstruction of the Perineum

Extra-levator APR traditionally results in a substantial defect and primary closure of the perineal wound is usually associated with high rates of complications and dehiscence, especially following neoadjuvant therapy [23]. Currently, there are two main alternative methods of closing this perineal defect: a myocutaneous flap reconstruction or insertion of a prosthetic mesh.

Perineal Reconstruction Using Tissue Flap

There are reports supporting the benefits of reconstruction with myocutenaous flaps, with both gluteal [5, 24] and rectus abdominus [25, 26] flaps described. Both options have their associated complications, including donor site morbidity, and can entail prolonged operating times and generally require the expertise of a plastic surgeon, which may not be available in every hospital. At present there is no clear consensus on which type of flap is optimal, although gluteal flaps seem the obvious choice if a laparoscopic approach has been adopted for the abdominal portion of ELAPR.

Two common techniques for perineal reconstruction using flaps are described as follows:

- Fasciocutaneous gluteal flap: The surgeon marks a flap based on a random pattern blood supply originating from the inferior gluteal artery and the flap is rotated cranio-laterally from the base. The skin incision is performed approximately 2 cm above the coccyx and continued laterally approximately distal to the infra-gluteal crease. The flap is then harvested superficial to the gluteal muscle and rotated to cover the defect. The apex of the flap is anchored with absorbable sutures deep to the fascio-periosteum of the coccyx or the sacrum and the flap is then secured subdermally with absorbable sutures and the skin with interrupted mattress nonabsorbable sutures over a suction drain.

- Vertical Rectus Abdominus Myocutanous (VRAM) flap: The VRAM flap is based on the deep inferior epigastric artery and vein. A skin pedicle is incised commencing from the level of the umbilicus and extending cephalad up to the costal margin. The width of the skin pedicle is dictated by a combination of the actual size of the perineal defect and the mobility of the abdominal wall so that the donor site defect can be closed. The rectus sheath is incised as an ellipse, extending inferiorly to expose the whole of the rectus muscle. The muscle is divided several centimeters superior to the skin and fascia paddle, and the flap is then raised out of the rectus sheath from superior to inferior. At the level of the arcuate line, the inferior epigastric artery and vein are identified as they enter the muscle laterally and carefully preserved. A gutter is created suprapubically for the flap to lie and the flap is rotated through a 270° angle to reach the pelvic floor. The flap is sutured in place and the abdominal wall is closed according to the surgeon's preference.

Perineal Reconstruction Using Mesh

Biologic prosthetic mesh has been proposed as an alternative method to close the perineum after ELAPR [27–29]. This option is quick, can be performed by colorectal surgeons alone, and has low morbidity and recurrence rates. Biologic meshes are favored over synthetic meshes as they are reputed to have a lower risk of complications such as fistulation and erosion. There are numerous products on the market derived from different animals (porcine, bovine) and tissues (intestinal submucosa, pericardium, dermis) and subjected to differing manufacturing processes (cross-linked or not). Generally, there is insufficient evidence to recommend any one specific biologic prosthetic mesh for perineal reconstruction.

- Technique of biologic mesh closure: A biological mesh (usually 10 × 10 × 0.1 cm in size) is secured to the cut edges of the levator ani muscle and the para-coccygeal ligament with interrupted monofilament nonabsorbable sutures. A subcutaneous drain is left superficial to the mesh prior to closure of the perineal wound in layers. We recommend closure of skin using interrupted nonabsorbable monofilament sutures.

Postoperative Care

Our initial experiences with his operation have confirmed that postoperative enhanced recovery pathway can be successfully adopted following laparoscopic APR [16]. Patients can be cared for on standard surgical ward, without the routine need for admission to a high dependency unit. Intravenous fluid is traditionally discontinued on the first postoperative day and patients are encouraged to eat and drink normally straight after surgery.

Epidural analgesia is continued for the first 48–72 h after surgery with introduction of oral analgesia including paracetamol and nonsteroidal anti-inflammatory drugs from the first day to allow smooth tapering of epidural analgesia.

Patients can be mobilized after day 1 without restriction if mesh reconstruction of the perineum is used. Mobilization may be delayed to allow graft and donor site healing if flap reconstruction is used. Prolonged sitting is avoided in both methods of reconstruction. A special valley cushion is available to reduce pressure on the suture line and we would recommend this—particularly after mesh closure. Skin sutures should be removed after 12 days. The perineal drain is usually removed when drainage ceases or drains less than 25 mL/day and should not be left later than day seven.

Stoma care education and training is traditionally provided in the immediate stage after surgery and patients are deemed to be fit to discharges if they are tolerating normal diet, mobilizing independently, comfortable on oral analgesia, and independent in stoma management.

Possible Complications

In addition to generic operative and postoperative complications such as bleeding, venous thromboembolism, and infection, there are specific complications that require some attention in this operation:

Operative Complications

Specific complications relating to laparoscopic APR include the following:

- Conversion to open surgery
- Bleeding (pedicle or presacral plexus)
- Bowel/mesorectal injury
- Collateral injury (left ureter, autonomic nerves, small bowel, large bowel)
- Tumor/bowel perforation during extraction
- Urethral injury during perineal dissection
- Bleeding from presacral plexus

Postoperative Complications

- Postoperative bowel obstruction: Occasionally, patients may develop a clinical picture of bowel obstruction following laparoscopic APR. This is usually attributed to small bowel filling the potential space offered by the empty pelvis, combined with the lack of adhesions following laparoscopic surgery. A CT scan is usually helpful to confirm that this is the case, and a conservative treatment approach is often successful. Omentoplasty has been proposed as a preventative measure; this can be performed laparoscopically, although it can often be technically challenging.
- Problems with perineal wound healing: Perineal wound complications are common after APR, especially following neoadjuvant radiation therapy [23]. Rates of perineal healing complications following mesh and flap reconstruction have been compared in a systematic review, and no significant difference was observed between the two methods [30]. It is noted that the majority of complications reported in this review did not require reoperation or vacuum-assisted closure.
- Perineal hernia: Reported rates of perineal hernia are low following flap or mesh closure of the perineum according to the systematic review. However, the quality of reporting on this condition is suboptimal in the available literature and ideally needs regular clinical and radiological evaluation of the perineum during follow up after APR.
- Chronic perineal pain: Chronic pain is recognized and acknowledged in a limited number of studies as a potential complication following biologic mesh repair [29]. Published series reporting this complication confirm that this does eventually resolve spontaneously in most cases, but it can last up to 6 months.

Follow Up

Traditionally, patients are followed up at the surgical outpatient clinic at approximately 2 weeks after discharge to review the clinical and histological outcomes. When required, patients would be referred to the oncologist for consideration of adjuvant chemotherapy. The stoma is usually reviewed by the stoma therapist and the perianal wound/flap are examined.

Further follow up from the cancer point of view is very variable as there is no international standardized care pathway for colorectal cancer follow up. However, our institution adopts the following model for 5-year follow up:

- Six-monthly outpatient clinic review with routine clinical evaluation, blood tests including carcinoembryonic antigen tumor marker concentration for 3 years, and then annually for an additional 2 years. During this consultation, routine clinical evaluation for parastomal, perineal, or trocar site hernia is usually performed.
- CT of the chest, abdomen, and pelvis at 1 and 2 years from surgery

- Colonoscopy at 1 and at 5 years from surgery (unless more frequent colonoscopy is indicated, e.g., due to polyposis)

Tips and Tricks

- Dual surgeon operating with breaks: Laparoscopic APR can be a technically challenging and prolonged operation. Ideally two senior surgeons should be available to perform the operation together. It is important that all team members are able to maintain concentration throughout, and the impact upon the patient of prolonged pneumoperitoneum and extremes of tilting must also be considered. Our practice is to take a 10 min pause at a convenient point after around 2–3 h in which the pneumoperitoneum is deflated and the operating table flattened.

Abdominal Phase

- Where to stop: Defining where to stop the mesorectal dissection can be tricky in both laparoscopic and open APR. However, we advise that the dissection posteriorly should advance as low as possible (unless there is a posterior tumor) to facilitate easy entry from the perineum into the correct plane outside the mesorectal fascia.
- Leave a swab: An opened-out surgical swab may be placed in the midline posteriorly at the distal extent of the mesorectal dissection prior to completing the abdominal phase of the procedure. This is then easily identified when entering from the perineal dissection and can ensure that the dissection follows the correct tissue plane.
- Prophylactic mesh reinforcement of stoma site: The end colostomy following APR will be permanent, and every care should be taken to optimize its creation. Parastomal hernia is a common complication, and the surgeon may wish to consider prophylactic mesh placement to reduce the risk.

Perineal Phase

- Prone positioning: Miles described performing the perineal dissection with the patient turned to the right lateral position [1]; recently, however, there has been growing enthusiasm for turning the patient prone [5]. Such a position may enable improved visualization and access to the pelvis—especially anteriorly, where higher rates of CRM are known to occur [31].

- Coccygectomy: Excision of the coccyx, or of its distal part, is essential for optimal access and facilitate safe entry into the pelvis with minimal postoperative consequences.
- Extraction of specimen: This should not be attempted too hastily, as struggling to extract a bulky specimen through a tight aperture can result in specimen/tumor rupture. This can be avoided by dividing the levator origins bilaterally prior to attempting a gentle extraction of the specimen.
- Avoiding urethral injury: The membranous urethra lies very close to the resection margin anteriorly and careful attention must be paid to the distal anterior dissection. The urethral wall can get drawn up away from the catheter and easily catch out the unwary surgeon. The planes in this region should be followed from lateral to medial in this region, with the midline being the last area to dissect. We find a useful approach is pinching the urethra between thumb and forefinger of the left hand and performing a careful sharp dissection using scissors sparing the urethra.
- Mesh reconstruction. We consider biologic mesh closure of the perineum to be ideally suited to maximize the benefits offered by a laparoscopic approach to APR. It avoids making further abdominal wall incisions to mobilize VRAM flaps and also avoids thigh or gluteal incisions that may impair postoperative mobilization and limit compliance with the enhanced recovery program. To secure the mesh to the pelvis, suture it to the remaining edges of the levator muscles. Permanent or long-lasting interrupted sutures should be used to ensure that the reconstruction is robust. Anteriorly do not place sutures in the midline as there is potential to injure the urethra. Also posteriorly the coccygectomy site will also prevent suture placement in the midline. In our experience, biologic meshes may encourage seroma formation, and we recommend siting a drain superficial to the mesh prior to closure of the skin to reduce the risk of wound breakdown or the development of a sinus.

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Chapter 7
Robotic Low Anterior and Abdominoperineal Resection: Hybrid Technique

Mark H. Hanna and Alessio Pigazzi

Introduction

Rectal cancer surgery remains as one of the most technically challenging techniques to a surgeon due to the limited operative space of the pelvis and the multitude of vital organs and structures in the vicinity of the area of dissection. Low anterior resection (LAR) for rectal cancer was revolutionized by Dr. Heald who introduced the concept of total mesorectal excision (TME) as the standard of surgical treatment [1]. This is defined as the en bloc resection of the rectum with complete dissection of the lymph-node bearing mesorectal envelope and negative margins.

Despite the improvements in pelvic and rectal surgery with the advent of laparoscopic techniques, the inherent difficulties of TME remain. Surgeons remain limited by a two-dimensional view, limited range of motion of long fixed laparoscopic instrument, and restricted 180° of motion. This has led to a very long learning curve and a high rate of conversion to open surgery (17–30 %) [2]. The surgical robot was developed to compensate for these laparoscopic limitations. It offers a magnified three-dimensional view of the operative filed and allows motion scaling of the surgeon's hand movements into smooth and finer motion of the instruments to allow for

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a more precise dissection. Furthermore, it provides a wider range of motion of the instruments that can fully rotate around their axis and thus provide 360° of freedom.

In this chapter, we describe a hybrid surgical technique described as a robotic-assisted laparoscopic LAR where laparoscopic mobilization of the vessels, left colon, and splenic flexure is first completed and is then followed with a robotic-assisted TME.

Indications and Contraindications

The indications for robotic LAR cover patients with mid-rectal tumors (defined as a tumor ~ 5–10 cm from the anal verge) and low rectal tumors (defined as tumors 0–5 cm from the anal verge). Patient with low rectal tumors need to have a distal margin of at least 1 cm or greater of rectum in order to allow for a stapled coloanal or colorectal anastomosis.

Contraindications to robotic LAR are similar to the contraindications for laparoscopy. The only absolute contraindications being patients who are hemodynamically unstable due to ongoing septic shock or cardiopulmonary compromise preventing the safe development of a pneumoperitoneum. Relative contraindications mostly depend on concurrent patient factors and the technical expertise of the surgical team. These include advanced age, morbid obesity, liver cirrhosis, enlarging abdominal aortic aneurysm, acute inflammatory bowel disease, large pelvic abscess or phlegmon, coagulopathy, pregnancy, and intra-abdominal adhesions from prior laparotomies. Patients with significant adhesions may be candidates for a laparoscopic lysis of adhesions prior to docking the robot. The surgical robot is not as mobile and thus we prefer a laparoscopic technique of dissection when the need arises to access multiple quadrants of the patient's abdomen.

Preoperative Workup

Patients with rectal cancer should undergo a complete evaluation including full history and physical, endoscopic, radiologic, and laboratory evaluation to confirm proper staging of their disease. Assessment of metastatic disease with CT scan of the chest, abdomen, and pelvis is also necessary. A multidisciplinary evaluation in conjunction with medical oncology and radiation oncology is also necessary to evaluate the patient's need for neoadjuvant chemoradiotherapy. In cases of neoadjuvant chemoradiotherapy, it is our preference to operate after 8–12 weeks from completion of neoadjuvant treatment.

Operative Details

Operating Room Organization

The surgical first assistant and the scrub nurse are positioned to the patient's right side. The surgical robot is parked at the patient's feet during the laparoscopic portion of the procedure and then docked via the patient's left hip during the robotic portion of the dissection. The laparoscopic monitors are positioned to the patient's left.

Positioning

The patient is brought into the OR and is then carefully transferred onto the OR table. The anesthesiologist then initiates general endotracheal intubation per standard protocol. A naso/orogastric tube is then inserted to decompress the patient's stomach. Prevention of slipping during the procedure when the patient is in steep Trendelenburg is necessary in order to avoid injuries. The use of a high-density viscoelastic foam mattress or a vacuum-assisted bag can help achieve this objective. The patient is then placed in a modified lithotomy position with Allen or Yellow Fin stirrups with the hips flexed and abducted, feet laying flat within the stirrups, and with care to avoid any direct pressure on the lateral aspect of the legs. The legs are oriented so that the toes, knees, and shoulders are all in line. The patient's arms are tucked and the patient is firmly secured to avoid shifting during the different tilting angles during dissection. The patient's legs should also be padded anteriorly to prevent any pressure injury from the robotic arms. We do not routinely use ureteral stents in cases where side wall involvement is not suspected based on preoperative imaging.

The abdomen is then prepped and draped in the usual standard fashion with care taken to position the sterile towels along the anterior axillary line laterally, up to the xiphoid superiorly and down to the pubis to allow for maximal exposure.

Port Placement and Docking

The following is our port placement designed for the S or Si robotic system. The port placement for the latest system—Xi- is usually in a straight line configuration opposite the target organ or pathology. The procedure is begun by establishing a pneumoperitoneum. This is done via entry into the abdominal cavity by a Veress needle or open Hasson technique based on the surgeon's preference. In a patient with a history of prior abdominal operations, we prefer to use Palmer's point (1–2 cm below the left subcostal border in the midclavicular line) as the point of entry of our Veress needle. Once safe entry into the abdomen is confirmed, it is insufflated to a pneumoperitoneum of 12–15 mmHg. The placement of the ports is done under the principle of triangulation. It is also our preference to have at least a handbreadth between the ports to allow good freedom of motion of each of the laparoscopic/robotic instruments.

A 30-degree 5 mm camera (C-port) is placed halfway between the xyphoid process and the symphysis pubis and an initial 4-quadrant survey is done to confirm the absence of any injuries from initial abdominal entry and to rule out any metastases of the patient's rectal cancer to other organs. Three robotic ports (R) are placed in total: R1 is a 12 mm trocar that is inserted in the midclavicular line halfway between C and the right anterior superior iliac spine, R2 is an 8 mm trocar inserted in the LLQ about 8–10 cm directly lateral to C, and R3 is an 8 mm trocar inserted 8–10 cm lateral to R2 usually directly above the left anterior superior iliac spine. Two additional laparoscopic ports are placed: L1 is a 5 mm trocar placed in the midclavicular line approximately 10 cm superior to R1 and L2 is a 5 mm port placed halfway between the midclavicular line and the midline approximately 10 cm superior to L1 (Fig. 7.1). All ports are placed under direct vision and in a controlled fashion by the surgeon's dominant hand. The patient is then placed in steep Trendelenburg position with the left side of the body tilted upward to maximize exposure of the left colon and remove the small bowel from the pelvis.

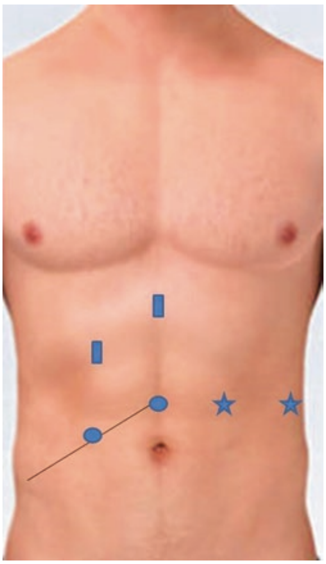

Fig. 7.1 Port placement for Hybrid LAR/APR. *Circle*: 12 mm laparoscopic trocars. *Star*: 8 mm robotic trocars. *Rectangle*: 5 mm assistant trocare

Laparoscopic Mobilization

The laparoscopic portion of the procedure is completed using R1, L1, L2, and C ports. This approach is begun by placing the patient in steep Trendelenburg position with the left side tilted up to allow for the small bowel to be swept away from the root of the mesentery. The mesentery is elevated and the IMV is identified and the dissection is begun there just lateral to the ligament of Treitz. The IMV is skeletonized circumferentially via blunt dissection from its attachments to the left mesocolon. Once this is achieved, the vessel is then ligated using a vessel sealing energy device, stapler, or locking hemoclips (Fig. 7.2). The sigmoid colon is then elevated toward the abdominal wall and the overlying peritoneum medial to the right common iliac artery at the sacral promontory is incised. The upward traction is maintained and a plane is developed bluntly under the superior hemorrhoidal artery. The left ureter is again identified and swept posteriorly and the dissection is continued to the origin of the IMA at the aorta. The IMA is then skeletonized circumferentially and the critical 'T' shaped view of safety is achieved. This is comprised of the junction of the left colic artery and superior hemorrhoidal artery with the IMA. The IMA is then ligated using a vessel sealing energy device, stapler, or locking hemoclips per surgeon's preference. The left colic artery is also divided in a similar fashion in most patients.

Attention is then direct toward laparoscopic mobilization of the left colon and splenic flexure; this is begun with retraction of the left colon superiorly and medially with atraumatic bowel graspers. At this point of the operation the patient must

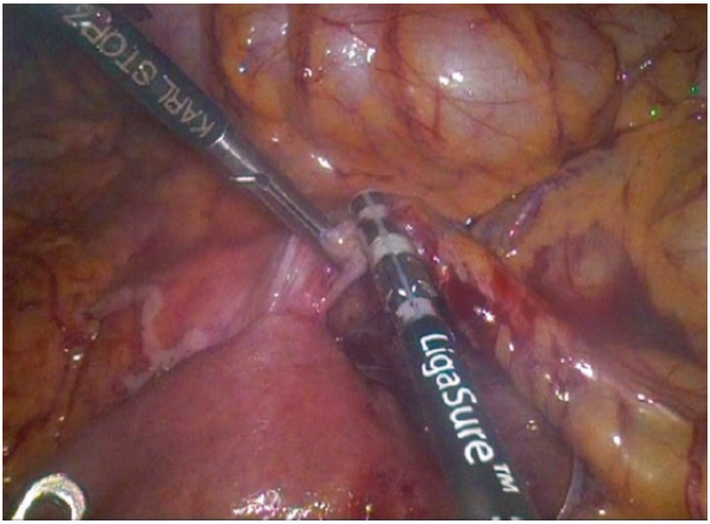

Fig. 7.2 Laparoscopic division of the inferior mesenteric vein just lateral to the ligament of Treitz and close to its insertion behind the pancreatic tail

be moved in a reverse Trendelenburg position to take advantage of the effect of gravity on the transverse colon. Optimal exposure of the avascular white line of Toldt in the left paragolic gutter allows for a bloodless dissection between the mesocolon and retroperitoneum. The left ureter and gonadal vessels are identified and protected and then mobilization is continued superiorly via division of the phrenocolic and splenocolic ligaments toward the splenic flexure. The dissection maybe facilitated by dividing the omentum overlying the middle colic vessels to further mobilize the transverse colon toward the splenic flexure. Mobilization of the splenic flexure is achieved by first opening the lesser sac and continuing the dissection down to the root of the mesentery freeing the attachments of the mesentery to the tail of the pancreas. Dissection during this step has to be slow and meticulous with care taken not to damage the tail of the pancreas, splenic vessels, and spleen itself. Ensuring that the left and proximal transverse colons have been freed from their attachments finally completes the dissection.

Robotic TME

The patient is placed again in Trendelenburg position and the four-arm surgical robot is docked via the patient's left hip, which allows access to the patient's anus during this portion of the procedure. The camera scope first inserted is a zero degree scope. Port and arm clutches are used to dock the arms to the camera and other three instrument ports. The robotic arms are docked as follows: R1 docks arm 1 and a hook cautery or monopolar scissors is placed through this port, R2 docks arm 2 and a bipolar grasper is placed through this port, and finally R3 docks arm 3 and a grasper is placed through this port. The first assistant remains on the patient's right side and uses L1 and L2 to provide retraction and suction/irrigation as needed.

Attention is then directed toward the pelvis and the surgeon at the robotic console begins mobilization of the rectum in the avascular plane between the mesorectum and the presacral fascia posteriorly (Fig. 7.3). Arm 3 is used for anterior retraction, while arms 1 and 2 are used for dissection. It is crucial to avoid grasping the mesorectum during dissection as it is highly prone to tearing or bleeding. We prefer to use monopolar scissors during this portion of the dissection to develop the plane of dissection between the presacral fascia and mesorectal fascia with minimal use of electrocautery. Adequate retraction of the proximal rectum by the assistant superiorly and laterally is paramount during this step as the dissection is carried posteriorly through Waldeyer's fascia (rectosacral fascia) all the way down to the level of the levator muscles. The dissection then proceeds by taking down the lateral rectal stalks with care to identify and avoid the lateral autonomic nerve plexus in this region. In this location, the middle hemorrhoidal vessels are usually encountered and can be easily controlled with bipolar cautery. The dissection is then shifted anteriorly opening the peritoneal reflection and continuing the dissection behind the seminal vesicles or the posterior vaginal wall (Fig. 7.4). This circumferential dissection of the rectum down to 1–2 cm distal to the tumor completes the total mesorectal

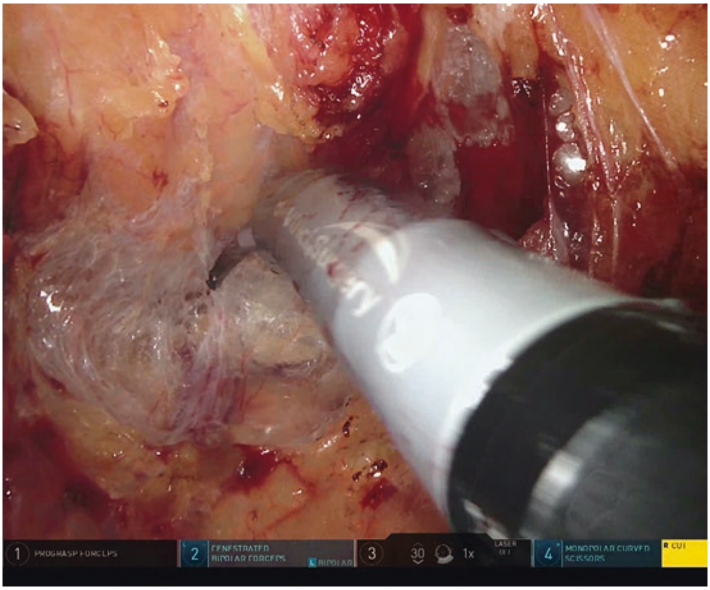

Fig. 7.3 Posterior dissection during robotic TME utilizing robotic scissors

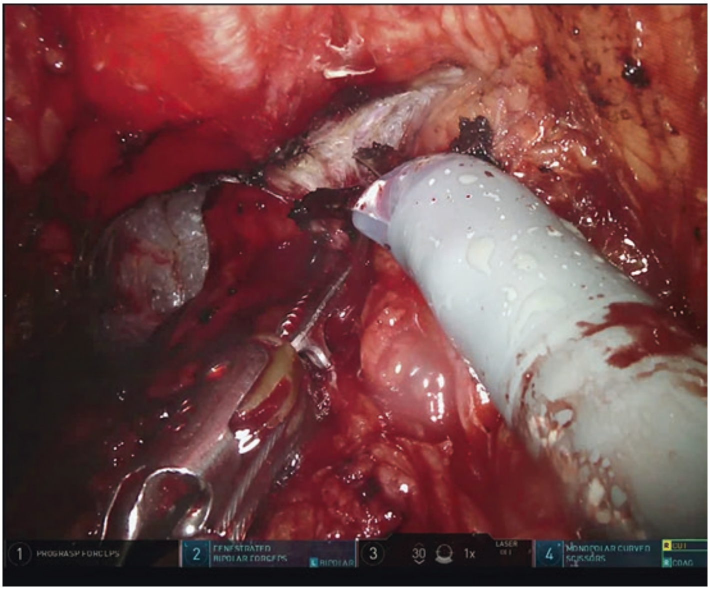

Fig. 7.4 Robotic anterior dissection at the level of the prostate

excision (TME) and the rectum is then inspected at the level of the desired transection. Frequent digital rectal examination and endoscopic assessment are necessary to ensure adequate distal margin clearance. It is usually not necessary to divide any fat when the rectum is divided at the level of the pelvic floor since the mesorectum is nonexistent at this level.

Anastomosis and Specimen Extraction

A digital rectal examination or intraoperative colonoscopy is then used to assess the distal margin of resection. For tumors >2–3 cm from the anal verge, the articulating stapler is placed at R1 and fired by the first assistant sequentially to complete the transection with care not to cross the previous staple line (Fig. 7.5). For tumors that are <1–2 cm from the anal verge, an intersphincteric resection with a hand sewn colo-anal anastomosis maybe required. Once the rectum is divided the surgical robot is dedocked and pushed back away from the patient. The specimen is then extracted via a 5 cm Pfannenstiel incision and placing a wound protector to cover the incision edges. The proximal bowel is divided and the anvil of the EEA stapler is introduced and secured to the proximal stump with a purse string suture. The proximal colon and anvil are returned into the abdominal cavity and pneumoperitoneum is reestablished. The colorectal anastomosis is then completed in a standard fashion with the EEA stapler under direct vision laparoscopically.

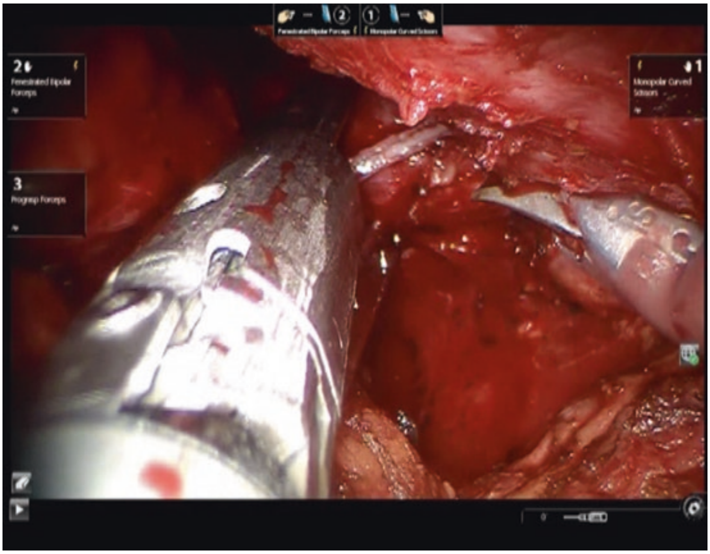

Fig. 7.5 Sequential stapling the distal rectum under robotic visualization utilizing a 45 mm articulating stapler

After completion of the colorectal anastomosis the stapler is withdrawn gently out of the rectum and the distal and proximal “donuts” are inspected for completeness and sent to pathology. A flexible sigmoidoscopy is then performed to assess the integrity of the anastomosis and test for an air leak. If there are any defects or signs of compromised perfusion of the anastomosis the decision to redo versus reinforce the anastomosis is made based on the surgeon’s judgment. The abdomen and pelvis are copiously irrigated and suctioned. Routine Pelvic drain placement is not mandatory and is left to the surgeon’s preference. If a drain is to be placed, it is usually a round 19 Fr Blake drain that is placed within the pelvis in the vicinity of the anastomosis.

Creation of Ileostomy

The creation of a diverting ileostomy is not mandatory and is left to the surgeon’s preference and judgment. It is usually preferred in high-risk anastomoses such as those in male patients, patients that have received neoadjuvant chemoradiotherapy, and low rectal anastomoses. A diverting loop ileostomy is created by selecting a loop of small bowel approximately 30–40 cm from the ileocecal valve and securing it below the skin marked stoma site. A circular stoma incision (usually as an extension of the R1 port incision) is then created and the subcutaneous fat and fascia are dissected down to the rectus muscles, which are then spread gently along their fibers. The peritoneum is then identified and divided delivering the laparoscopic grasper and loop of bowel through the incision. The small bowel mesentery is thoroughly inspected to ensure proper orientation and confirm the absence of twisting. The fascia and skin of the other incisions are then closed in standard fashion. After all the wounds are closed and covered with sterile towels the ileostomy is matured in standard Brooke fashion. This is done by making a transverse enterotomy on the efferent side of the limb. The cut edges are then everted to create the spigot shape of the ostomy. The bowel edges are sutured to the surrounding skin by taking full thickness bites of the edges of the ileum, then a seromuscular bite at the base of the ostomy, and then to the dermis of the skin. This is carried out around the complete circumference of the ostomy. The ostomy appliance is then placed ensuring an adequate seal.

Robotic Abdominoperineal Resection

Robotic abdominoperineal resection (APR) is reserved for cases of gross or suspected sphincter involvement by the tumor, or cases in which sphincter preservation is technically possible but the patient’s quality of life is expected to be severely compromised by a low rectal anastomosis because of medical comorbidities, poor mobility, or cognitive impairment. The technique for robotic APR is identical to that of LAR except for the following steps:

1. Mobilization of the flexure is unnecessary since no anastomosis is created.
2. Division of the IMV and IMA at the origin is also unnecessary since the mobilization required to reach the abdominal wall is usually minimal. Therefore, the superior hemorrhoidal artery can be divided at the takeoff from the IMA.
3. The most important step in APR is to avoid lifting the mesorectum completely off the levator planes and potentially exposing the tumor-bearing area and compromising the radial margin. Thus, the levators should be divided widely at their origin on the pelvic side wall performing the so-called extralevator APR (eAPR).

The port placement and patient positioning are identical in APR. The dissection proceeds circumferentially all the way down to the levator plane. At this point the operation can be completed through the perineum or robotically by opening the levator muscle using cautery and entering the ischiorectal fossa and proceeding distally as far as the robotic arms can reach on both sides (Fig. 7.6). By utilizing this technique the patient can be left in lithotomy position also for the perineal part since most of the dissection will have been completed from the abdominal side. Closure of the perineal wound can be accomplished with a V-Y flap to decrease the rate of perineal wound infection. The use of flaps is not routinely advocated unless a very large defect is expected.

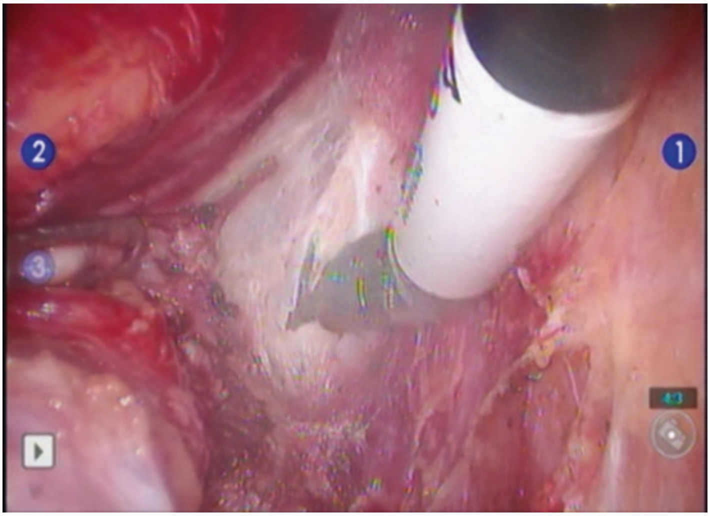

Fig. 7.6 Division of the levator muscle on the right side during robotic extralevator APR

Postoperative Care

Postoperative care of robotic hybrid TME follows the same protocol after laparoscopic LAR. Patients should be enrolled in a standardized clinical pathway (enhanced recovery protocol) to minimize variations in postoperative care and expedite their recovery from laparoscopic LAR. This involves the avoidance of NGTs and abdominal drains unless absolutely necessary. Foley catheters should be discontinued within 48 h after surgery and once the patient demonstrates adequate mobility. The patient should be enforced into postoperative mobilization on the first day after surgery and this should be maintained consistently with a dedicated physical therapist throughout their hospital stay. Patients are allowed ice chips and clear liquids on the first postoperative day. This is then advanced to a full liquid and then low residue diet once they demonstrate appropriate return of bowel function. Mechanical and chemical DVT prophylaxis are started on POD1 and maintained throughout the patient's hospitalization. Incentive spirometry is encouraged to decrease the risk of postoperative atelectasis and pneumonia.

Patients who receive stomas will need reevaluation by the enterostomal nurse and receive the appropriate teaching and supplies to care for them at home before discharge. Patients who undergo a hybrid robotic LAR are ready and safe for discharge by approximately postoperative days 4–5 if they are able to adhere to all the steps of their enhanced recovery protocol.

Possible Complications

Complications after robotic hybrid TME can be divided into specific robotic intraoperative complications and more universal postoperative complications:

Intraoperative complications	
Complication	Prevention/intervention
Thermal or traumatic injuries outside field of vision	• Increased magnification and narrower field of vision of surgical robot lead to injuries outside the field of vision of the console surgeon
	• This is prevented by keeping the robotic instruments in the field of vision at all times
Unintentional tissue injury	• One disadvantage of robotic technique is loss of haptic feedback leading to unintentional tissue injury
	• Attention must be paid to the visual cues of tearing the bowel and mesentery
	• Console surgeon's hand movements should be smooth, minimal, and deliberate

(continued)

(continued)

Intraoperative complications	
Complication	Prevention/intervention
Surgical robot technical problems	• Surgeon and OR staff must be thoroughly trained and well versed with the surgical robot setup and how to troubleshoot it
	• Technical support from the robot manufacturer should be readily available
	• Frequent collisions between robotic arms are a sign of suboptimal port placement. Always maintain the principle of triangulation and adequate spacing (at least one handbreadth) between ports
Longer operative time with surgical robot	• Robotic setup time is longer but can be shortened by having a dedicated robotic OR team that is experienced with the required preparation
	• The assistant surgeon must possess advanced laparoscopic skills to be able to facilitate all critical portions of the case
Postoperative complications	
Anastomotic leak	• Symptomatic leak incidence ~12 %, with associated risk of mortality of ~15 % [3, 4]
	• The literature has shown a similar rate of leak between laparoscopic and robotic technique [5, 6]
	• Leak may require conservative medical treatment, percutaneous drainage, or operative drainage depending on the extent of the leak and the patient's clinical status
	• Diverting loop ileostomy is to be considered if the patient is not already diverted
Bladder or sexual dysfunction due to hypogastric nerve injury	• Maintain sharp and precise pelvic dissection by maintaining a dissection plane that is anterior and medial to the nerve plexus. The nerve fibers should be dissected carefully toward the pelvic side wall
LAR Syndrome: increasing diarrhea, incontinence, and urgency	• Imodium and stool bulking agents to help with diarrhea
	• Maintain fluid intake to prevent dehydration
	• 5–6 small, frequent meals a day
	• Muscle strengthening exercises combined with dietary changes may help with urgency and stool incontinence

Follow Up

Long-term rectal cancer follow-up involves serum CEA levels and physical examination including a DRE and proctoscopy every 3–6 months for the first 2 years postoperatively and then every 6 months for an additional 3 years after. PET-CT scan of the chest, abdomen, and pelvis is required yearly for the first 3 years postoperatively. Colonoscopy is preformed 1 year after the patient's initial resection and then on 3-year intervals if no additional polyps are seen. If polyps are found the patient is kept under a stricter endoscopic surveillance regimen of once a year or more.

Tips and Tricks

Preoperative workup	• Obtain a full H&P and confirm and document patient's baseline level of continence, urinary, and sexual function
	• Patient who have had their colonoscopies done by other providers should still undergo flexible sigmoidoscopy in the clinic to confirm tumor location
Robotic setup	• The patient's legs should also be padded anteriorly to prevent any pressure injury from the robotic arms
	• It is crucial to avoid grasping the mesorectum during dissection as it is highly prone to tearing or bleeding
	• We prefer to use monopolar scissors during this portion of the dissection to develop the plane of dissection between the presacral fascia and mesorectal fascia with minimal use of electrocautery
Total mesorectal excision	• Always maintain visualization and position of bilateral ureters
	• Avoid injury to the hypogastric plexus laterally
	• Maintain dissection in the avascular plane of the presacral space

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Chapter 8
Robotic Low Anterior Resection: Fully Robotic Technique

Fabrizio Luca and Paolo Bianchi

Colorectal carcinoma is the third leading cause of cancer death worldwide and the second most common malignancy in Europe and the United States in both males and females [1, 2]. Over the past three decades, we have witnessed a progressive increase in survival from rectal cancer, due to the diffusion of colorectal cancer screening leading to early detection, advances in surgical techniques, and the improvement of combined radiochemotherapy efficacy [2–5].

Despite the advantages of a minimally invasive approach, laparoscopic rectal surgery still accounts for only a small percentage of the overall rectal procedures carried out. Since the 1990s the technical complexities that characterize this type of surgery such as the two-dimensional view of the operative field and the poor ergonomics of the laparoscopic instruments, which are limited in their motion, have discouraged the widespread use of this technique [6–8].

Since the introduction of robotic surgical platforms, many surgeons have speculated that robotic surgery could overcome the drawbacks of laparoscopy that hinder the expansion of laparoscopic colorectal surgery [9]. The magnified vision, the superior dexterity, and precision of movements of the robotic arms allow the surgeon a better view and greater ergonomic comfort offered the promise that it would

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be possible for more surgeons to conduct this challenging minimally invasive operation [10, 11].

However, the first model of the robotic da Vinci system (Intuitive Surgical, Inc, Sunnyvale, CA) had a limited working area that did not allow the surgeon to work in multiple abdominal quadrants. Also the procedure for undocking, moving, and redocking the surgical cart was difficult and time consuming. Because of these limitations the traditional approach was a hybrid one with a laparoscopic phase for vessel ligation and splenic flexure mobilization and a robotic phase for pelvic dissection [12, 13].

In the hybrid approach, however, an expert laparoscopic team is required and often the port layout is different for the two phases and additional trocars should be placed [14].

The second generation of the da Vinci robot, known as the “S” model, had an increased maneuverability of the robotic arms allowing for multiquadrant surgery, and more flexibility in robotic cart movements and docking. These technological improvements spurred various authors to explore the possibility of taking advantage of the robotic features during the entire intervention with or without repositioning or redocking the robotic cart.

In fact, regarding fully robotic anterior resection, the techniques described can be classified into two main types: single stage and dual stage, according to whether or not it is necessary to change the location of the robotic cart during the surgical procedure.

The aim of this chapter is to analyze the indications and the limits of both the single-stage and the dual-stage fully robotic surgical techniques for robotic rectal resections.

Operative Details

Fully Robotic “Single-Stage” Technique

In 2009, three articles describing a single-stage fully robotic technique appeared in the literature, followed by a fourth report in 2010 [15–18]. In this procedure, the robotic cart is maintained in a fixed position for the whole intervention while the setup of the trocars remains unchanged or is modified according to the different alternatives of the technique that have been reported.

Robotic cart setup: the best position for the robotic cart is considered to be on the lower left side of the surgical table, angled at approximately 30–45° with respect to the major axis of the bed (Fig. 8.1). Conversely, with the hybrid technique, the robotic cart is usually positioned between the patient’s legs thus limiting the external access to the pelvis. On the other hand, side docking is an excellent approach for pelvic procedures permitting easy accessibility in case intraoperative rectal exploration and/or colonoscopy are needed.

Patient positioning: the patient is placed in a modified lithotomy position at 15/30° Trendelenburg tilted to the right side to free the operative field from the bowel

Fig. 8.1 Robotic cart position for single-docking fully robotic anterior resection of the rectum

loops. The patient's arms are secured to the body to allow enough space for an assistant operating from the right flank.

Trocar placement: the layouts of the port placement presented in the literature differ from each other although the shared aim was to find a configuration that could maximize the workspace while at the same time reducing the risk of collision between the robotic arms [19].

It is crucial to keep a distance of at least 8 cm between the ports and to verify that the angle between the robotic arms is the widest possible. In fact, the smaller the angle between the robotic arms, the greater the chance of extracorporeal collision between them. Moreover, one should take into account that for geometrical reasons the angles become narrower as the instruments get closer to the lateral limits of the operating field. The solutions adopted by the authors to minimize this limitation consisted either in using only three robotic arms for the first surgical phase and dock the fourth only for the TME or by swapping the positions of the trocars (Fig. 8.2).

Noteworthy is the "arm flipping technique" in which before proceeding to the pelvic phase, arm n3 is flipped to the right side of the robotic cart, near the robotic arm n2, and redocked to the same trocar to align the robotic instrument on arm n3 toward the pelvis and maximize the operative field of action of the instruments. The robotic arm, in fact, is disconnected from the trocar, rotated behind the robotic cart, and reconnected to the same trocar but in the opposite side and direction [20].

Fully Robotic "Dual-Stage" Technique

Several descriptions of the dual-stage technique have been reported in the literature [21–23].

For this procedure it is necessary to reposition and redock the surgical cart when passing from splenic flexure mobilization to pelvic dissection.

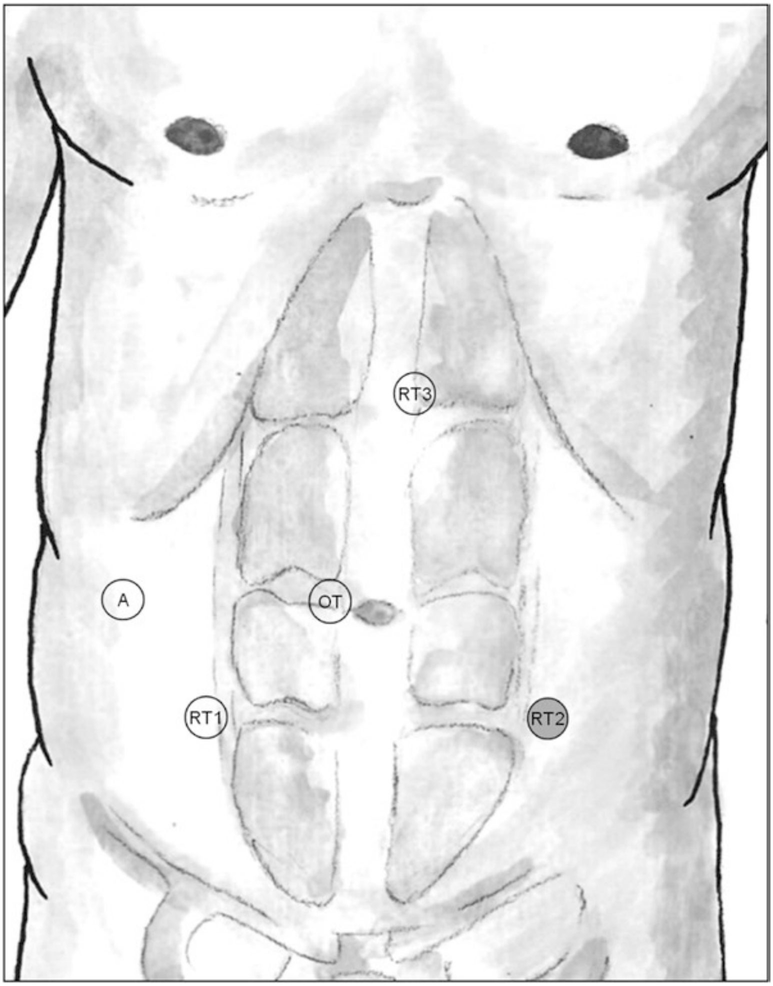

Fig. 8.2 Port placement schemes in use for fully robotic single-docking anterior resection of the rectum

Robotic cart setup: for primary vascular control and splenic flexure mobilization, the robotic cart is docked in the left upper quadrant area (Fig. 8.3a). Once this phase is completed the cart is moved to approach the patient from the lower left side, angled at approximately 30–45° as in the "single-stage" fully robotic technique(Fig. 8.3b).

Patient positioning: during the first phase, the patient is usually placed in the reverse Trendelenburg position tilted to the right side (15–30°). Once the mobilization of the left colon is complete, before redocking the cart from the lower left side, the patient is placed in the Trendelenburg position with the left side up (15–30°) again in the same fashion as in the "single-stage" technique.

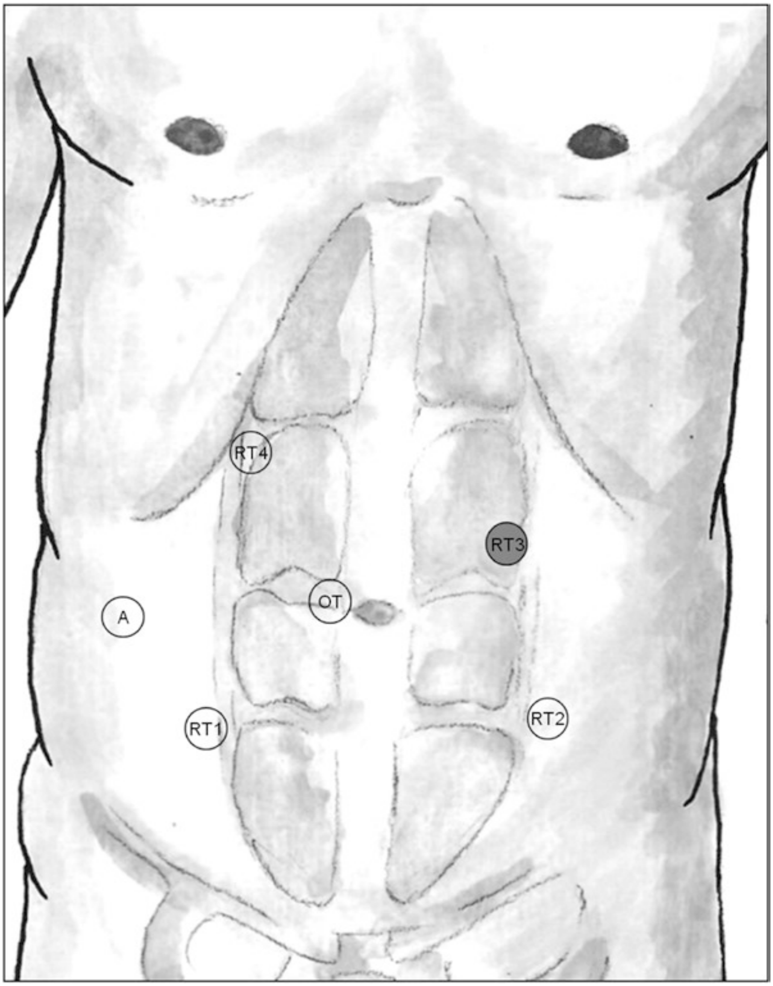

Fig. 8.2 (continued)

Trocar placement: Fig. 8.4 shows the port placement for the vessel dissection and left colon mobilization (A) and for the surgical phase of isolation of the mesorectum (B).

Vascular control and splenic flexure mobilization can often be achieved with only two robotic arms reducing the number of ports needed for the procedure.

Instrument use: several methods have been described and are available in literature regarding the use of instruments; therefore, general technical descriptions will be provided.

Both fully robotic techniques are essentially divided into two surgical steps. The first incorporates the isolation of the inferior mesenteric vessels and the mobilization of the mesocolon; the second, the isolation of the mesorectum.

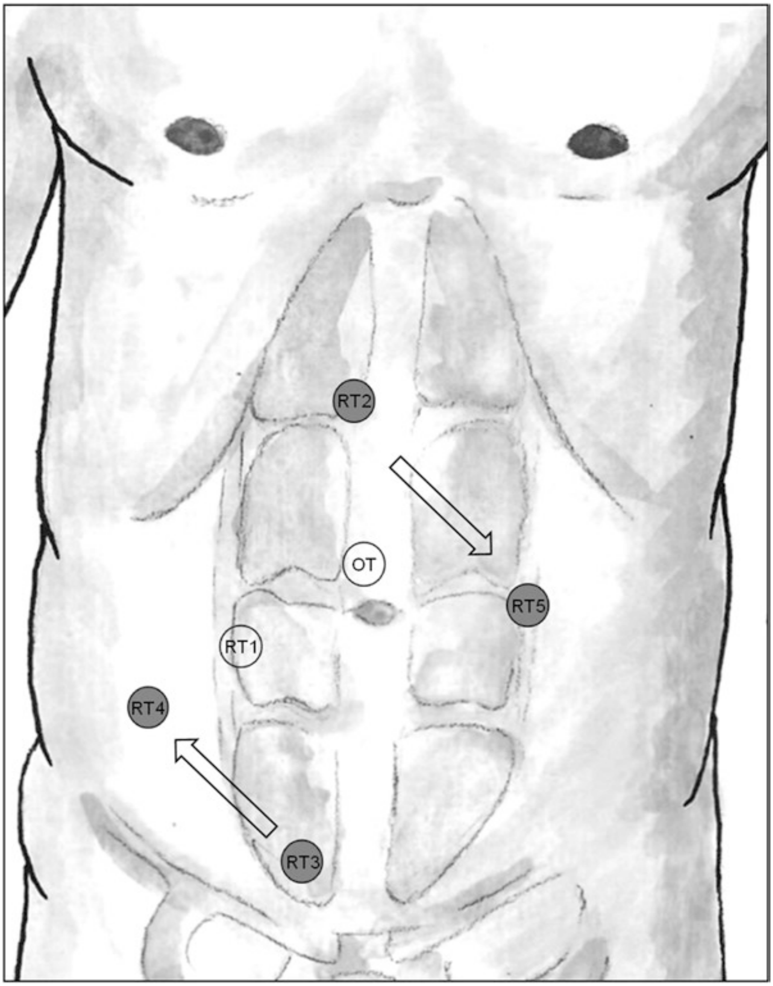

Fig. 8.2 (continued)

The exposure and division of the inferior mesenteric vessels can either start with the vein or with the artery depending on the anatomical characteristics of the patient and on the surgeon's preference.

In general, the primary exposure and high ligation of the IMV permits an easier identification of the plane between Toldt's fascia and the left mesocolon (Fig. 8.5). On the other hand the vertical traction of the mesosigmoid and the incision of the peritoneum on the right side at the promontory facilitate the division of the artery at origin and the preservation of the superior hypogastric plexus, especially in high BMI patients when the IMV is not easily localized (Fig. 8.6).

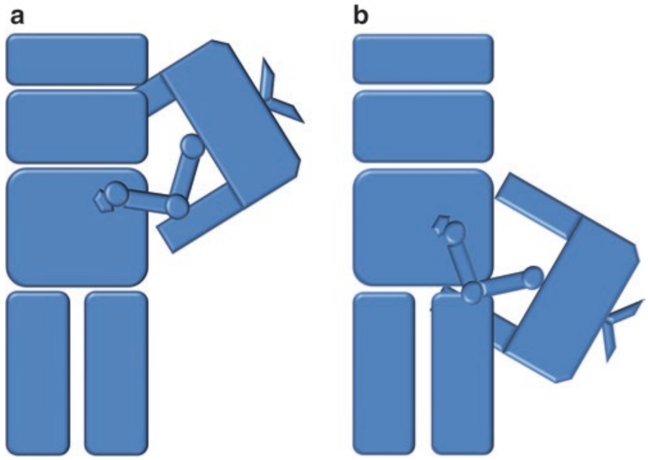

Fig. 8.3 Robotic cart positions for dual-docking fully robotic anterior resection of the rectum. Position A. Position B

For the vascular phase and left colon mobilization, the instruments are used as follows. One of the robotic arms mounts the dissecting instrument: an ultrasonic device, monopolar hook, or robotic scissors. A second arm mounts a Maryland or bipolar grasper. The assistant holds the suction irrigation device or the laparoscopic clip applier through the assistant's trocar.

Once the descending and sigmoid colon are completely freed, the splenic flexure is mobilized.

In the second phase, the dissection continues in the pelvis with the incision of the peritoneum and the complete isolation of the rectum, preserving the mesorectal fascia, in accordance with the principles of total mesorectal excision (Figs. 8.7 and 8.8).

For the TME, the robotic arm corresponding to the surgeon's predominant hand mounts the instrument for dissection. In this case, the monopolar hook should be avoided in order to reduce the risk of thermal injury to the nervous branches directed to the genitourinary structures. The second arm mounts a grasper and is used for traction and dissection by the surgeon, while a third arm, usually placed in the left iliac fossa or in suprapubic region, harbors another grasper and helps dissection by granting a stable retraction of the tissues or by lifting up the uterus and/or the bladder. The assistant at the operating table holds the suction irrigation device and provides countertraction of the rectum facilitating the dissection (Fig 8.9).

Nerve preserving techniques: urinary and sexual dysfunction are severe complications mainly caused by mechanical, thermal, or vascular damage to the hypogastric plexus during robotic TME [24]. Excessive traction can either cause the accidental division of the nerves or can lead to a temporary or permanent blockage of nerve conduction known as neuropraxia [25]. Traction-free techniques and gentle

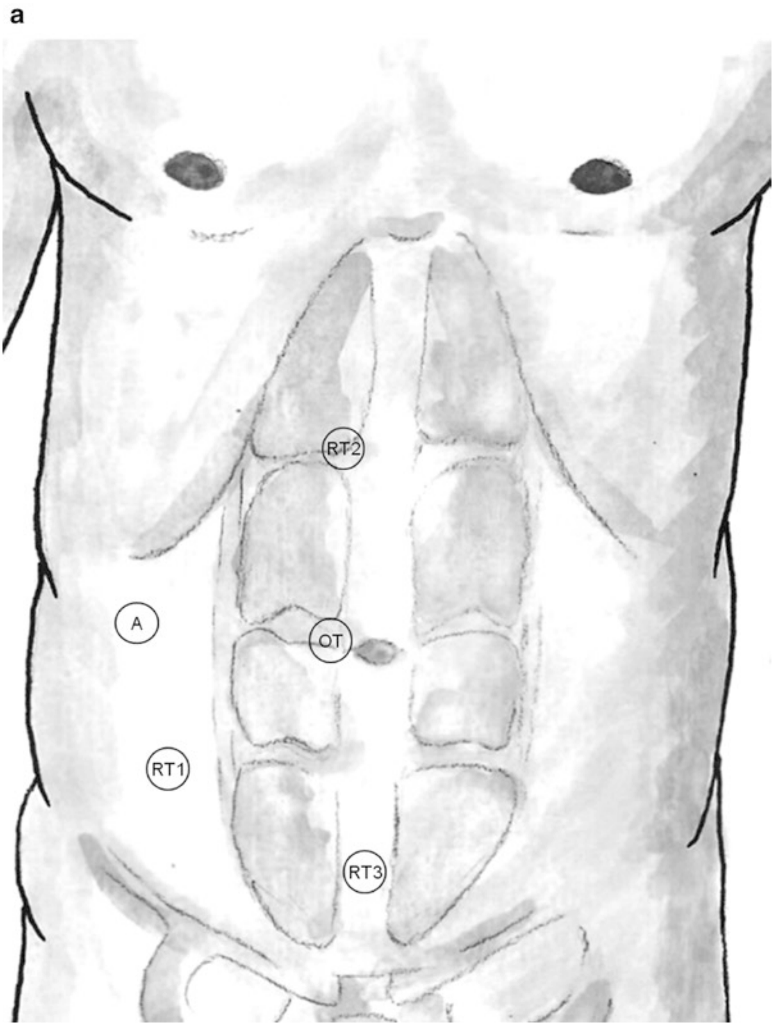

Fig. 8.4 Port placement schemes in use for fully robotic dual-docking anterior resection of the rectum. Position A. Position B

handling should therefore always be followed by both the surgeon at the console and the bedside assistant, who provides countertractions during the procedure. Delicate handling is also important in order to prevent ischemic damage to the neurons. Nevertheless, thermal injury is probably the principal cause of nerve damage. Therefore, irrespective of the preferred instrument for dissection, extensive use of electrocoagulation should be avoided, in particular on the anterolateral plane, lateral b

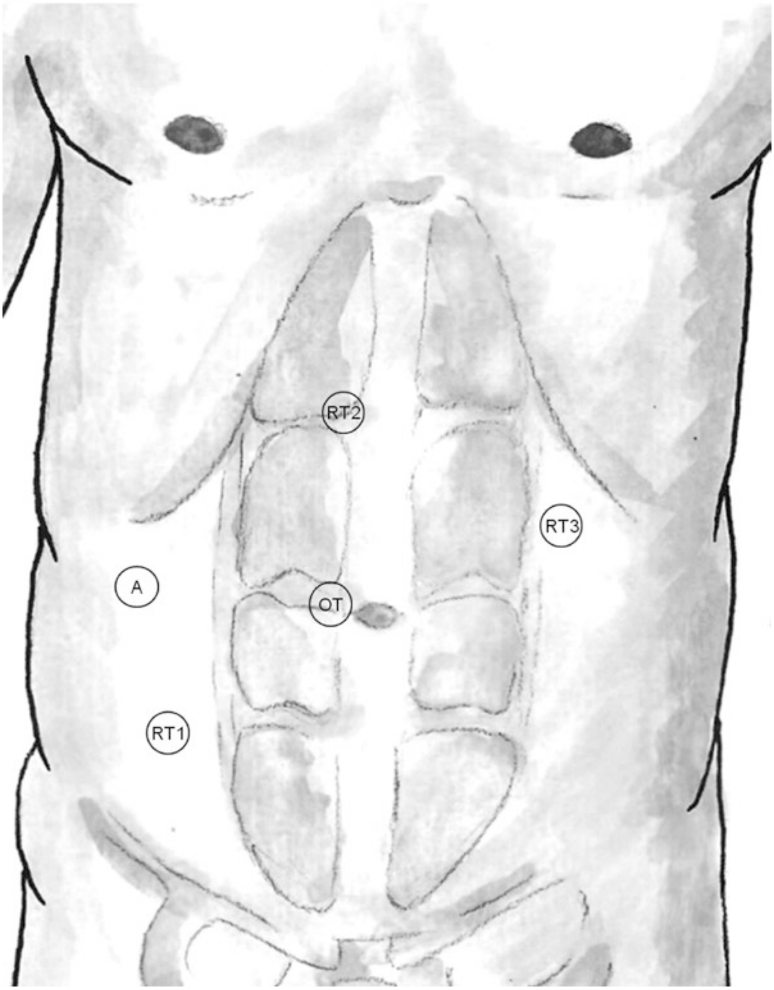

Fig. 8.4 (continued)

to Denonvillier's fascia, near the vesicles. At this level, both sympathetic and parasympathetic fibers of the hypogastric plexus join to form the neurovascular bundle which supply innervation to the bladder and sexual organs.

It is also important to bear in mind that most of the instruments currently used for dissection and hemostasis have a tridimensional thermal spread and that they maintain a high temperature at the tip for a considerable time [26].

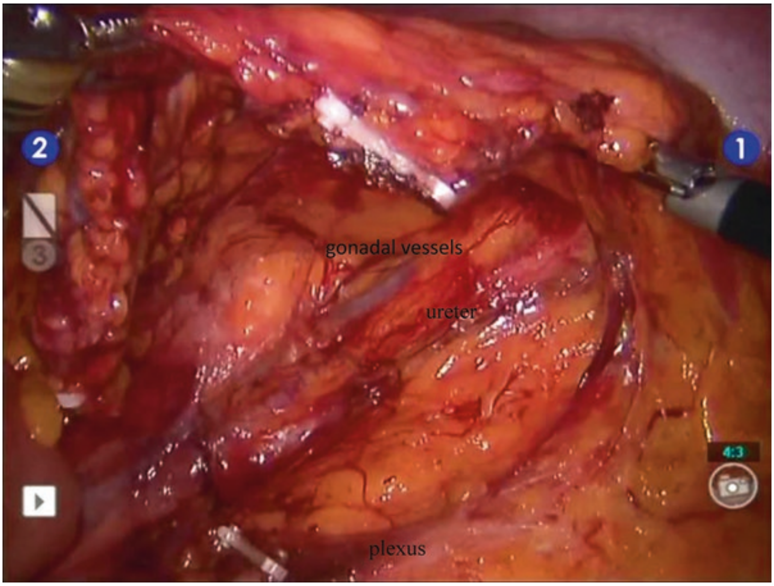

Fig. 8.5 Medial-to-lateral dissection: hypogastric nerve, ureter, and gonadal vessels are progressively identified

Indications and Contraindications

Is not easy to set the bounds between indications and contraindications for each different fully robotic surgical technique used for the treatment of rectal cancer. Port layouts and setups are the result of continuous work carried out over time in single clinical centers and the procedures have been constantly adapted to take advantage of the upgraded models of the robotic surgical system.

Nevertheless, both techniques exploit the advantages of the robot during the whole intervention: better visualization of the target anatomy and fine instrument control, thus facilitating complex procedures, such as the dissection of the inferior mesenteric vessels and thereby contributing to reducing the risk of accidental damage to the superior hypogastric plexus. This is expected to result in a safer lymphadenectomy and a reduction of genitourinary complications.

Moreover, side docking used in both the single- and double-docking technique is excellent for pelvic procedures and maintains easy accessibility to the anus and the vagina during the whole intervention, simplifying intraoperative colonoscopy and digital exploration of the rectum and the vagina.

The distinct characteristics of the fully robotic dual-stage techniques are a lower risk of external collision and a wider operative field of action for the robotic arms. Consequently, this technique is to be preferred for extended colorectal resections. Moreover, redocking and repositioning the robotic cart facilitates the mobilization of the splenic flexure of the colon particularly in patients with a high body mass index.

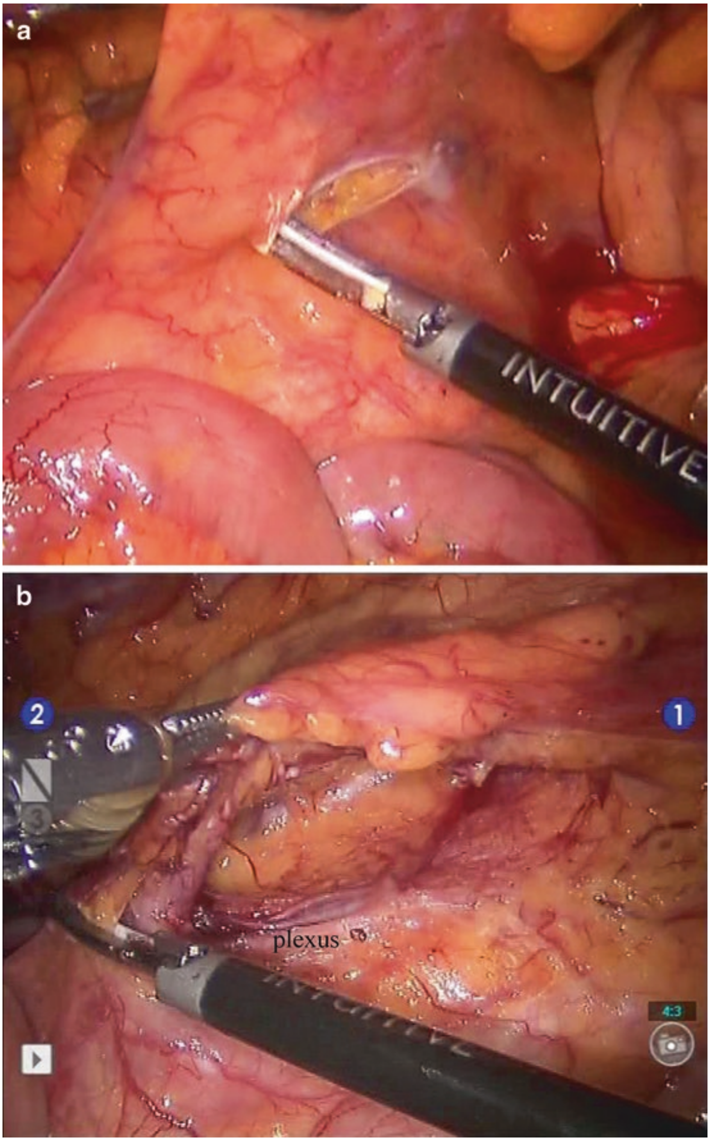

Fig. 8.6 Incision of the peritoneum at the promotory. Vertical traction of the mesosigmoid opens the angle between aorta and IMA (**a**) and facilitate the preservation of the superior hypogastric plexus (**b**)

Fully robotic single-stage techniques, on the other hand, expedite the surgical procedure and do not break the continuity of the operation. In addition, fewer ports and instruments are usually needed, thus contributing to a reduction in costs. Nevertheless, with the single-position technique it is of prime importance to establish the ideal conditions: check the docking, separate instrument arms, respect the

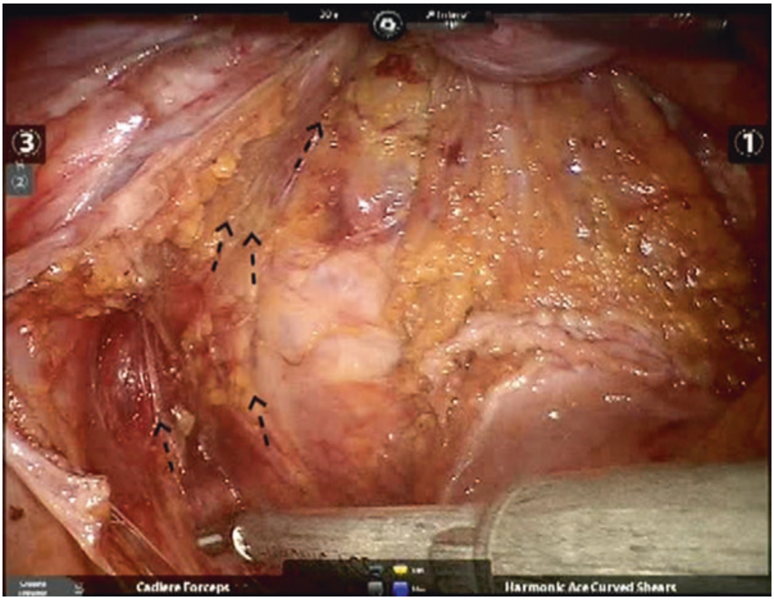

Fig. 8.7 Total mesorectal excision. The *arrows* show the hypogastric plexus

Fig. 8.8 Robotic TME specimen showing shiny intact mesorectal fascia

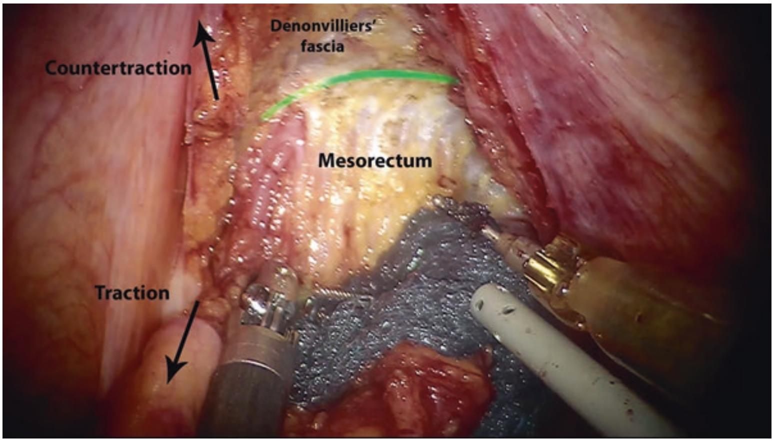

Fig. 8.9 Total mesorectal excision. Anterior dissection plane

distance between the ports, and check setup joint angles to minimize potential collisions and to maximize the range of motion for the instrument arms (Video 8.1: Docking and port placement).

It is fundamental to understand the drawbacks and the advantages of both the "single-stage" and "two-stage" fully robotic techniques and apply accordingly that which most usefully matches the characteristics of each case. Additionally, a comprehensive knowledge of robotic surgical procedures may also help to gradually build up the learning curve, tailoring it to the surgeons' experience and preferences. Dual docking, for instance, can represent an easier approach to robotic surgery for surgeons without an extensive laparoscopic background, and who are therefore less familiar with the limitations of movements and the two-dimensional vision of laparoscopic surgery. This technique has also been recommended for the transition from hybrid to fully robotic surgery [27].

Conversely, fully robotic single-stage techniques may facilitate those surgical teams who are more experienced and are willing to expedite the procedure and reduce the operative time.

It is relevant to bear in mind that this is a relatively new type of surgery. The use of a robotic system for performing a colectomy was first reported in 2002 [28], and since then improvements have been continuously made to overcome the limitations and the hindrances of the robotic surgical system. At the time of writing this book chapter, a new model of the surgical cart, the Xi system that allows, for multiquadrant surgery, has been released and will be available for clinical use in the future. In consequence, it is predictable that new procedures will be designed by surgeons to take advantage of the technological upgrades and overcome the current limitations.

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Chapter 9
Minimally Invasive Techniques for Inflammatory Bowel Disease

Michael A. Valente and Tracy L. Hull

Introduction

Minimally invasive rectal surgery for inflammatory bowel disease (IBD) encompasses a variety of techniques and nomenclature. Laparoscopic rectal techniques have been employed over the last decade for IBD, namely, for ulcerative colitis in the setting of total proctocolectomy (TPC) with ileal pouch anal anastomosis (IPAA), TPC with end ileostomy (EI), or completion proctectomy (CP) after subtotal colectomy (STC) with EI for acute colitis. Laparoscopic surgery for Crohn's disease has also evolved over the same time period, with strong evidence initially for ileocolectomy in ileocolonic disease, but advances in technique and surgeon skill set have also allowed for more challenging situations amendable to laparoscopic approaches, including proctectomy. The recent advent of robotic surgery is also being used for rectal dissection and pelvic surgery in the setting of IBD. This review will concentrate on laparoscopic rectal surgery for IBD.

The most common pathologic diagnoses for which laparoscopic rectal surgery is undertaken for inflammatory bowel disease include ulcerative colitis, indeterminate colitis, and Crohn's colitis. The vast majority of laparoscopic rectal surgery for IBD at ours and most other institutions is for chronic ulcerative colitis in the form of a TPC with EI or TPC with IPAA. TPC with EI or IPAA is also undertaken for indeterminate colitis and for very select Crohn's colitis cases as well. Other surgical options for Crohn's or UC are total abdominal colectomy (TAC) with ileorectal anastomosis or TPC with a continent ileostomy, and these will not be discussed in this review.

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Definitions of Laparoscopic Procedures

Wide varieties of techniques are labeled as “laparoscopic” in colorectal surgery and are open to varied interpretation. A procedure is generally considered *laparoscopic* if the procedure is completed laparoscopically and the main incision is used for extraction of the specimen; *laparoscopic assisted* usually refers to procedures in which a portion of the case is performed extracorporally. In *hand-assisted* laparoscopic procedures, a 6–8 cm incision is used to place a hand into the abdomen to help facilitate the operation. A *hybrid* approach is employed when a portion of the case is performed laparoscopically (i.e., abdominal colon mobilization) and then a small incision (Pfannenstiel or infraumbilical midline) is made to facilitate the pelvic mobilization (i.e., rectal transection and construction of ileal pouch with subsequent anastomosis).

There are several combinations of the above-mentioned techniques that are currently used by colorectal surgeons, and in our department, a wide variety of laparoscopic techniques also exist and are utilized for various disease processes. The main determining factor for the minimally invasive approach used is a combination of surgeon experience and preference, coupled with patient-specific factors, including body habitus, sex, and severity of the inflammatory bowel disease.

Indications and Contraindications

Indications

The indications for minimally invasive rectal surgery in inflammatory bowel disease are essentially the same for open rectal surgery:

Ulcerative Colitis

- failed/complications of medical therapy
- pediatric failure to thrive
- patient preference
- dysplasia or carcinoma

Indeterminate Colitis

Crohn’s disease

- proctocolitis
- severe/fulminant perianal disease
- dysplasia or carcinoma

Relative Contraindications

- fulminant colitis
- toxic megacolon, perforation, massive hemorrhage (avoid rectal dissection)
- extensive adhesions from previous surgery

Contraindications

- Inability to undergo general anesthetic/pneumoperitoneum

Preoperative Workup

There are no specific preoperative needs for laparoscopic proctectomy in patients with inflammatory bowel disease that differs from the conventional open approach. For all patients undergoing elective surgery, formal preoperative assessment is conducted which includes basic blood work and appropriate imaging tests to prepare the patient for the operating room. Nutritional parameters are checked, including albumen and prealbumen. All patients receive preoperative oral antibiotics, a full mechanical bowel preparation and are provided a chlorohexidine body wash for the night prior to surgery.

All patients see a member of the enterostomal nursing team to appropriately mark the planned ileostomy/colostomy site (temporary or permanent) before the operation. Appropriate education on ostomy care is given before the surgery, during, and after the patient's hospitalization.

On the day of the operation, patients who have been on a prolonged course of steroids will receive an intravenous "stress dose" and then will be tapered appropriately in the postoperative period. It should also be noted that recent use of biologics in the preoperative setting has shown an increase in pouch-related complications and pelvic sepsis. Our department will advocate a three-stage procedure for any patient currently on biological therapy or those who have been on biologics within a 6–8 week time period.

NSQIP guidelines for appropriate antibiotic use are strictly followed in all patients which consist of 2 g of intravenous ceftriaxone and 500 mg intravenous metronidazole within 60 min of incision; penicillin allergic patients will receive 400 mg intravenous ciprofloxacin and 500 mg metronidazole. Routine postoperative antibiotics are not given.

Operative Details

Positioning

Due to extremes in patient positioning, successful laparoscopic surgery begins with proper and safe patient positioning on the operating room table. Patients are placed in a modified lithotomy position and legs are placed in stirrups or alternatively, a “split-leg” table is used (Fig. 9.1). It is imperative that the legs, if using Allen-type stirrups, are positioned within 5° of being parallel with the abdominal wall, so that instrumentation do not interfere with the thighs while working in the upper abdomen. Both arms are tucked at the patient’s sides and bony prominences are padded appropriately. To prevent passive slipping of the patient during the procedure, we employ strapping the chest to the operating room table, and if the split leg table is used, taping and strapping of the legs is also performed. Alternatively, egg-crate foam or an inflatable “bean bag” is utilized by some members of our department. The patient then undergoes a tilt test in extremes of bed positioning to ensure fixation to the table. A commercially available warming device is utilized to maintain normothermia and compression devices are placed around the patient’s legs. Orogastric tube and bladder catheter are utilized as well.

Port Placement

The location and number of ports used for laparoscopic rectal surgery in IBD varies considerably between colorectal surgeons. There are multiple variations and configurations that can be used; most surgeons at our institution gain access via a cut down

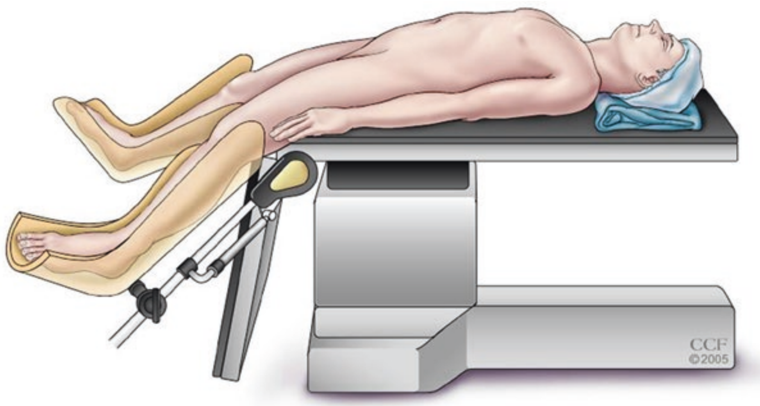

Fig. 9.1 Modified lithotomy position. Arms are bilaterally tucked to the side and all bony prominences are padded and supported appropriately. The use of straps or commercially available antislide devices is strongly encouraged

technique and place a 10-mm port in the supraumbilical position. After gaining adequate pneumoperitoneum (between 12 and 14 mmHg), a generalized exploration is undertaken of the abdominal and pelvic cavities; additional ports can then be placed under direct visualization. Most often, a left sided 5-mm port is placed along with a right lower quadrant 5- or 12-mm port. Additionally, a suprapubic port of either 5- or 12-mm is placed as well. Depending on the planned extraction site and how the rectum is transected will dictate the exact number, location, and size of the ports. Additionally, some surgeons in our department will use the planned ileostomy site as a port and as the extraction site. Furthermore, if a single-port device is utilized for the rectal dissection, it can similarly be placed at the planned ileostomy site (see video).

Colectomy

The laparoscopic abdominal colectomy portion of the procedure has been described previously from our unit. When a laparoscopic STC and EI is performed for acute colitis in a 3-stage procedure for UC, the authors routinely implant the rectosigmoid stump above the fascia at the extraction site which is via a small Pfannenstiel or lower midline incision, due to the friable nature of the tissues. We prefer a controlled wound infection rather than a rectal stump "blowout" in the pelvis, which will undoubtedly make the future proctectomy more difficult and technically challenging, especially laparoscopically. In terms of colon mobilization, the authors prefer a medial-to-lateral approach, working sequentially from the right to left side. Most often, vascular division is performed with tissue sealing devices and are only performed in a high ligation fashion if there has been biopsy-proven carcinoma or dysplasia with or without a dysplasia-associated lesion or mass (DALM).

Proctectomy

Either performed as part of a TPC or as the second stage as a completion proctectomy, rectal dissection is essentially done the same way. If a STC and EI have been performed previously, the long rectosigmoid stump (if implanted above the facial level) is identified in the subcutaneous tissues at the previous extraction site and is dissected free and then placed inside the abdominal cavity. In cases where the stapled off rectal stump has been left in the pelvis, the surgeon can use the same laparoscopic ports from the previous abdominal colectomy to perform the operation.

Whether performing a CP or the initial TPC, dissection at the sacral promontory is achieved by scoring the mesentery cephalad to the inferior mesenteric artery, which is then ligated (after proper identification of the left ureter) with a tissue sealing device; it is not mandatory to perform a high ligation of this vessel, unless carcinoma or dysplasia has been established (Fig. 9.2). Complete mobilization to the pelvic floor is accomplished with the use of tissue sealing devices or alternatively

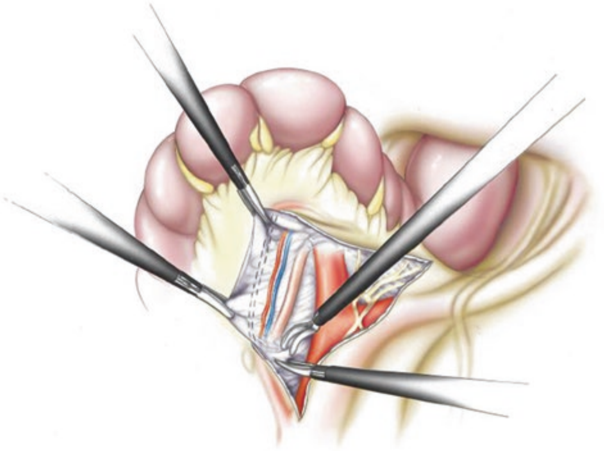

Fig. 9.2 Isolation of the inferior mesenteric vessels. Careful attention is paid for identification of the left ureter and other retroperitoneal structures before these vessels are ligated

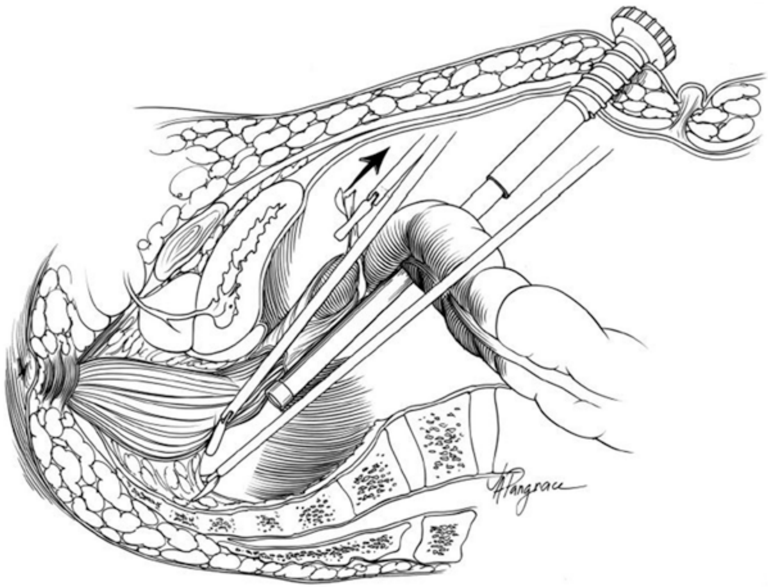

Fig. 9.3 Laparoscopic total mesorectal dissection (TME)

can be accomplished with electrocautery or scissor dissection, which many believe can provide a more "accurate" dissection. A nerve-sparing compete mesorectal dissection is undertaken (Fig. 9.3). Laterally, the left pararectal peritoneum is scored followed by medial dissection to the sacral promontory. At the sacral promontory, identification of the hypogastric nerves is accomplished and these are spared; often if the loose areolar tissue at the sacral promontory is dissected too close to the bone, one can actually get behind the nerves and cause damage. Laterally on the right, the right ureter is identified and the peritoneum is scored. We tailor the mesorectal excision so that the lateral dissection is performed closer to the rectal wall than to the pelvic sidewalls to minimize the risk of nerve injury at this level. The dissection continues posteriorly and laterally to the pelvic floor.

Once posterior and bilateral mobilization is complete, attention is turned anteriorly, which usually is the most challenging portion of the operation. In the male patient, care is taken to protect the seminal vesicles and the prostate and in the female patient, the dissection of the rectovaginal septum off the rectum may prove difficult. Occasionally, insertion of a sponge stick (or other instrument) is inserted into the vagina to help facilitate dissection of this plane. Unless the patient has carcinoma or dysplasia anteriorly in the rectum, Denonvillier's fascia is preserved.

An appropriately completed rectal dissection to the level of the pelvic floor (levators) should expose the distal rectum as a tubular structure not covered by fat or mesorectum at the level of the anorectal ring. At this time, as in an open approach, digital rectal exam with the index finger is performed to confirm the appropriate level of dissection has been reached. Often the proximal interphalangeal joint at the level of the anal verge provides a useful estimate of the appropriate level of transection (Fig. 9.4). The vast majority of IPAA performed at our institution entail a stapled anastomosis at the top of the anal canal, thereby preserving the anal transition zone, unless there is rectal cancer or dysplasia of the rectum—in this scenario, a mucosectomy with hand-sewn anastomosis is preferable.

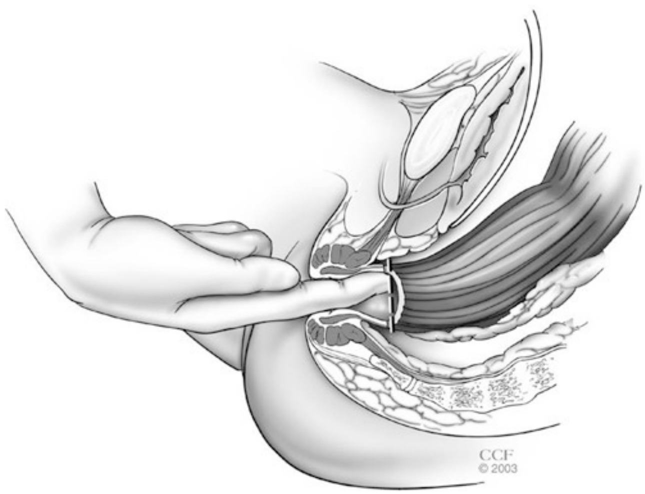

Fig. 9.4 The surgeon's index finger is placed per anus to the level of the first interphalangeal joint to provide an estimate of the appropriate level of transection

When a stapled transection of the rectum is chosen, appropriate stapler and port sites should be well planned out beforehand. There are various ways to deploy the articulating stapler, and no one technique is proven to be more beneficial than the other. At our institution, several variations exist; some surgeons will use the right lower quadrant 12-mm port, some will use the planned ileostomy site as their port and some will use a suprapubic port, and others will use open devices and transect the rectum via lower midline or Pfannenstiel incision (extraction port). The exact orientation of the staple line is not a critical factor, provided that the staple line is intact, at the level of the anorectal ring, and a limited number of staple firings are used. We try to optimize the distal rectal dissection so no more than two stapler cartridges are required for distal transection, as it has been shown that this may increase anastomotic complications. For example, an anteroposterior staple line such as created by using the suprapubic port has not shown to compromise the integrity of the subsequent IPAA and may well be the best technical option depending on exposure and body habitus in the deep pelvis.

Following complete mobilization of the colon and rectum the specimen is exteriorized by either enlarging the suprapubic port via a Pfannenstiel or lower midline incision to approximately 4–5 cm in length. Alternatively, the ileostomy site can be used. Regardless of extraction site, a wound protector is always placed and the entire specimen is removed in continuity with the terminal ileum. If an end ileostomy is performed, ileal transection is accomplished and a standard ostomy is fashioned. If intestinal continuity is not restored (as in severe Crohn's proctocolitis) and no cancer or dysplasia is present in the rectum, an intersphincteric dissection is carried out from below after the dissection has been carried down to the levators. It is common for us to do this portion of the operation in the Kraske position for enhanced exposure and ease of operation.

If an IPAA is undertaken, the pouch size and configuration are constructed as previously described by our institution (Fig. 9.5). Briefly, a 15–20 cm J-pouch is created by using two cartridges of the ILA-100 stapler device (same as an open approach) (Fig. 9.6). The anvil of the circular stapler is then placed in the distal, lateral opening of the ileum used to create the J-pouch and secured with a purse string suture. Pneumoperitoneum is then reestablished by replacing the port through the wound protector at the extraction site with the aid of a Penrose drain or towel clips. The anastomosis is made in the usual fashion under direct visualization. It is our practice to advance the spike of the circular stapler posterior to the rectal staple line in order to keep any anterior structures (i.e., the vagina) from getting trapped in the anastomosis (Fig. 9.7). After the pouch anal anastomosis is created, routine air-leak test is performed (Fig. 9.8), followed by the construction of a temporary diverting loop ileostomy (Fig. 9.9).

Postoperative Care

At the completion of the surgery, the orogastric tube is removed and patients are placed on a clear liquid diet. Early ambulation is mandatory. Most patients will receive patient-controlled anesthesia (PCA) and postoperative antibiotics are not routinely given.

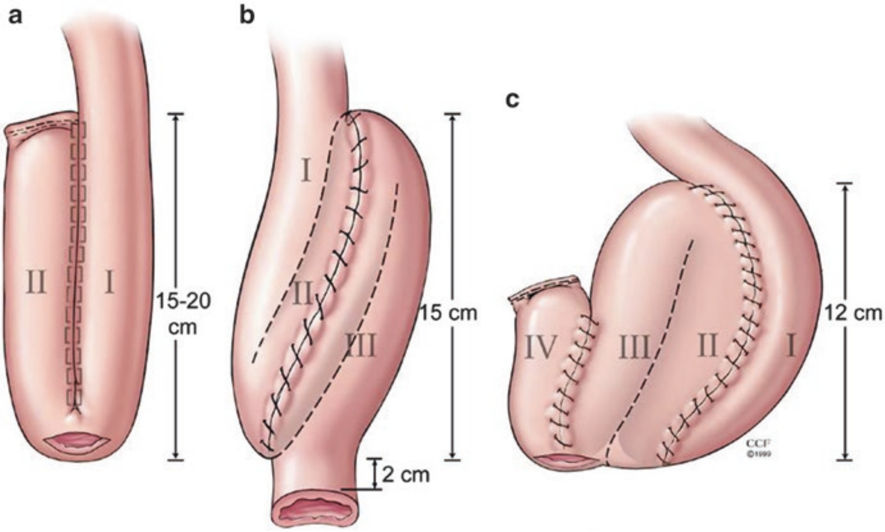

Fig. 9.5 Various ileal-anal pouch configurations. (**a**). J-pouch (**b**). S-pouch (**c**). W-pouch

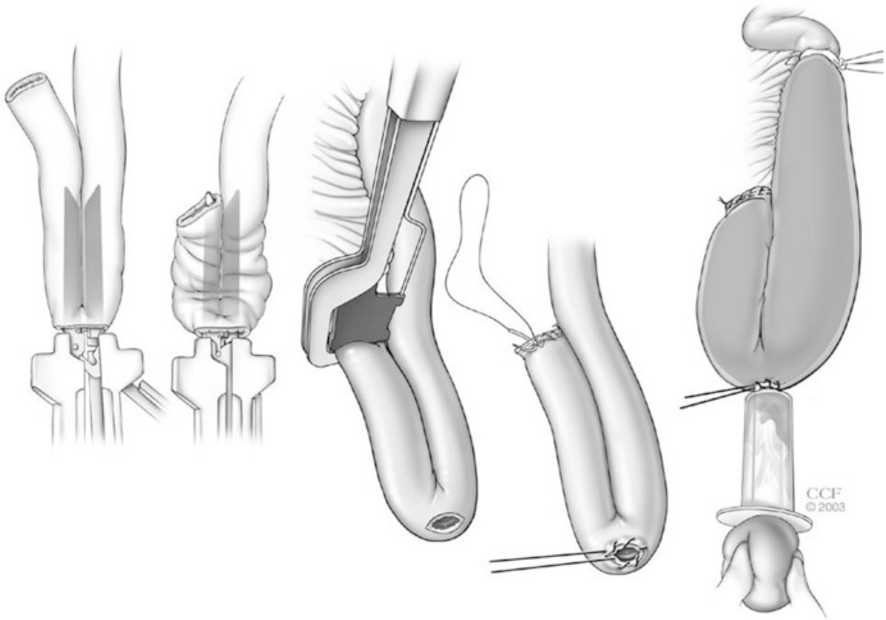

Fig. 9.6 Construction of the J-pouch ileal-anal anastomosis

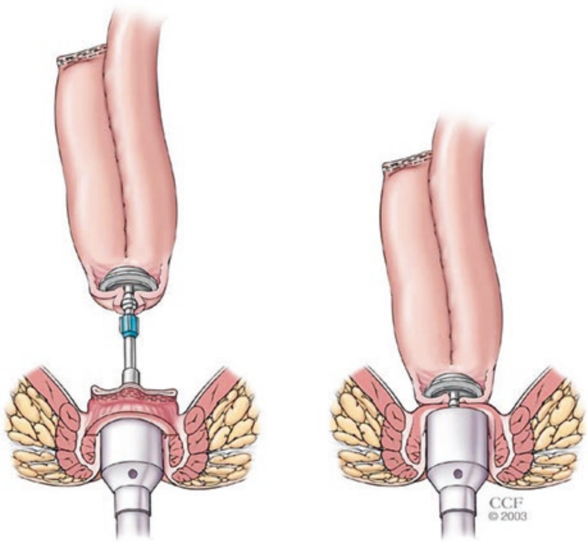

Fig. 9.7 Double stapled J-pouch ileal-anal anastomosis. Notice the spike of the circular stapler is advanced posterior to the anal staple line to prevent trapping any anterior structures into the anastomosis

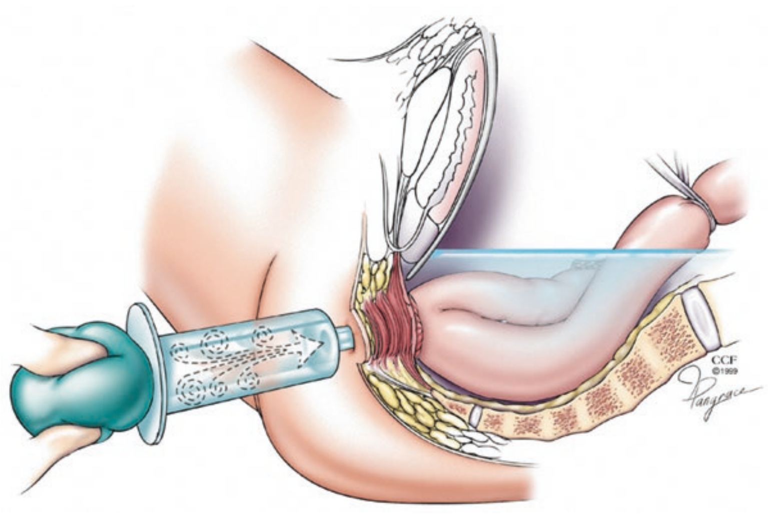

Fig. 9.8 Routine air-leak test is performed on all ileal pouch anastomoses

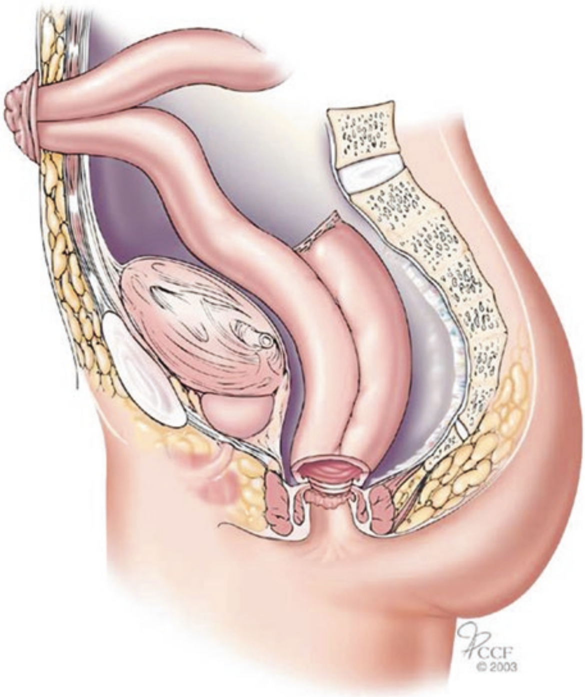

Fig. 9.9 Ileal-anal J pouch anastomosis with defunctioning loop ileostomy

All patients receive anticoagulation in the form of subcutaneous heparin or low molecular weight heparin and lower extremity compression devices are also employed. The urinary catheter is removed by postoperative day 1 or 2 in most circumstances. Once bowel function returns (either via ileostomy or per anus), diets are advanced gradually to low residue and patients are transitioned to oral analgesia. Ileostomy care and teaching is started on postoperative day one as well as dietician consultation on the potentials of dehydration and incorrect food choices.

Possible Complications

The potential complications of minimally invasive/laparoscopic rectal surgery for IBD, whether it be UC or Crohn's are very similar to the traditional open approach. However, some complications may be reduced in the laparoscopic approach compared to open. The most common complications are paralytic ileus, partial small bowel obstruction, hemorrhage, various ostomy complications, wound infection, sexual dysfunction, and pelvic sepsis/pouch leak. Overall outcomes are similar comparing laparoscopic and open rectal surgery for IBD, with the exception that patients who undergo the laparoscopic approach tend to have fewer adhesions which may result in fewer bowel obstructions. Additionally, with less adhesions, maintenance of female fecundity may be achieved.

Conclusion

Minimally invasive surgery involving the rectum is a safe and reliable approach for IBD patients. The laparoscopic approach offers equivalent outcomes to open surgery and may avoid certain complications. A high level of laparoscopic experience may be needed due to the potentially profound inflammatory alterations and fragility of the bowel. There exists several variations in technique for rectal laparoscopic surgery available to the surgeon, and the operative approach should be dictated by surgeon skill, experience, and disease-specific characteristics.

Suggested Readings

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Chapter 10
Natural Orifice Specimen Extraction in Laparoscopic Colorectal Surgery: Transanal Approach

Morris E. Franklin Jr. and Miguel A. Hernández

Introduction

For years, the conventional laparoscopically assisted colon resection has been the most accepted approach worldwide for all pathologies in the right colon, left colon, and rectum. The necessity of an abdominal incision to retrieve the specimen is accompanied by a significant number of complications, such as infection, incisional hernia, pain, longer hospital stay, and more discomfort for the patient.

Natural Orifice Specimen Extraction (NOSE) has been postulated as an alternative approach to deliver the resected specimen from the peritoneal cavity through an anatomic passage rather than an abdominal incision after laparoscopic colorectal surgeries [1–6]. The advantages associated with transanal approach in comparison with transabdominal specimen extraction include decreased further abdominal wall trauma, reducing postoperative pain, quickening postoperative recovery, and shortening hospital stay.

This transanal approach is indicated in patients with diagnosis of colorectal diseases including cancer, diverticulitis, and other pathologies that have been confirmed by preoperative colonoscopy.

The specimen needs to be isolated as quickly as possible with stapling devices or endoloops around the proximal and distal segments of the bowel prior to placing the segment of the colon in a bag. We try to use no touch technique of the tumor site when using laparoscopic surgery for cancer. We use a special bag for specimen removal to prevent stool contamination and tumor cell spillage in malignant disease [7].

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Preoperative Planning

The patient and the operating team must be adequately informed of the laparoscopic procedure, and the patient and the family must know that the laparoscopic procedure may have to be converted to open procedure. The workup of the colon is a crucially important part of preoperative patient preparation to allow the accurate tumor or colon lesion localization. In our institute, we prescribed 5 day prior surgery a low fiber diet, 3 days prior surgery a full liquid diet, and 2 days prior surgery clear liquids, adding four tablespoons of Milk of Magnesia in the middle of the day and four tablespoons more 6 h later. The day of surgery we recommended continue with clear liquids and saline enema 8 h previous to surgery.

The decision to use transanal approach for retrieval of specimen is an agreement between the surgeons and patient; the surgeon must explain the benefits of the approach compared with traditional approach and potential complications. The surgeon must analyze the size and characteristic of the tumor or lesion.

Surgical Procedure

Under general anesthesia, the patient is placed supine in modified lithotomy position, with the arms tucked to the table, the thighs are kept in a straight line with the patient's body, and legs are placed in semiflexure to permit a better approach to the anus and instrument manipulation (Fig. 10.1). The surgeon should stand between the patient's legs or on the patient's right, with the assistant camera holder on the patient's right and, if available, another assistant on the left side. The nasogastric tube and bladder catheter are placed with additional monitoring devices as needed.

Fig. 10.1 Modified lithotomy position

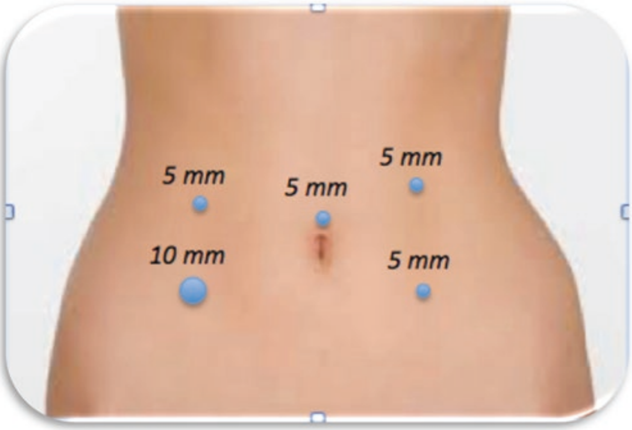

Fig. 10.2 Trocar placement configuration

The abdomen is prepped and draped in the usual manner, with care taken to preserve anal access to facilitate intraoperative colonoscopy and specimen extraction in cases of subtotal colectomy. The abdomen is insufflated with a Veress needle in an alternative location (usually left lower and often upper quadrant) to avoid possible small bowel injury due to adhesions in the midline. Typical trocar placement is shown in (Fig. 10.2). Usually, we use four to six trocars to facilitate the approach to all four quadrants. Initially, the surgeon is stationed between the legs of the patients and the abdominal cavity is surveyed to evaluate the anatomy of the colon and to perform adhesiolysis if needed. The surgeon is then moved to the right side of the patient and lifting up the sigmoid colon and dissecting the mesentery until the inferior mesenteric artery is identified. Care must be taken with multiple anatomic variations in the area and all the branches should be divided most expeditiously with LigaSure device. The sigmoid colon is then mobilized from its lateral attachments and the ureter is clearly identified and preserved (Fig. 10.3). Dissection is carried out along the pelvic floor, identifying and preserving the parasympathetic nerves. Posterior dissection is carried out in the avascular plane until deep in the pelvis, and the lateral dissection is carried out to identify the middle hemorrhoidal vessel when present (Fig. 10.4). Dissection is continued to the left from a posterior approach, being the mindful of the location of the left ureter; staying in the correct plane ensures protection of the ureter. The colon is then elevated and posterior dissection is continued to the elevator ani level in the avascular presacral plane if it's necessary. Then the entire descending colon and sigmoid are dissected free from the lateral pelvic attachment and mobilized medially. Dissection at the splenic flexure is carried around this plane, freeing completely (Fig. 10.5). The dissection may be carried out along the gutter of the descending colon until the entire splenic flexure of the colon is completely mobilized. With the colon thus mobilized and the peritoneal reflection taken down, we placed two endoscopic bulldog Glassman clamps in the descending colon using laparoscopic bulldog applier, and a colonoscopy may be performed to

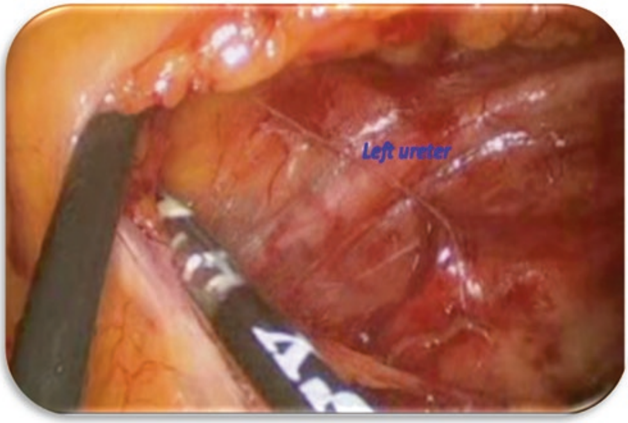

Fig. 10.3 Medial dissection and left ureter localization and visualization

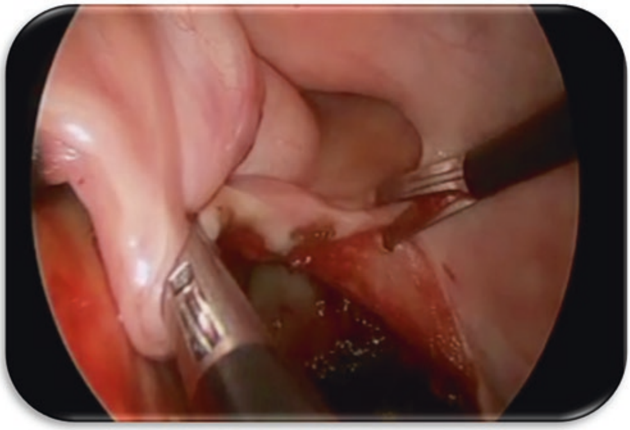

Fig. 10.4 Posterior and lateral dissection in the avascular presacral space

ensure the margin of resection. At this moment, the distal end of the colon is resected using scissors. The lumen is irrigated with Betadine supplied from the standard irrigation sources; the distal end of the specimen is immediately closed with an endoloop to protect the abdominal cavity from spillage. The proximal line of resection is then identified and transected using a scissors too. It is important to emphasize that the minimal amount of bowel should be cleaned to protect against ischemia and a subsequent higher risk of stenosis at the anastomosis. In case of colon cancer, first we introduce a specially designed bag with a purse-string suture that allows closing around the bag. This bag can be introduced through a 5–12 mm trocar or through the anus, and the colon can be deposited inside the bag and closed with the purse-string and also using an extra endoloop. The specimen and the bag are then

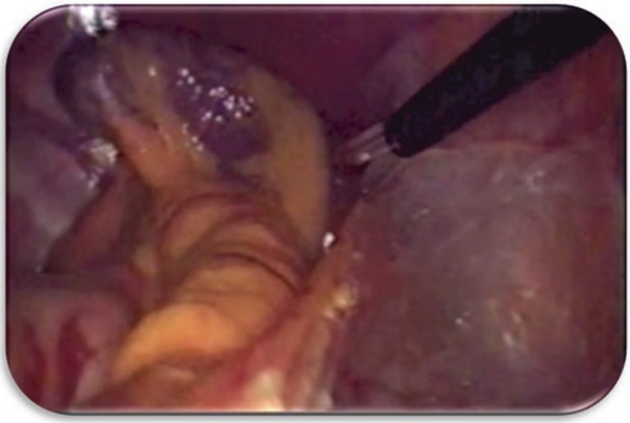

Fig. 10.5 Splenic flexure mobilization

turned around so that the endoloop end of the bag face the rectum. A ring forceps are brought through the rectum and the size of the rectum is compared with the size of the tumor. An exceptionally large tumor obviously cannot be removed transanally, but most tumors up to about 5 cm can be readily removed through this route. The anus in these patients is carefully dilated until two fingers can be easily reached. The bag and the colon are then grasped and slowly "snaked" out of the bag through the rectum. The bag is then removed, and the pelvis is inspected for bleeding or tearing. It is irrigated with Betadine solution. The circular stapler is then brought into the rectum (Fig. 10.6). The size of the proximal end of the colon has been previously determined and an appropriately sized stapler chosen. We have found that 28 or 29 mm stapler usually allows passage of the anvil and results in a very adequate lumen. The EEA circular stapler can be used to introduce the anvil into the abdominal cavity through the rectum; this anvil is placed in the proximal margin of the previously opened proximal colon. The anvil is secured using an endoloop, and the excess of tissue surrounding the anvil is trimmed to ensure a complete exposure of the tissue with staples. Then the rectal stump is closed using a 45 or 60 mm Endo-GIA linear stapler and the rim of tissue thus separated is removed through the right lower quadrant trocar, then is checked again for bleeding and a colonoscopy is performed to ensure the impermeability of the rectal stump. The EEA stapler is introduced through the rectum and the spike is slowly extruded through the center of the rectal stump; and then the anvil and the stapler are united and the stapler is fired in a convectional manner.

The amount of tension is double-checked, and a second colonoscopy is performed to ensure the absence of leaks or bleeding in the anastomotic ring. We fill the pelvis with saline solution and inject air through the colonoscope into the bowel lumen. Any leak should be repaired immediately by sutures placed intracorporeally. The clamps on the colon that were left in place during the resection are removed after the colonoscopy is completed.

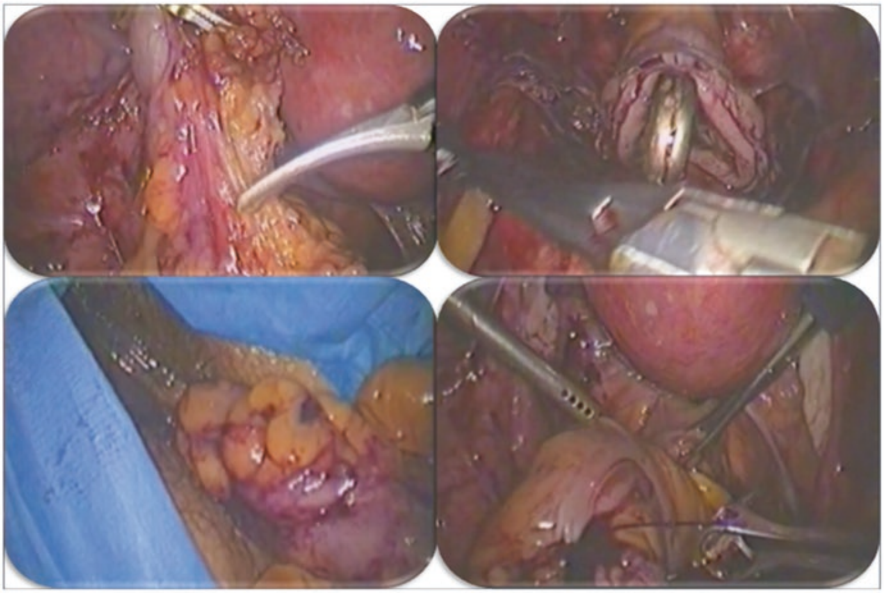

Fig. 10.6 Colon transection and transanal specimen extraction

After we ensure the absence of leaks, the entire cavity, and particularly the trocars are irrigated with Betadine solution, we aspirate all the solution, and a 10 mm flat Jackson-Pratt drain is then placed in the pelvis and brought out through the left lower quadrant trocar. All trocar larger than 10 mm should be closed using 0 Vicryl and a Carter-Thomason suture passer. The entire abdominal cavity is reinspected; all Betadine is washed free with normal saline, and the peritoneal cavity is suctioned dry. The patient is placed in the slight reverse Trendelemburg position, and the abdomen is deinsufflated; after the trocars are removed, all ports sites are immediately closed. The subcutaneous tissue is irrigated thoroughly with Betadine solution and closed; the skin is closed with staples or sutures in a subcuticular fashion and Steri-strips. In cases of anastomosis with high risk of dehiscence, such as difficulty performing anastomosis, previous radiation, leaks repaired intraoperatively, or other entities, we recommend the construction of a protective ileostomy.

Complications

The highest potential for complications of transanal specimen retrieval are tear of the rectum or anus, due to large specimen or a hard traction of the bag with the specimen. In our experience, we have not observed any malfunction of the rectum, and to the best of our knowledge, we cannot say that can be a risk factor for anastomosis complications.

Postoperative Management

The patients are under intravenous fluids dependent on their requirement, adjusting IV fluids to maintain the urine output of 1 ml/kg/h. A nasogastric tube may or may not be left in place depending on the manipulation of the bowel, length of surgery, age of the patient, bowel movements, etc. We installed antibiotics that cover colon flora for 24 h; analgesics for controlling the pain and medication for postoperative nausea.

We resume diet when the intestine is passing gas and the colon movements are present. Once the patient is tolerating the regular diet, their medical problems are under control, they can ambulate, there is no report of fever in last 24 h, the pain must be under control, all drainages had been removed, and the wounds must be clean and healing, and the patient can be discharged satisfactory.

Conclusions

NOSE in laparoscopic colorectal surgery means a real minimal invasive procedure. Transanal specimen extraction is safe and effective, suggesting it can be integrated into laparoscopic colorectal surgeries for colorectal pathologies with possibly lower postoperative complication rates.

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Chapter 11
Natural Orifice Approaches in Rectal Surgery: Transanal Endoscopic Proctectomy

Uma M. Sachdeva and Patricia Sylla

Abbreviations

APR	Abdominoperineal resection
BMI	Body mass index
CD	Crohn’s disease
CRM	Circumferential resection margin
DRE	Digital rectal examination
IBD	Inflammatory bowel disease
IPAA	Ileoanal pouch anastomosis
ISR	Intersphincteric resection
LAR	Low anterior resection
NOTES	Natural Orifice Endoscopic Surgery
TAMIS	Transanal minimally invasive surgery
taTME	Transanal endoscopic total mesorectal excision
TME	Total mesenteric excision
UC	Ulcerative colitis

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Introduction

Total mesorectal excision (TME) has become the standard of care for resection of rectal cancer, with en-bloc removal of the rectum and the surrounding lymphatic tissue by sharp dissection within the plane between the pelvic visceral and parietal fascia, with or without preservation of the sphincter mechanism [1]. Widespread adoption of TME technique in combination with systematic use of neoadjuvant chemoradiation has substantially improved oncologic outcomes of resectable locally advanced rectal cancer. Laparoscopic approaches for TME have slowly gained wider acceptance over traditional open approaches in low anterior resection (LAR) or abdominoperineal resection (APR) when possible, due to well-documented advantages from multiple randomized trials including decreased blood loss and length of hospital stay, faster return of bowel function, with equivalent oncologic outcomes [2–4]. However, laparoscopic TME is associated with longer operative time and similar surgical morbidity as the open approach, including wound-related complications, as it does not obviate creation of a sizeable abdominal incision for specimen extraction. For tumors located within the distal 5 cm of the rectum, laparoscopic TME is associated with a long learning curve due to the technical complexity of achieving negative resection margins both circumferentially and distally, in addition to sphincter preservation, particularly in obese patients with a narrow pelvis. Rates of positive circumferential resection margins (CRM) with laparoscopic TME remain 10–18 %, and conversion rates are as high as 30 %, even in experienced hands [2–4]. Not surprisingly, adoption rates of laparoscopic techniques for rectal cancer resections remain approximately 30 % of less, with recent interest in robotic techniques as a potential solution to bridge the technical gap required for these complex procedures [5].

An even greater technical challenge is posed by ultralow rectal tumors, located in close proximity to the dentate line, and that require either partial or complete intersphincteric resection (ISR) in combination with TME in order to achieve oncologically adequate resection while preserving the sphincter complex. Combined abdominal and perineal dissection is required, where inferior mesenteric vessel ligation, splenic flexure mobilization, and TME down to the level of the levator ani are performed using an open or laparoscopic transabdominal approach, followed by the perineal ISR phase. During the perineal dissection, a variable length of distal rectum and mesorectum are dissected beyond incision of the anorectal mucosa and internal anal sphincter [6] and is typically limited by poor exposure with conventional anorectal instruments. Abdominal and perineal dissection planes are ultimately connected and the specimen is extracted transanally when feasible, followed by coloanal anastomosis. While ISR has been associated with good short- and long-term oncologic outcomes [7, 8], its widespread adoption has been limited by the technical challenges of achieving an R0 resection, as well as concerns over poor functional outcomes, which have largely favored APR over ISR, especially in the United States.

The concept of Natural Orifice Translumenal Endoscopic Surgery (NOTES), whereby complex abdominal procedures can be performed endoscopically without the need for abdominal incisions, is ideally suited for colorectal applications. By virtue of the availability of multitasking and multiport transanal endoscopic platforms (TEM, TEO, TAMIS), transanal NOTES rectosigmoid resection has rapidly transitioned from experimental animal models and human cadavers into clinical practice [9]. The adoption of NOTES techniques in colorectal surgery led to the evolution of transanal specimen extraction, and transanal NOTES TME (taTME), performed either using a hybrid approach with laparoscopic, robotic, or open transabdominal assistance, or using a pure transanal NOTES approach [10]. Since the report of the first case of a laparoscopic-assisted transanal NOTES TME for a midrectal cancer in 2010 [11], taTME has been gaining momentum with over 250 cases published to date. Cumulatively, the published data from case series on transanal endoscopic TME demonstrates the technical feasibility and preliminary oncologic safety of this approach in carefully selected patients with resectable upper, mid, and low rectal cancers, with overall good quality TME, adequate lymph node harvest, adequate distal margins and CRM's, as well as morbidity comparable to that following laparoscopic TME [10, 12–22].

Although taTME is used for tumors throughout the rectum, the majority of reports describe the use of taTME for mid and lower rectal tumors. The quoted benefits of a transanal endoscopic approach for very low rectal cancers in particular include the ability to expand the upper limit of intersphincteric resection (ISR) and facilitate completion of a complete rectal and mesorectal dissection using a primarily transanal approach, particularly in patients with substantial visceral obesity and narrow pelvises with anticipated difficulties completing the TME from an abdominal approach. Additional benefits include improved visualization provided by transanal endoscopic platforms (rigid and disposable platforms including TEM, TEO, and TAMIS platforms, combined with HD or 3D imaging), early identification of the distal resection margins which may reduce the incidence of margin positivity, and avoidance of an abdominal extraction site when transanal specimen extraction is feasible.

Indications and Contraindications for Transanal Endoscopic Proctectomy

Although the data from published series has not yet matured with respect to oncologic and functional outcomes, transanal endoscopic proctectomy, with or without TME, has been shown to be feasible and effective in the treatment of benign and malignant diseases of the rectum. Based on the data published on this approach to date, there is a growing consensus regarding specific indications and contraindications for this approach based on specific pathology, tumor stage, and favorable vs. unfavorable anatomic factors.

Benign Indications

Transanal endoscopic completion proctectomy is a particularly attractive approach when seeking to avoid abdominal entry during removal of retained rectal stumps. Indications for a transanal endoscopic approach are the same as for any other approach to completion proctectomy and include refractory proctitis from diversion, ulcerative colitis (UC), or Crohn's disease (CD). Depending on the length of residual rectal stump to be removed, a pure transanal endoscopic approach or hybrid transanal/abdominal approach can be performed. The transanal approach also lends itself well to intersphincteric proctectomy in cases of refractory radiation proctitis or fecal incontinence, strictures, rectovaginal fistulas, or other complex pelvic fistula, as well as anastomotic complications from prior proctectomy. Depending on the specific pathology warranting proctectomy, rectal dissection can be carried out along the rectal wall with preservation of the mesorectum, or in combination with total mesorectal dissection.

To date, there have been four series published on transanal endoscopic proctectomy for benign indications, describing outcomes in a total of 36 patients. Procedures performed included transanal endoscopic completion proctectomy, transanal endoscopic-assisted proctectomy, transanal endoscopic-assisted restorative proctectomy [13, 23–25] and proctocolectomy with IPAA [25] for refractory diversion and radiation proctitis, IBD, large carpeting villous adenomas of the rectum, fecal incontinence, rectal strictures, and complex fistulas (Table 11.1). The length of the resected retained rectal stumps ranged from 8 to 30 cm. There were no mortality or major procedural complications except for conversion to open proctectomy due to intraabdominal adhesion [13]. The cumulative morbidity across the series was 39 % (14/36 cases) and included urinary tract infections, a hematoma, several cases of delayed perineal wound healing, a perineal dehiscence requiring reoperation, an incarcerated parastomal hernia, and a colocutaneous fistula to the perineum requiring reoperation [13, 24, 25] (Table 11.1).

Rectal Cancer

Unlike benign disease, proctectomy for rectal adenocarcinoma strictly requires total mesorectal excision. Oncologically, adequate resection with a complete mesorectum and negative margins is critical to minimize the chance of local recurrence, with the CRM being a major determinant of overall survival following curative rectal cancer resection. Of critical importance in the early stages of adoption of transanal endoscopic TME for rectal cancer (taTME) was the demonstration of the feasibility of achieving adequate mesorectal dissection and satisfactory short-term oncologic outcomes. The major drive behind increased adoption on this approach has been the suggested improvement in access to the low rectum and mesorectum relative to open and laparoscopic approaches and an enhanced view of dissection planes

Table 11.1 Published clinical series on transanal endoscopic proctectomy for benign diseases

Series	*N*	Age (years)[a]	Gender	BMI (kg/m²)[a]	Rectal stump length (cm)[a]	Indication	Abdominal assistance	Procedure	Transanal platform	Complications
McLemore et al. [25]	6	49.1	F (4) M (2)	30.2 (22–51)	10 (8–15)	IBD (4), radiation (1), diversion (1)	None (6)	Completion proctectomy (4) LAR (1), IPAA (1)	Disposable	Delayed healing (1), dehiscence (1), UTI (1)
Liyanage et al. [24]	12	66.3	F (5) M (7)	NR	17.3 (8–30)	IBD (9), radiation (1), adenoma (2)	Open (1) none (11)	APR (1), completion proctectomy (1)	Rigid	Delayed healing (3), incarcerated parastomal hernia (1), colocutaneous fistula (1)
Bremers et al. [23]	9	NR	NR	NR	14.4 (8–20)	IBD (6), Lynch (1), collagenous colitis, leak (1)	Open (1) none (8)	APR (3) LAR (6)	Rigid	None
Wolthuis et al. [13]	9	62.4	F (8) M (1)	25.6 (22–31)	NR	fistula (1), FI (1), anastomotic complications (2), IBD(2), adenoma (2)	NR	Completion proctectomy (9)	Disposable	Minor (6): fevers, UTI, bleeding

[a]Given as mean (range)

F female, *M* male, *NR* not reported, *IBD* inflammatory bowel disease, *FI* fecal incontinence, *cx* complications, *APR* abdominoperineal resection, *LAR* low anterior resection, *IPAA* ileoanal pouch anastomosis, *UTI* urinary tract infection achieved through the transanal platforms. This bottom-up approach may provide a less obstructed view and manipulation of the perirectal and mesorectal planes, facilitating the mesorectal dissection, especially for low rectal tumors in narrow pelvises.

Since the first published case report of laparoscopic-assisted taTME in 2010 for a mid-rectal T2N1 cancer treated with neoadjuvant therapy [11], at least 12 case series including 247 patients have since published their preliminary perioperative and oncologic results with taTME performed with either open, laparoscopic, robotic, or with no abdominal assistance. Across the 12 published series, 8 % (21/247) of taTME cases were performed as part of an APR, and 92 % as part of sphincter-preserving restorative proctectomy (Tables 11.2 and 11.3).

Tumor Stage

With respect to tumor selection for taTME, the large majority of studies performed taTME for non-obstructing, resectable tumors including preoperatively staged T1, T2, and T3, N0 or N1 tumors. When studies were performed under protocol [15, 21, 22], and early in their operative experience, most authors specifically excluded T4 and metastatic tumors, local recurrences, and tumors with threatened CRM margins based on staging MRI. Cumulatively, across the 12 published series with sample size ranging from 4 to 56 patients, the mesorectum was complete in 90 % and near complete in 8.7 % of patients, with negative resection margins achieved in 95 %, and an average of 12–33 lymph nodes harvested (Tables 11.2 and 11.3). Although five publications included one to two unsuspected T4 rectal tumors [10, 16, 18, 20, 21], only one study specifically selected unfavorable tumors in male patients for this approach, including large T3 and T4 tumors, located anteriorly, in the distal 5 cm of rectum, and with threatened positive CRM's [14], all radiated preoperatively. The rationale for this patient selection was to facilitate completion of sphincter-preserving good-quality TME in cases that were otherwise predicted to be technically challenging and associated with a high risk of incomplete mesorectal specimens. The authors were able to achieve a complete mesorectum in every case, but reported a 13 % incidence of positive margins, and 80.5 % overall survival at 24 months, reflecting the advanced stage of the tumors [14].

In the largest and only multicenter taTME series published to date, 56 patients with locally advanced tumors ≤ 5 cm from the anal verge, most of which treated with neoadjuvant treatment (84 %), underwent taTME with laparoscopic assistance with complete or near complete mesorectum achieved in all cases, and a 95 % R0 resection rate [21]. There were three conversions and six cases of delayed anastomosis, no mortality, and a 26 % morbidity rate including anastomotic leakage, pelvic sepsis urinary dysfunction, bleeding, and a cerebrovascular accident. Local recurrence rate at a median follow-up of 29 months was 1.7 %, with 96.4 % overall survival [21].

Table 11.2 Postoperative outcomes of published clinical series on transanal TME

Series	Length of stay (days)[a]	Intraoperative complications (n)	Postoperative complications (n)	Oncologic outcomes (n)	Functional outcomes
Sylla et al. [11, 15]	5	None	None	NR	NR
Chen et al. [32]	NR	None	None	NR	NR
Tuech et al. [21]	NR	NR	NR	NR	NR
Zorron et al. [10]	6	None	Feet paresthesia related to intraoperative positioning (1)	NR	NR
Dumont et al. [12]	13 (10–21)	None	Anastomotic fistula (treated with antibiotics, drainage) (1)	No recurrence at 4.3 month follow-up	No severe incontinence (median Wexner score 5) at 3 month follow-up
de Lacy et al. [22]	4.7 (4–5)	None	Dehydration requiring readmission (1)	NR	NR
Velthuis et al. [33]	NR	Pneumatosis of small bowel mesentery (1)	Pneumonia and ileus (1), presacral abscess (1)	NR	NR
de Lacy et al. [22]	6.5 ± 3.1[b]	None	Urinary retention (2), ileus (1), dehydration (1)	No recurrence at 30 day follow-up	NR
Rouanet et al. [14]	14 (9–25)	Conversion to open (2), urethral injury (2), air embolism (1)	Peritonitis (2), septic shock (1), bowel obstruction (2), anastomotic leakage (1), urinary dysfunction (2)	No recurrence (13), treated for recurrence (12), cancer-related deaths (4) at 21 month follow-up	40 % continent, 15 % incontinent to liquids, 35 % to gas, 25 % with stool fragmentation (median Wexner score 11) at 12 month follow-up ($n = 12$)

(continued)

Table 11.2 (continued)

Series	Length of stay (days)[a]	Intraoperative complications (*n*)	Postoperative complications (*n*)	Oncologic outcomes (*n*)	Functional outcomes
Sylla et al. [11, 15]	5.2 (4–10)	None	Urinary dysfunction (2), ileus (1)	No recurrence at 5.4 month follow-up	NR
Leroy et al. [34]	NR	None	Small pelvic hematoma (treated with CT-guided drainage) (1)	NR	NR
Zhang et al. [35]	NR	None	None	NR	NR
Atallah et al. [18]	4.5 (3–24)	None	Wound infection (2), pelvic abscess (4), prolonged ileus (4), pneumonia (1), acute renal failure (1), anastomotic leak requiring reoperation (1), peri-anastomotic fluid collection (2)	No local recurrence at 6 month follow-up. 1 patient with distant metastases found 9 months after surgery.	"Most" patients with mild fecal incontinence (<1 accident/day) 8 weeks after ileostomy closure. 1 patient with lifestyle-limiting incontinence (Wexner score 16)[c]
Chouillard et al. [16]	10 (4–29)	None	Small bowel obstruction requiring reoperation (2), pelvic abscess requiring reoperation (1)	No recurrence at 9 month follow-up	NR
Overall	9.5 (3–29)	6 intraoperative complications	39 postoperative complications	–	–

[a]Given as mean (range) for series with $n \geq 3$
[b]Data reported as mean ± standard error of the mean
[c]Functional outcomes were reported in the 14 patients who underwent diverting ileostomy closure
TME total mesorectal excision, *NR* not reported

Table 11.3 Patient outcomes following transanal TME from published reports

Series	*N*	Final TNM stage	Lymph nodes[a]	TME quality	Resection margins[a]	Oncologic outcomes	Functional outcomes
Dumont et al. [12]	4	NR	16	Complete	Negative	No LR at 4.3 month	No severe incontinence (median Wexner score 5) at 3 months
Sylla et al. [15]	5	T0(0), N0 (2), yN0(2), T1(1), T2(1), N1(1), yT2 (2)	33	Complete	Negative	No recurrence at 5.4 month follow-up	NR
Rouanet et al. [14]	30	T1(1), T2(8), T3(18), T4(3), N0(14), N1(13), N2(3)	13	Complete	Positive (4)	LR (12), cancer-related deaths (4) at 21 month follow-up	40 % continent, 15 % incontinent to liquids, 35 % to gas, 25 % with stool fragmentation (median Wexner score 11) at 12 months ($n = 12$)
de Lacy et al. [22]	20	HGD(2), stage I(4), stage II (7), stage III (6) stage IV (1)	15.9	Complete	Negative	No recurrence at 30 days	NR
Atallah et al. [18]	20 (5 APR)	yT0N0(5), yT0N2(1), yT2N0(3), yT3N0(4), yT3N1(2), yT3N2(3), yT4N0 (2)	22.5	Complete (11) NC (6), incomplete (2)	Positive (2)	No local recurrence at 6 month follow-up. 1 patient with distant metastases found 9 months after surgery	"Most" patients with mild fecal incontinence (<1 accident/day) 8 weeks after ileostomy closure, 1 with lifestyle-limiting incontinence (Wexner score 16)[b]
Zorron et al. [10]	9	T2(3),T3(5),T4(1), N0(5),N1(4),M1(1)	13	Complete	NR	NR	NR

(continued)

Table 11.3 (continued)

Series	*N*	Final TNM stage	Lymph nodes[a]	TME quality	Resection margins[a]	Oncologic outcomes	Functional outcomes
Wolthuis et al. [13]	5 (4 APR)	NR	NR	NR	NR	NR	NR
Velthuis et al. [20]	25 (6 APR)	T1(1),T2(11), T3(13), N0 (17), N1(5), N2(3)	14	Complete (24) NC (1)	Positive (1)	NR	NR
Chouillard et al. [16]	16 (2 APR)	Ty(1), T1(3), T2(4), T3(7), N0(8), N1(4), N0(3), N2 (1), T4(1)	21	NR	Negative	No recurrence at 9 months	NR
Chen et al. [17]	20	I(6), II(6), III (5), Tis(1), pyT0(2)	19.7	NR	NR	NR	NR
Fernández-Hevia et al. [19]	37	T1(3),T2(7),T3(22), T4(1),N0(26),N1(8), N2(3)	14.3	Complete (34), NC (2), incomplete (1)	Negative	NR	NR
Tuech et al. [21]	56 (4 APR)	T0(11),T1(7),T2(16), T3(21),T4(1),N0(41), N1(9),N2(6)	12	Complete (47), NC (9)	Positive (3)	LR (1), DR (1) at 18–54 months, OS 96.4 % at a median of 29 months	Median Wexner score 5 at ≥12 months post-stoma closure, 3 (5.7 %) with severe FI requiring colostomy, 28 % with fragmentation

[a]Given as mean
[b]Functional outcomes were reported in the 14 patients who underwent diverting ileostomy closure
NR not reported, *HGD* high grade dysplasia, *NC* not complete, *LR* local recurrence

Although the international experience with taTME is still preliminary with no randomized trial yet comparing taTME with open or laparoscopic TME, two retrospective studies compared outcomes of matched cohorts of patients who underwent taTME vs. laparoscopic TME [19, 20]. Fernandez-Hevia et al. retrospectively case-matched 37 cases of laparoscopic-assisted taTME with 37 cases of laparoscopic TME for rectal cancer and demonstrated no significant differences with respect to quality of the mesorectal specimen, lymph node harvest, resection margins, or intraoperative complications [19]. They also demonstrated comparable 30-day postoperative complications, but a statistically significant lower readmission rate in the taTME group (2 % vs. 6 %) [19]. Velthuis et al. retrospectively matched 25 cases of laparoscopic-assisted taTME with 25 cases of laparoscopic TME, and interestingly, they found that taTME was associated with a significantly higher rate of complete mesorectum than laparoscopic TME (92 % vs. 72 %) [19].

Tumor Location

With respect to location, there are no absolute contraindications to performance of the TME, either in part or completely, using a transanal endoscopic approach. As demonstrated in the published series on transanal proctectomy for benign indications, a pure transanal endoscopic approach can be used in completion proctectomy for short rectal stumps. For longer stumps, or when there is concern of possible pelvic adhesions to the proximal stump, transanal procedures are performed with abdominal assistance [13, 23, 24].

With respect to rectal cancer, based on the 12 series of taTME cases published to date, the majority of tumors were located in the mid- and low rectum (<10 cm from the anal verge), with only five studies including high rectal tumors (≥10 cm from the anal verge) [10, 14, 15, 20, 22] (Tables 11.2 and 11.3). Most authors determined that the benefit of using a transanal approach was less evident for upper rectal tumors, where standard laparoscopic techniques can usually achieve adequate TME and sphincter preservation. TME for mid- and low rectal tumors can be performed using a pure transanal endoscopic approach when feasible, or with a hybrid approach with abdominal assistance. Depending on the level of distal rectal or anorectal transection, stapled or handsewn coloanal anastomosis is performed, with or without creation of a colonic J pouch, based on the surgeons' preference.

Across the series reporting on outcomes of taTME for tumors of the distal third of the rectum, advantages of the transanal approach cited by authors include early and accurate assessment of the distal resection margins which is an essential prerequisite for achieving sphincter preservation and R0 resection. For tumors located ≤1 cm from the anorectal ring, taTME is performed with intersphincteric resection with handsewn coloanal anastomosis, in order to achieve negative margins. For tumors invading the external sphincter muscle or for other contraindications to sphincter preservation such as baseline fecal incontinence, taTME was performed in conjunction with APR [13, 16, 18, 20, 21].

Anatomic Factors

Across published series, and reflecting the centers' learning curve, most patients were carefully selected with respect to BMI, prior abdominal and pelvic operations, prior pelvic radiation, and any other anatomic features that might significantly complicate transanal dissection and increase intraoperative complications such as rectal perforation, organ injury, bleeding, and conversion. The average BMI across 12 series including 247 patients ranged from 23.4 to 27.9 (Tables 11.2 and 11.3) with a cumulative incidence of intraoperative complications of 8 %, which included mostly conversion to open proctectomy and rectal perforation (Tables 11.2 and 11.3). In Rouanet's series of 30 males with high-risk low rectal tumors, two urethral injuries occurred early in the authors' experience, highlighting the importance of careful patient selection early in the surgeon's operative experience [14]. This is particularly true in males with very low rectal tumors, when ISR is required and is extended cephalad using a transanal endoscopic approach. Anterior rectal dissection within a radiated field can be particularly arduous, and as with APR, can result in rectal perforation and urethral injury.

Taken altogether, taTME has thus far been demonstrated to be safe and effective in the oncologic resection of carefully selected resectable rectal cancer and is particularly well-suited for tumors of the mid- and low rectum. Relative contraindications, particularly early in the operator's learning curve, include bulky tumors, T4 tumors, prior pelvic surgery and radiation with anticipated dense pelvic adhesions, visceral obesity, and any other unfavorable anatomic factors, as they have been associated with a higher rate of intraoperative complications, as well as higher risk of positive margins. However, preliminary oncologic data from taTME series, including the analysis of the quality of mesorectal excision, have shown that taTME is associated with a high rate of complete mesorectal specimens, which may surpass that achieved using a laparoscopic approach. Further comparative studies, including randomized trials, will be needed to evaluate these differences further.

Preoperative Workup

Evaluation of surgical candidates for transanal endoscopic proctectomy follows the same principles as for any other approaches to the rectum. Preoperative workup includes a complete medical and surgical history, colonoscopy with biopsies, and a comprehensive physical exam, including a digital rectal exam (DRE). Preoperative assessment should take into account patients' baseline activity level, defecatory function, as well as urinary and sexual function. For newly diagnosed rectal cancer, laboratory studies include complete blood count, serum chemistries, liver function tests, and baseline serum carcinoembryonic antigen level. Staging CT scans of the chest, abdomen, and pelvis should be completed in addition to a pelvic MRI for tumor staging and to assess the status of the CRM. Endorectal ultrasound can be performed in conjunction with pelvic MRI. Patients with locally advanced disease should undergo standard long-course neoadjuvant treatment, although in some cases, short-course radiation may be elected, and neoadjuvant treatment avoided altogether in carefully selected T3a rectal tumors [19].

Preoperative DRE should assess anal sphincter function and localize the tumor along the rectum, determine fixity and distance from the anorectal ring, and dentate line and anal verge. Preoperative evaluation should also include proctoscopy or flexible sigmoidoscopy to visualize the rectal tumor or affected region of the rectum for surgical planning. DRE, office endoscopy, and/or pelvic MRI may be repeated following completion of neoadjuvant treatment, to assess tumor response, as that may impact the operative plan with respect to sphincter preservation. Transanal proctectomy for rectal cancer is typically performed 6–10 weeks following completion of neoadjuvant treatment, which is standard of care in the management of locally advanced rectal cancer.

Candidates for sphincter-preserving proctectomy using transanal assistance should be extensively counseled regarding temporary fecal diversion, as well as anticipated functional disturbances and quality of life issues following ileostomy closure, especially if radiation was administered preoperatively. This is particularly important for very low rectal tumors, when partial or complete ISR might be required in order to achieve negative resection margins.

Operative Details

With the exception of completion proctectomy, patients undergoing transanal endoscopic restorative proctectomy (LAR or IPAA) usually undergo mechanical bowel preparation, either orally and enemas, or with enemas alone, the night prior to surgery [13, 23–25]. Standard perioperative antibiotic prophylaxis is administered parentally, and while most surgeons perform these procedures with patient in lithotomy position, completion proctectomy can be performed in prone position, which can be helpful in cases where hip flexion is severely limited [25]. Most authors perform on-table rectal irrigation with dilute betadine. A Foley catheter is routinely placed, and the abdomen and perineum are both prepped and draped to allow simultaneous or sequential access during hybrid transanal procedures.

Hybrid Procedures

If abdominal assistance is planned, it can be provided using standard laparoscopic access (single-incision, hand-assisted, multiport, or robotic) or using an open approach. Laparoscopic access is usually obtained as the first step, which allows thorough evaluation of the abdominal cavity. Laparoscopic assistance can then be performed simultaneously with, prior to, or following transanal proctectomy. There may be some advantages with a dual-team approach where the abdominal and perineal teams work simultaneously with respect to operating time (Fig. 11.1). While the transanal team performs the proctectomy, the abdominal team proceeds with splenic flexure takedown, inferior mesenteric vessel dissection and division, followed by assistance during completion of the transanal TME. In a cohort of 20 patients undergoing hybrid taTME, Chen et al. found that using a two-team approach in 8 patients significantly reduced the operative time relative to a single team approach in 12 patients (226 ± 32 vs. 157.5 ± 31.7 min) [17]. Furthermore, in their comparative study of 37 hybrid taTME cases performed using two surgical teams to a matched cohort who underwent laparoscopic TME for rectal cancer, the authors reported significantly shorter mean operative time in the taTME group (215 ± vs. 252 ± 50 min) [19].

Transanal Endoscopic Completion Proctectomy, Proctocolectomy, and Apr

In cases of proctocolectomy, laparoscopic, robotic, or open abdominal total colectomy is usually performed first followed by ligation of the inferior mesenteric vessels, creation of an end-ileostomy, or end-colostomy. For APR, the rectosigmoid

Fig. 11.1 Dual team set-up for laparoscopic-assisted transanal endoscopic proctectomy with TME (taTME). The abdominal and transanal teams are working simultaneously. While the abdominal team performs laparoscopic splenic flexure and mesenteric vessel division, the transanal team performs endoscopic rectal and mesorectal dissection through the transanal platform

colon is mobilized and transected, with or without splenic flexure takedown, followed by mesenteric dissection and creation of the end-colostomy. Transanal endoscopic perineal proctectomy is performed simultaneously or sequentially. Whether performed first, during or following abdominal procedures, the transanal team prepares the rectum for proctectomy by suturing the anus closed, initiating intersphincteric or extrasphincteric proctectomy using a standard open transanal approach, and continuing the dissection until the puborectalis is reached [25]. At that level, the transanal endoscopic platform (rigid metal or disposable) is inserted, CO_2 insufflated, and rectal dissection is extended proximally through the endoscopic platform. Depending on the pathology, the posterior dissection is carried out either within the mesorectum, or along the presacral plane, according to the principles of TME. Alternatively, in cases of completion proctectomy for benign indications, the endoscopic platform is first inserted, the rectum is divided full-thickness circumferentially starting above the dentate line, and the rectal and mesorectal dissection carried until the rectal stump is entirely mobilized and exteriorized transanally. Then, intersphincteric dissection of the anal canal and distal rectal wall is carried out [23]. Transanal endoscopic dissection of the rectum can be safely performed without abdominal assistance, as long as there are no pelvic adhesions precluding safe dissection of intraperitoneal portion of the rectal stump. If extensive pelvic adhesions prevent adequate visualization and safe dissection of the rectal stump, abdominal assistance should be used. The rectum is subsequently removed transanally, the cavity irrigated, and the perineal wound closed in layers with or without the use of drains.

Transanal Endoscopic-Assisted Restorative Proctectomy

Transanal endoscopic proctectomy with TME is most commonly performed for resectable rectal cancer of the mid- and low rectum. Transanal procedures typically start with confirmation of the location of the tumor in relationship to the anorectal ring and dentate line (Fig. 11.2a). For tumors that are well above the dentate line and $\geq$1 cm above the anorectal ring, the rectum is occluded with a pursestring suture below the tumor (Fig. 11.2b), and a transanal endoscopic platform is inserted with insufflation of CO_2. Through the transanal platform, the rectal mucosa is scored circumferentially with cautery (Fig. 11.3a) and full thickness rectal and mesorectal dissection is initiated (Fig. 11.3b) and extended proximally along the anterior, lateral, and posterior planes (Fig. 11.4).

For rectal tumors that are less than 1 cm from the top of the anorectal ring and abutting the dentate line, partial ISR is first performed using standard technique. For tumors that are at the level of or just below the dentate line, total ISR is performed [21], with preservation of the uninvolved external sphincter muscle for later coloanal anastomosis. ISR is extended cephalad using an open approach until the levator ani is identified posteriorly, and the rectoprostatic or rectovaginal plane is identified anteriorly. At that point, depending on the preference of the operator, additional

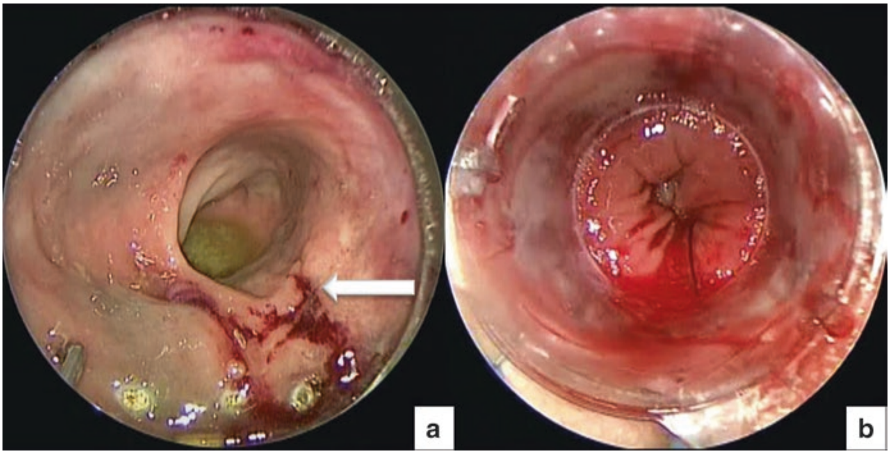

Fig. 11.2 Occlusion of the rectum. The rigid transanal endoscopic platform is inserted and the residual rectal cancer identified along the posterior rectal wall (*arrow*, **a**). The rectum is occluded with a pursestring suture 1 cm below the tumor (**b**)

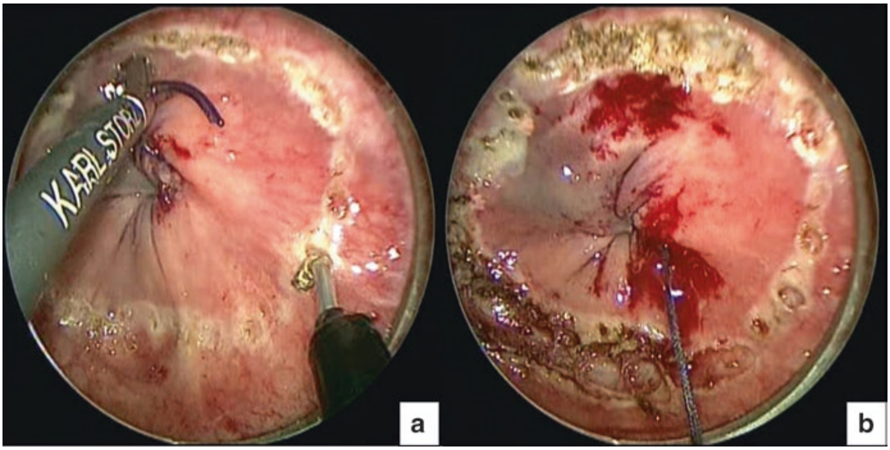

Fig. 11.3 Scoring of the rectal mucosa. The rectum is insufflated with CO_2 and the rectal mucosa is scored circumferentially with cautery (**a**). Rectal dissection is extended full-thickness (**b**)

intersphincteric dissection is completed using an open approach, or through the transanal endoscopic platform, after airtight closure of the anal stump. Further superior mobilization includes division of the anococcygeal raphe posteriorly, leading to the presacral space and bottom of the mesorectum. Anteriorly, further mobilization includes extending sharp dissection along the rectoprostatic or rectovaginal plane. At that point, if not done earlier, the anorectal stump is tightly occluded with a pursestring suture to avoid fecal spillage, leak of CO_2 into the colon, and potential spillage of tumor cells in the operative field. The endoscopic platform is inserted

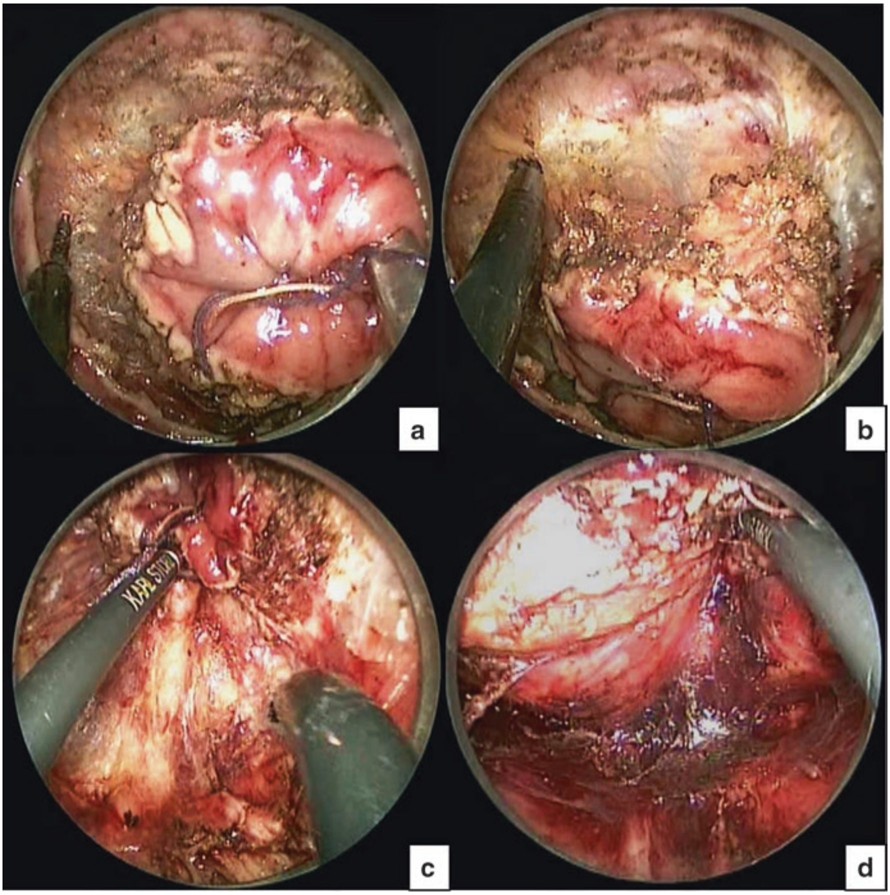

Fig. 11.4 Rectal and mesorectal dissection proceeds anteriorly, between the rectum and vaginal (**a**), laterally (**b**), and posteriorly, the mesorectum in sharply dissected along the presacral plane (**c**, **d**)

transanally, and rectal and mesorectal dissection is completed circumferentially using monopolar cautery, with or without bipolar energy (Fig. 11.4). Typically, the anterior dissection is extended proximally until the peritoneal reflection is reached, divided, and the peritoneal cavity is entered. Posteriorly, the dissection is extended towards S1–S2 levels and is usually limited by the sharp angle of the sacral promontory, preventing further cephalad exposure. If technically feasible, the taTME can be extended into the abdominal cavity with division of the inferior mesenteric vessels using a bipolar device or surgical stapler inserted through the transanal platform. In some cases, the left colon is mobile enough not to require splenic flexure takedown, and alternatively, the splenic flexure can be mobilized transanally until it is mobile enough to allow a tension-free coloanal anastomosis [16]. In most cases, however, abdominal assistance is required for splenic flexure takedown, mesenteric vessel ligation, and completion of the mesorectal division (Fig. 11.5).

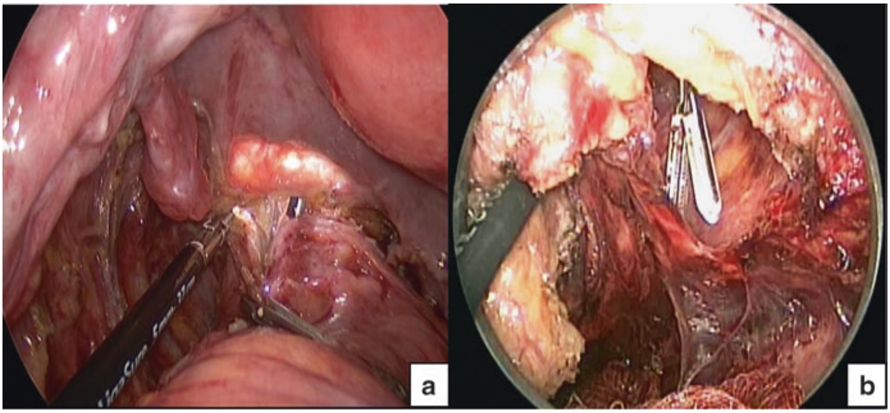

Fig. 11.5 Completion of taTME. Rectal and mesorectal dissection is extended proximally and the peritoneal cavity is entered transanally. Residual attachments are divided using combined abdominal and transanal approach (**a**, **b**)

Following completion of the TME, the specimen is exteriorized either transanally or through a small abdominal incision, if the specimen is too bulky [14, 22], followed by handsewn coloanal anastomosis or stapled colorectal anastomosis, depending on the height of distal anorectal cuff and the surgeon's preference (Fig. 11.6). Either end-end or side-end anastomosis is constructed with or without creation of a colonic J pouch. In the large majority of published cases, a diverting loop ileostomy is performed to protect the anastomosis, with liberal use of pelvic drains.

Of note, when restorative proctectomy or proctocolectomy is used in combination with ileoanal J pouch reconstruction in IBD, the colectomy and pouch creation are completed using an abdominal approach followed by transanal proctectomy. Transanal procedures are typically initiated by placement of a self-retaining retractor and circumferential sleeve mucosectomy starting at the dentate line is then followed by full-thickness rectal transection as described above [25]. Alternatively, following pursestring occlusion of the low rectum just above the anorectal ring, full-thickness rectal transection is initiated transanally followed by completion of the proctectomy, with or without TME [23].

Robotic Transanal Dissection

Most recently, several groups have described laparoscopic-assisted taTME, with the transanal dissection performed using the robotic arms inserted through a TAMIS platform (Table 11.4) [26–29]. The robot is docked over the left or right hip, and transanal dissection is performed using 2 robotic arms and the camera, with or without the use of an assistant port. Although the data is relatively preliminary, with only

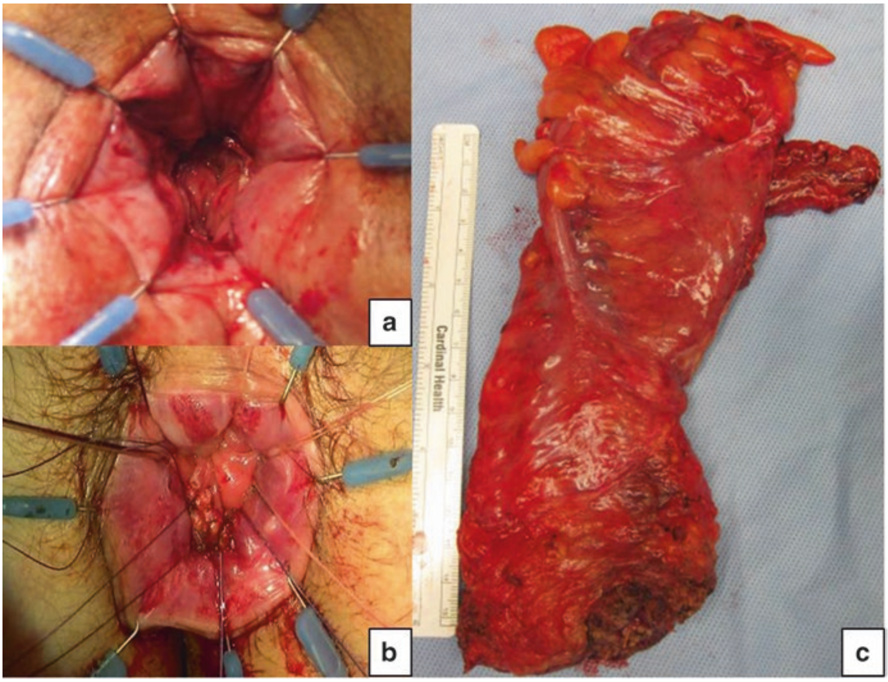

Fig. 11.6 Specimen extraction and coloanal anastomosis. Following specimen extraction, stapled (**a**) or handsewn (**b**) coloanal anastomosis is performed. A complete TME is achieved with negative margins (**c**)

four case series with sample size ranging from 1 to 7, outcomes from the 16 patients who have undergone this procedure suggest the feasibility and preliminary safety of this approach in carefully selected patients with rectal cancer [26–29] by highly skilled robotic surgeons. There were wide variations in the average operative time across the series, ranging from 165.7 to 398 min, likely reflecting the learning curve. With the majority of tumors located in the low rectum (≤5 cm from the anal verge), R0 resection was achieved in all cases, and the mesorectum was complete in 81 % of cases, or nearly complete in 19 % of all cases. There were no conversions or mortality, and the morbidity rate was 25 % (4/16 cases).

Postoperative Care

Patients are admitted to the surgical service postoperatively. A urinary catheter is typically kept in place for at least 48 h postprocedure given the relatively high incidence of postoperative urinary retention following perineal dissection, especially in

Table 11.4 Published clinical series on laparoscopic-assisted ta TME using the robot

Series	*N*	Age (years)[a]	Gender	BMI (kg/m^2)[a]	Tumor location (cm)[a]	Robot position	OR time (min)[a]	Final TNM stage (*n*)	Lymph nodes [a]	TME quality	Resection margins	Complications
Verheijen et al. [27]	1	58	F	23.6	8 cm from AV	Left docking	250	ypT0N0	18	Complete	Negative	None
Atallah et al. [26]	3	45	M (2) F (1)	32 (21–38.5)	<5 cm from AV	Right docking	376	pT3N2	30	Complete (1) NC (2)	Negative	PE (1), dehydration (1)
Gómez Ruiz et al. [29]	5	57	M (4) F (1)	25.8 (22–31)	5 cm from AV	Left docking	398	ypT0N0 (1) ypT2N0 (1) ypT3N1 (1) ypTisN0 (1) dysplasia	14	Complete	Negative	Anastomotic leak (1)
Huscher et al. [28]	7	63.2	M (3) F (4)	29.9 (21.5–37.5)	4.4 cm from AV	Right docking	165.7	pT1N0 (2) pT2N0 (2) pT3N0 (2) pT3N1 (1)	14	Complete (6) NC (1)	Negative	Bleeding (1)

[a]Given as mean (range)
F female, *M* male, *AV* anal verge, *NC* near complete, *PE* pulmonary embolism

males [14, 15, 17, 21]. A total of one to two doses of parenteral antibiotics are administered postoperatively as is standard of care. Patients are usually managed using enhanced recovery protocols including immediate initiation of oral intake as tolerated. Pain control is provided as per enhanced recovery pathways including aggressive non-narcotic regimens. Patients are extensively counseled regarding management of ostomies prior to discharge, especially with respect to hydration. Average length of hospital stay ranges from 2 to 5 days for benign disease [13, 23–25] and 4.5–12 days following taTME based on published reports (Tables 11.2 and 11.3). In the retrospective case-matched study by Fernandez-Hevia comparing 37 patients who underwent hybrid taTME to 37 patients who underwent laparoscopic TME, although there were no differences in the length of hospital stay, there were statistically more readmissions in the laparoscopic group than in the taTME group (22 % vs. 6 %) [19].

Possible Complications

Based on the published reports on transanal completion proctectomy for benign disease, the cumulative rate of postoperative complications was 39 % (Table 11.1) with no mortality. The majority of complications were minor with the most serious and frequent complication consisting in non-healing perineal wounds [24, 25].

Based on the 12 published series of pure and hybrid taTME for rectal cancer, the cumulative intraoperative complication rate was 8 % (20/247 cases) and mostly consisted in conversions to open proctectomy due to technical difficulties during transanal dissection (Tables 11.2 and 11.3). Other intraoperative complications included urethral injuries, air embolism, rectal perforation, and the need for delayed anastomosis due to technical difficulties. Forty percent of all reported intraoperative complications (5/20 cases) occurred in the Rouanet study, which was not entirely surprising given selection of high-risk patients, including males' very low, bulky, and mostly anterior tumors [14]. The authors pointed out that the two urethral injuries occurred early in their learning curve and during dissection of bulky anterior tumors, one of which with concomitant prostatic carcinoma [14].

The incidence of postoperative complications based on the 12 published case series is within the range of that anticipated from laparoscopic TME, and cumulatively, that rate was 30 % (70/247 cases). There was no 30-day mortality. Major complications included anastomotic leak, intraabdominal abscess, sepsis, SBO, bleeding, ileus, and transient urinary retention (Tables 11.2 and 11.3). In the only comparative matched series of taTME to laparoscopic TME that evaluated early oncologic as well as perioperative outcomes, there were no statistically significant differences in complication rates between the groups (32 % vs. 51 %) [19].

Follow-Up

Postoperative visits and evaluation following taTME are routine and per standard following rectal cancer resection. In patients with locally advanced rectal cancer treated with neoadjuvant treatment, ileostomy closure is usually deferred until completion of adjuvant treatment. Endoscopic and radiographic evaluation of the coloanal anastomosis is performed prior to reversal, and anastomotic complications such as strictures, leaks, and fistulas are managed using standard protocols. Oncologic surveillance following rectal cancer resections also follows standard NCCN guidelines. Regarding functional outcomes, patients who have undergone partial or complete intersphincteric resection are at increased risk for poor functional outcomes and require long-term monitoring of their defecatory function and aggressive management of their fecal incontinence.

Tips and Tricks

Procedural Training

Despite the lack of published data on the effect of the learning curve or the impact of inanimate training model on surgeon's performance during transanal proctectomy, data from prior experimental studies on this technique have highlighted the importance of fresh human cadavers as the best suited training model for this technique [30]. Total mesorectal dissection is accurately reproducible in human cadavers, as most of the dissection in patients is bloodless, as long as rectal and mesorectal dissection proceeds along the anatomically correct planes. In their series of consecutive transanal endoscopic rectosigmoid resection in 32 human cadavers, based on the significant decrease in operative time in completing the procedures after five cases, the authors concluded that the learning curve for taTME was likely around five cadavers with regard to procedural training [30].

Operating Teams

Although not absolutely necessary, a dual team approach may have the potential to reduce operative time as well as intraoperative complications. Simultaneous visualization of the pelvis from the transabdominal and transanal sides may increase the accuracy of the dissection, particularly with regard to the pelvic side walls (to avoid nerve and ureteral injury), and during anterior peritoneal entry (to avoid inadvertent organ injury).

Smoke Evacuation

With the exception of one of the rigid metal platforms that provides continuous CO_2 insufflation and suction, all other commercially available transanal endoscopic platforms lack a built-in mechanism for balanced smoke evacuation. Cyclical insufflation through standard laparoscopic insufflators result in intermittent and bothersome rectal flapping as a result of the fluctuations in pressures as occurs with smoke suctioning. It was recently suggested that the use of commercially available high-flow CO_2 insufflators might solve this technical issue by maintaining a set working pressure via high-flow CO_2 insufflation in response to smoke evacuation [31].

Anterior Dissection for a Very Low Rectal Tumor in a Male

In cases of a rectal tumor located ≤1.5 cm from the dentate line, it is safest to avoid initiating intersphincteric dissection directly through the transanal endoscopic platform. It is much safest to initiate ISR using standard open transanal techniques and to only insert the transanal platform once the anatomic landmarks have been identified, including the puborectalis and inferior aspect of the mesorectum posteriorly, and the rectovaginal or rectoprostatic plane anteriorly. As is the case in a difficult APR, there is a risk of dissecting above the anal sphincters during anterior perineal dissection, and erroneously dissect too anteriorly which could result in dissection of a plane above the prostate rather than in the rectoprostatic plane. Prostatic urethral injury is then likely to result and has been reported during taTME, which might be more likely to occur when intersphincteric resection is attempted endoscopically.

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Chapter 12
Minimally Invasive Surgery for Rectal Prolapse: Laparoscopic Procedures

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Introduction

Surgical treatment of external rectal prolapse, internal intussusception (or internal rectal prolapse), and rectocele is still a challenging clinical problem in colorectal surgery [1, 2]. These conditions may be associated with various pelvic floor disorders, including motility and morphological/functional disorders, ranging from constipation to fecal incontinence, thus significantly affecting the patients' quality of life [3, 4]. A large variety of surgical procedures exists. The literature offers abundant publications, the main problem for an informed decision on the perfect surgical technique being an often large variability of patients' selection, diagnostic assessment and variation within the same surgical technique and materials. As a consequence, the colorectal surgeon still lacks a standardized diagnostic assessment as well as a clear ideal surgical technique [5]. Perineal procedures, such as Delorme's or perineal rectosigmoidectomy or stapled transanal rectal prolapse resection, are indicated for elderly and frail patients, who are not fit for an intervention under general anesthesia, but they have poor efficacy in terms of functional outcomes and recurrence, which may be up to 26 % [6], and also an increasing risk for postoperative incontinence [7]. Abdominal procedures, on the other side, either open or laparoscopic, employing rectal mobilization and fixation, colonic resection or a combination of both, show lower recurrence rates and better functional results, but may cause postoperative worsening of constipation, mostly due to the full rectal mobilization and the consequent possible autonomic nerve injury, which is responsible for dysmotility and impaired evacuation [8]. Laparoscopic ventral mesh recto(colpo)pexy has been introduced in order to obtain good results in terms of

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functional outcome of the abdominal procedures while avoiding postoperative constipation and incontinence, offering the advantages of anterolateral mobilization, mesh repair and of a laparoscopic approach compared to an open one [9].

In 2000 Brazzelli et al. published a Cochrane review of ten trials about surgical treatment of rectal prolapse, either retrospective or prospective. Its aim was to demonstrate the advantage of either abdominal or perineal prolapse procedures, to clarify which technique of rectopexy was the best, whether a laparoscopic approach was better compared to the open, and whether a resection should be added to the procedure to overcome the risk of ‘ex novo’ postoperative constipation [7]. Only two prospective randomized trials analyzed the short-term outcomes after open and laparoscopic rectopexy, demonstrating the superiority of a laparoscopic approach in terms of a shorter hospital stay, reduced postoperative pain and global morbidity, and faster return of gut function, along with high satisfaction of the patients with aesthetic results. On the other hand, operative time is longer in the laparoscopic group [10–12]. Long-term results regarding the same series of patients, however, showed no significant differences in functional outcomes between the laparoscopic and open approach. In fact, recurrence rates, continence, and constipation scores were almost the same in the two groups [13].

Another meta-analysis on laparoscopic versus open rectopexy, published in 2005, highlighted other outcomes of interest: blood loss and the need for opiates were less in the laparoscopic series, as well as the costs, although the expense for the surgical materials was higher. This could be related to the lower morbidity of the lap approach, which consequently has a minor burden on the hospital balance [14]. Nonetheless, the reduced hospital stay has a great effect in minimizing the negative psychological effects of hospitalization.

A more recent meta-analysis published by our group in 2012 considered eight comparative studies, consisting of 467 patients, of which 275 were operated using an open approach and 192 using a laparoscopic one. The analysis of the data demonstrated once again that there were no statistically significant differences between the two techniques in terms of longer-term results regarding constipation and incontinence as well as recurrence rates. This article adds weight to the previous meta-analysis and Cochrane review cited above and demonstrates that a laparoscopic approach provides good outcomes and a comparative risk of recurrence compared to open surgery, with all the advantages related to laparoscopic surgery, especially in terms of reduced postoperative pain, shorter hospital stay, and a shorter convalescence period [15]. Moreover, Magruder and colleagues demonstrated in 2013 that surgical site infection rates in a series of 685 patients were lower after laparoscopic procedures compared to open ones [16].

In 2011 Wijffels and colleagues published a paper about Laparoscopic Ventral Rectopexy (LVR) in elderly patients. They demonstrated the feasibility and safety of this type of laparoscopic surgery in elderly patients with a good functional outcome, zero mortality, a very low-morbidity (only one major complication: an intraoperative inferior myocardial infarction successfully paced), and low recurrence rates (3 %). Many surgeons believe the perineal approach to be superior to the laparoscopic in the elderly due to its anesthetic requirements and better tolerance of spinal anesthesia. However, it is to be considered that the prone position, frequently used in the perineal approaches, may cause circulatory abnormalities requiring intravenous fluid boluses. Spinal anesthesia is only practicable with the patient in lithotomy position, due to its uncontrolled spread of local anesthetic with the prone position [17].

The aim of this chapter is to describe the different laparoscopic approaches available for the treatment of rectal prolapse and to highlight the advantages of laparoscopic procedures in comparison to open ones.

Current Laparoscopic Procedures for the Treatment of Rectal Prolapse

Laparoscopic abdominal procedures are all characterized by rectal mobilization and fixation, but they are different in terms of the extent of rectal mobilization and method of fixation. The different techniques may involve rectopexy, with or without sigmoid resection, with ventral or posterior techniques, with the use of a mesh to fix the rectum to the sacrum or not. Finally, the mesh can be synthetic or biological and absorbable or non-absorbable. We will describe in this chapter the currently used procedures.

Suture Rectopexy

This technique was first described by Cutait in 1959 [18]. In this procedure the rectum and the rectosigmoid are entirely mobilized as low as possible to the levator ani muscle and subsequently the rectum is secured to the sacrum or the presacral fascia. The laparoscopic approach follows the same principles of the open technique.

The patient is positioned in a modified lithotomy position and bilateral ports are needed. The sigmoid colon and rectum are firstly controlled for redundancy. The peritoneal reflection is incised and a posterolateral rectal dissection is performed, with a deep posterior mobilization through the avascular plane, avoiding hypogastric nerve injuries and bleeding. The ureters are identified and preserved during the lateral dissection. After the full rectal mobilization the rectum is sutured to the sacral promontory or the presacral fascia using interrupted non-absorbable sutures or staples [19]. Suture rectopexy is probably the most diffuse and simple abdominal approach, provided colonic resection is not added to the procedure. Blatchford et al. reported a single recurrence in a series of 43 patients with a follow-up longer than 2 years [20]. In a large series of 150 patients undergoing laparoscopic rectopexy, the conversion rate was about 5 % and main reasons for conversion were bowel injury, poor visibility, and adhesions in four patients [21].

Constipation and anal incontinence are two associated problems with complete prolapse of the rectum. Patients with complete rectal prolapse have markedly impaired rectal adaptation to distension which may contribute to anal incontinence and consequently, more than half of the patients with rectal prolapse have coexisting incontinence [22].

In a series of 72 patients with a median follow-up of 48 months, 34 % experienced postoperative constipation while recurrence was observed in 9 % of cases [23]. Constipation is a common problem after rectopexy, particularly so after posterior mesh rectopexy . Studies have demonstrated that constipation increased from 10 to 47 % and suggested a link with denervating the left colon and rectum with possible kinking at the rectosigmoid junction by a redundant, unresected sigmoid colon prolapsing into the pouch of Douglas [24]. This may be particularly so because the lateral ligaments containing the parasympathetic inflow to the left colon, may be cut during mobilization. At least two studies have demonstrated a higher incidence of constipation with significant changes in rectal sensation when lateral ligaments are divided as compared to sparing of the lateral ligaments [25, 26]. Suture rectopexy has been shown to be as effective as mesh rectopexy in preventing recurrence, but it avoids the problems of postoperative sepsis and increased constipation [27].

Frykman-Goldberg Procedure

In 1969 Frykman and Goldberg described a series of 80 cases and published the classic description of their procedure: the Frykman-Goldberg resection-rectopexy with the aim to avoid postoperative constipation. It consists of a rectopexy combined with a sigmoidectomy, in order to avoid postoperative constipation [28]. Several reports have confirmed that this resection-rectopexy mitigates postoperative constipation resolving outlet obstruction in about 80 % of the patients and fecal incontinence in more than 70 % [29, 30]. This technique also adapts well to the minimally invasive approach. Four ports are placed at the lower abdomen. The left and sigmoid colon are mobilized from the splenic flexure. The peritoneum is incised at the median level, from the inferior mesenteric vessels down to the pelvis. Then the rectum is dissected circumferentially, down to the level of the levator ani muscles. An endoscopic stapler is used to divide the rectum and mesorectum at about 15 cm from the anal verge. Then, the inferior mesenteric vessels are divided between clips. After the site of proximal resection is decided, a 4 cm incision is made at the site of the left port and the redundant sigmoid colon is divided. The anastomosis is performed transanally with a circular stapler. Finally, the rectal stump is fixed to the presacral fascia with non-absorbable sutures at each side [31]. Laubert and colleagues reported the largest experience on 152 patients. Conversion rate was less 1 % mortality rate less 1 % with a major and minor morbidity of 4 % and 19 %, respectively with a mean hospital stay of 11 days. At 4 years constipation was cured in 81 % and incontinence in 67 % with an overall recurrence rate of 11 % [32].

Husa et al. performed this technique on 48 selected patients with complete rectal prolapse. Prolapse recurred in 4 (9 %) of the 45 patients followed up for 1–10 (mean 4.3) years. Bowel habits improved in 23 patients (56 %), especially in those with chronic constipation [33]. However should be considered that resection comes with a risk of anastomotic leakage or stricture [34, 35]. Compared with the Wells' procedure, resection-rectopexy has lower morbidity, but produces similar functional results and has similar relapse rate.

Mesh Rectopexy

Synthetic meshes were introduced into pelvic floor surgery to enhance organ suspension thus reducing the high recurrence rate. There are no doubts that with the use of mesh materials a reduction of recurrence up to 30 % can be observed, but concerns exist about mesh erosion, infection, and dyspareunia. These issues led to the introduction of biological meshes into pelvic floor surgery. A more natural tissue repair was hoped for, thus reducing these risks. The ideal mesh is one that is flexible, shows good tissue integration, has low infection rates, is biocompatible, chemically inert, non-carcinogenic, and non-allergenic [36]. It should also be cost-effective and readily available.

There is currently no consensus on the role of biologics in the surgical management of pelvic organ prolapse and obstructed defecation. Biological meshes appear to be as effective as synthetic meshes in the short-term results. Long-term follow-up is required to ascertain if these findings persist. However, synthetic meshes are associated with the risk of erosion and infection, reasons, why biological meshes were introduced into pelvic floor surgery. Still, there is no convincing evidence proving the superiority of one mesh over the other [37]. Biological meshes consist of a collagen matrix functioning as biological scaffolds for soft tissue remodeling and regeneration, allowing possibly for a "safer" reconstructive procedure regarding their "softer" physical surface qualities, while synthetic foreign materials may support a chronically persistent infection, may it be due to the material itself or its mechanical surface qualities [26]. The abundantly cross-linked dermal porcine collagen (Permacol) is one of the most widely used biological meshes in pelvic floor surgery, as cross-linking delays degradation of the biological material.

Laparoscopic Orr-Loygue Rectopexy

Orr described this elegant technique in 1947 using a strip of fascia lata to anchor the rectum to the sacrum. Loygue et al. as well as Orr et al. subsequently modified the procedure including a full rectal mobilization with a very low prolapse recurrence (3.6 %) despite two deaths [38]. Similarly other authors confirmed low recurrence rates, usually within 10 % [39]. However, despite the initial enthusiasm in terms of

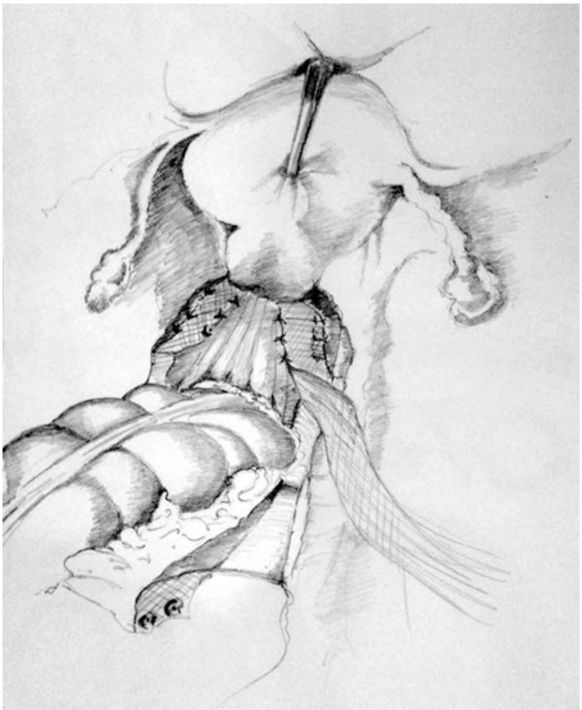

Fig. 12.1 Laparoscopic Orr-Loygue rectopexy: After a limited posterior and lateral rectal dissection, the rectum is fixed to the sacrum using a polypropylene trouser-shaped mesh

low recurrence rates, this approach showed a consistent rate of severe evacuation difficulties over time due to the complete and very low rectal mobilization. Nowadays the Orr-Loygue technique involves a limited posterior and lateral rectal dissection, with no lateral ligament division, and a fixation to the sacrum using a polypropylene trouser-shaped mesh (Fig. 12.1). The mesh is sutured to the anterolateral rectal walls and its distal ends are sutured to the vaginal fornix or vaginal vault (Fig. 12.2). Despite the reduction of posterior rectal mobilization, however, this altered Orr-Loygue procedure is still associated with new onset constipation [13].

Laparoscopic Ventral Mesh Rectopexy

Firstly described by D'Hoore in 2004, laparoscopic ventral mesh rectopexy (LVR) is effective in treating rectal prolapse associated with obstructed defecation syndrome (ODS) and fecal incontinence (FI) [9, 40], improving respectively in 37–86 % and 4–91 % of the patients [41]. LVR shows good results also on dyspareunia and sexual dysfunction, which improve in 39 % of patients [42].

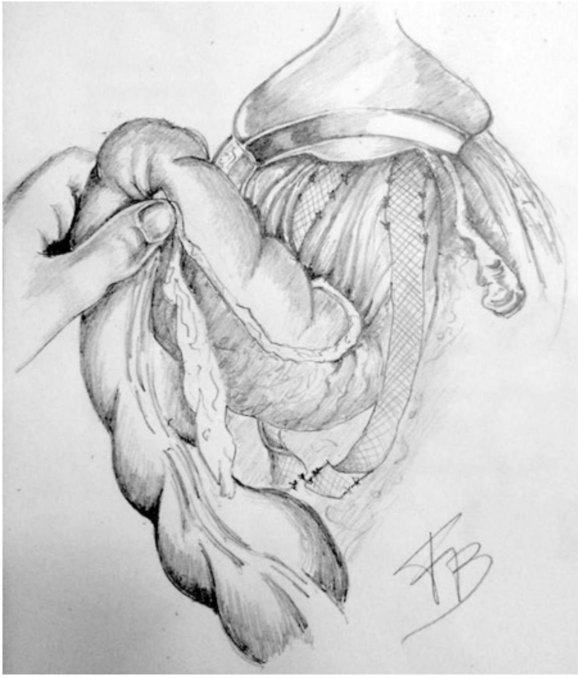

Fig. 12.2 Laparoscopic Orr-Loygue rectopexy: The mesh is sutured to the anterolateral rectal walls and its distal ends are sutured to the vaginal fornix or vaginal vault

Literature data show that LVR can be the treatment of choice for elderly. It also treats the middle as well as posterior pelvic compartment (Colpo-recto sacropexy), rectocele, enterocoele, and sigmoidocoles, if present. Usually it is performed with synthetic meshes which allows stable results but can be associated to a mesh erosion risk close to 3 % during follow-up.

The few reports on LVR using biological mesh show 82–95 % improvement of ODS symptoms and 73–95 % improvement of FI [43] with a significantly reduced risk of erosion. However, new and more data are necessary to establish the superiority of one mesh over the other, in terms of short- and longer-term functional outcomes [44].

Using a four trocar technique and a 30° scope, an anterolateral dissection is carried out between the rectum and the vagina starting from the sacral promontory, down to the levator ani muscle (Fig. 12.3). A 3 × 18 cm tailored strip of biological mesh is positioned at the level of the levator ani muscle and sutured to the anterior wall of the rectum using two parallel rows of non-absorbable 2-0 sutures (Fig. 12.4).

During this stage, the rectum is retracted cranially in order to visualize the levator ani muscle and the position of the first two distal sutures, which are confirmed to be approximately at 2–3 cm above the dentate line by rectal examination or proctoscopy (Figs. 12.5 and 12.6). The mesh is then sutured to the sacral promontory

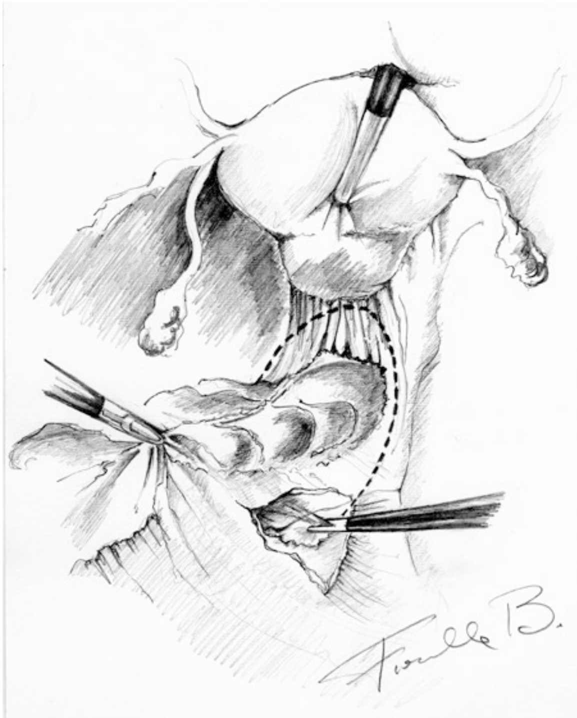

Fig. 12.3 Laparoscopic ventral mesh rectopexy: An anterolateral dissection is carried out between the rectum and the vagina

using non absorbable sutures or the ProTack™ device (Autosuture, Covidien, UK) and the vaginal vault (or cervix) is fixed to the mesh without traction using two additional absorbable sutures (vicryl 2-0), while a retractor is positioned and pulled into the vagina, in order to completely distend the posterior vaginal wall. The surgery is concluded with the closure of the peritoneal incision using a running absorbable 2-0 sutures (Fig. 12.7).

Recently, Formijne Jonkers published a paper about an international survey filled in by the European and American colorectal surgeons regarding evaluation, treatment, and follow-up of patients with internal and external rectal prolapse: LVR is the most popular treatment in Europe, for both external and internal rectal prolapse, while laparoscopic resection-rectopexy (LRR) is the most used technique in North America [45]. The authors concluded that both LVR and LRR are effective for the treatment of rectal prolapse. Although both techniques offer significant improvement in functional symptoms, continence may be better after LRR. However, LRR also has a higher complication rate than LVR.

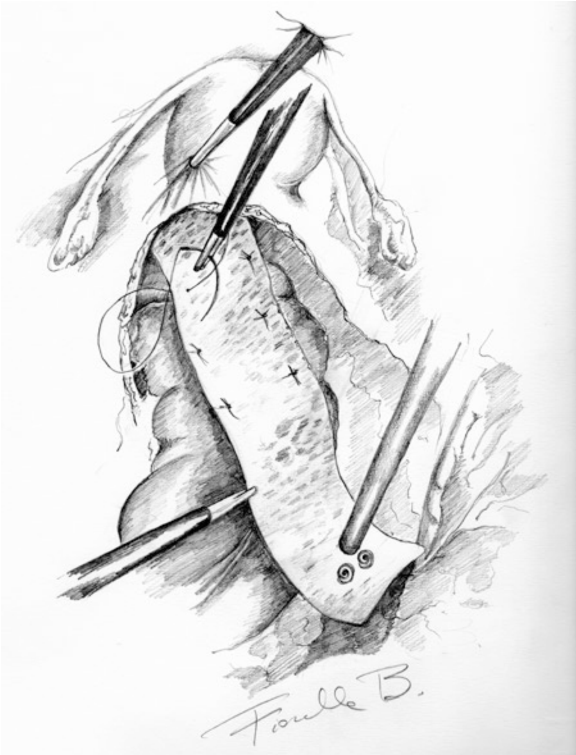

Fig. 12.4 Laparoscopic ventral mesh rectopexy: A biological mesh is positioned at the level of the *levator ani* muscle and sutured to the anterior wall of the rectum. The mesh is then sutured to the sacral promontory using the ProTack™ device

Laparoscopic Ripstein Technique

The Ripstein technique, initially described by Ripstein in 1965, was the most diffuse approach to treat rectal prolapse in USA before the introduction of sutured posterior rectopexy. It involves a complete mobilization of the rectum and its fixation at the hollow of the sacrum using a sling of Teflon, Marlex, or Gore-Tex to place around the anterior surface of it and bilaterally anchored on the sacrum. The mesh is trimmed before positioning and sutured on the seromuscular of the rectum with the rectum under cranial retraction. The suturing is started usually in the right aspect of the sacrum and ended on the left side leaving a centimeter behind the mesh to avoid tension and stricture at this level. Three to five non-absorbable sutures are used (Fig. 12.8). The laparoscopic approach is carried on similarly to the open. However, the results in terms of constipation are disappointing with a persistence

Fig. 12.5 Laparoscopic ventral mesh rectopexy: The rectum is retracted cranially in order to visualize the *levator ani* muscle and the position of the first two distal sutures, which are at 2–3 cm above the dentate line

rate of preoperative constipation as high as 57 % (compared to 17 % after resection-rectopexy, $p = 0.03$). Moreover, in 12 % of patients a new onset of constipation was described, reason why this procedure should be avoided in case of rectal prolapse with constipation [46].

Wells' Technique

The Wells technique consists of the opening of the pararectal peritoneum on both sides to the holy plane, with a dissection of the mesorectum down to the level of the levator ani plane, avoiding any injuries of the presacral nerve plexi. The peritoneum is entered at the ombelicus with three additional trocars placed in the right lower

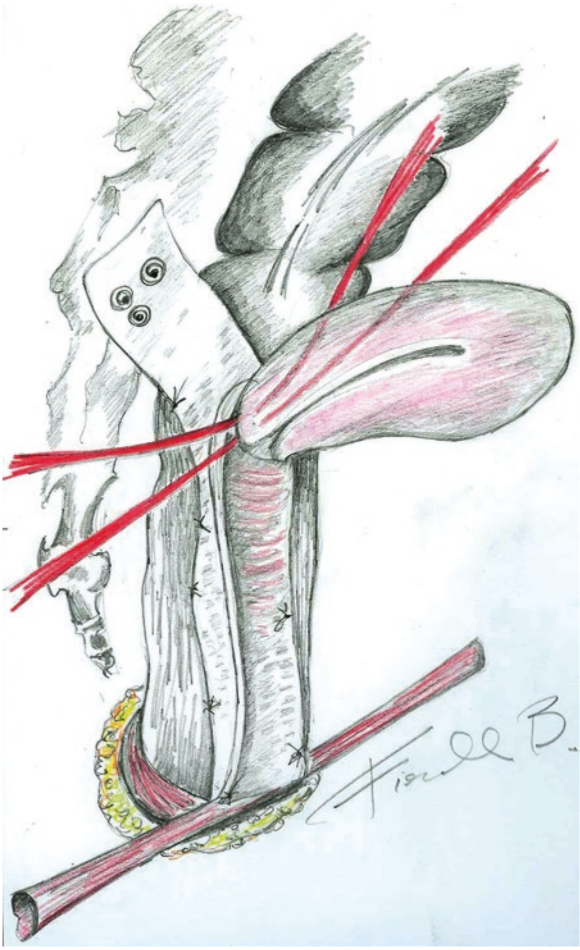

Fig. 12.6 Laparoscopic ventral mesh rectopexy: The rectum is retracted cranially in order to visualize the *levator ani* muscle and the position of the first two distal sutures, which are at 2–3 cm above the dentate line

quadrant on the anterior axillary line, at the level of the iliac crest, and the last in the lower left quadrant. If necessary, an additional trocar is placed suprapubically. Dissection is initiated opening the right-sided parietal peritoneum lateral to the rectum. A retro-rectal window is created anteriorly to the sympathetic plexus. The dissection is conducted down to the levator ani muscle. Then the sacral promontory is completely exposed reaching the iliac common vessels on the right side. A non-absorbable mesh is tailored in a T shape and oriented with the long limb of the 'T' along the hollow of the sacrum and the short arm behind and perpendicular to the rectum at the level of the sacral promontory. The mesh is then fixed to the sacrum and its lateral wings are fixed laterally to both sides of the rectum [47]. Using this

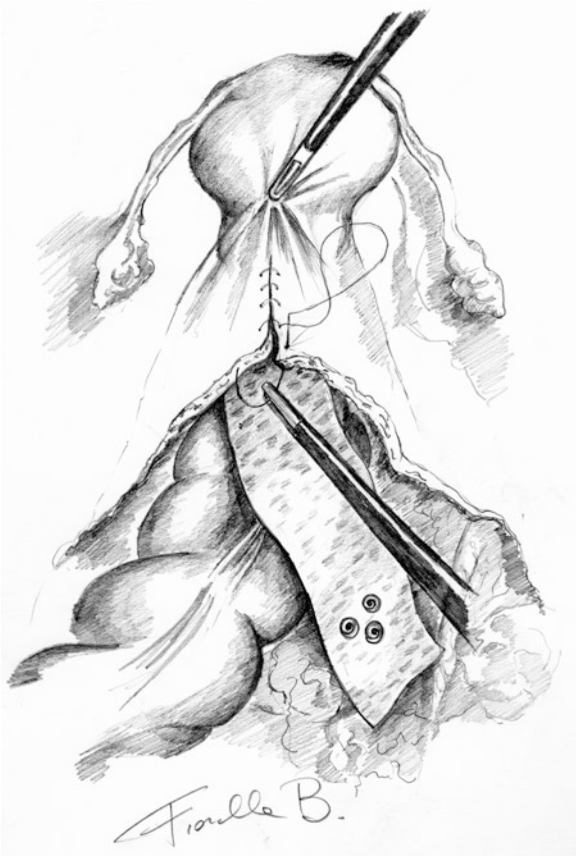

Fig. 12.7 Laparoscopic ventral mesh rectopexy: Closure of the peritoneal incision using a running absorbable 2-0 sutures

technique, constipation improvement is achieved in 36 % of cases, while there is an 18 % new onset constipation [48]. Laparoscopy has also been successfully applied to this technique, with no major intraoperative or postoperative complications. In a series of 37 patients who had undergone laparoscopic Wells technique, incontinence was cured in 92 % of patients, while a not acceptable 38 % rate of postoperative constipation was described [49].

Pelvic Organs Prolapse Suspension

This is a new technique developed by Longo which aims to address not only the posterior but also the middle and anterior pelvic compartments prolapse. Using a three-trocars technique the operation starts with an exploration of the

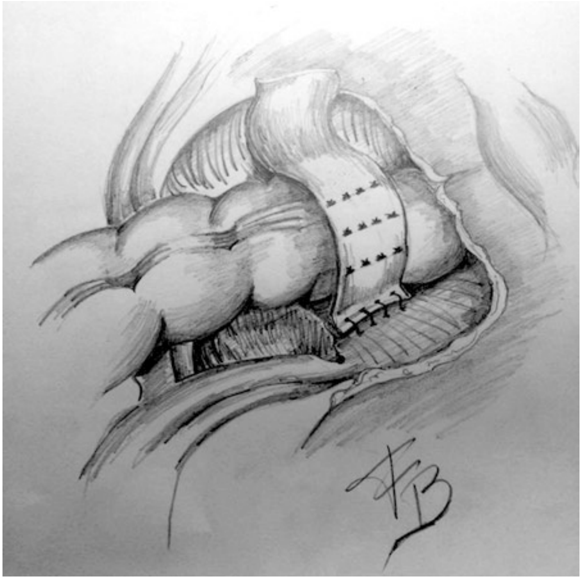

Fig. 12.8 Laparoscopic Ripstein technique: After complete mobilization of the rectum, it is fixed at the hollow of the sacrum using a sling of Teflon, Marlex, or Gore-Tex, placed around the anterior surface of it and bilaterally anchored on the sacrum

peritoneal cavity. The patient is then positioned in Trendelenburg. A vaginal flat retractor is positioned into the anterior fornix. A 30×30 cm prolene mesh is tailored in a V-shaped 25-cm length strips and 2 cm wide and introduced into the abdominal cavity through the 10-mm trocar. A 2-cm incision of the peritoneum is performed at the level of the apex of the anterior vaginal fornix, where the mesh is fixed using a 0 prolene stitch. Then, 2-cm bilateral cutaneous incisions are performed 2 cm above and 2 cm posteriorly to the anterior superior iliac spine and a subperitoneal plane is reached. Through this incision, a forceps is introduced and, under laparoscopic vision, a subperitoneal tunnel is created until reaching the anterior fornix of the vagina. At this point, the tip of the clamp is forced out of the peritoneal incision previously performed and one end of the V-mesh is pulled out through the subperitoneal tunnel, bilaterally. Pelvic organ suspension is achieved by making symmetrical tractions on both mesh strips. Finally, 5 cm of excess mesh strip is fixed to the muscles' fascia using vicryl 2/0 stitches. At the end of the procedure, a circular anal dilator (CAD) is positioned and an evaluation of the rectal prolapse is performed. If a residual recto-anal prolapse and/or an anterior rectocele is still evident, a STARR (Stapled TransAnal Rectal Resection) procedure is performed.

The overall rate of surgical complications was 14.3 %. The Longo's ODS score fell from an average of 14.55 to an average of 3.03 [50]. F. Ceci et al. evaluated the preliminary results of laparoscopic POPs + STARR in 54 women with a mean age of 55.2 and a BMI of 28.3. The authors had no relapses and the preliminary results were excellent (rectocele treated in 83 %, rectal prolapse treated in 76 %, enterocele-treated in 57 %); there were no cases of de novo dyspareunia, and all patients with this preoperative affliction reported cure or significant improvement at 1 year of follow-up [51]. However larger series with data and longer-term follow-up are needed.

Robotic Rectopexy

Robotic assistance in laparoscopic surgery may help in shortening operating times and the surgeon's learning curve in some laparoscopic tasks. Several studies demonstrated that robotic rectopexy is safe and feasible, leading to high-definition stereoscopic vision and intuitive tremor-free movements of instruments, excellent ergonomics, and motion scaling. However, significantly longer operating times compared to the laparoscopic technique have been described, probably due to the limited experience in robotic surgery at this moment and to the laborious difficulty in changing robotic instruments [52]. In a series of 44 patients who had undergone robotic-assisted ventral mesh rectopexy compared to 74 patients who had undergone laparoscopic ventral mesh rectopexy, early complications were significantly lower following the robotic approach. Also, ODS scores demonstrated a significantly better effect on constipation with the robotic-assisted approach, probably due to several technical advantages of robotic-assisted surgery, such as improved autonomic nerve-sparing, deeper mesh placement, and major reduction of rectoceles. There were no differences in recurrence rates and postoperative sexual function between the two groups [53].

The procedure is the same as in the laparoscopic procedures previously described, and performed with the aid of the four-armed Da Vinci-S surgical system (Intuitive Surgical Inc., Sunnyvale, California, USA). Deep access and dissection in the pelvis is easier with the robotic arms, with the possibility of suturing the mesh to the lateral stalks of the rectum [51].

Robotic-assisted rectopexy may be performed also in elderly patients, with no differences in terms of recurrence, short- and long-term function for both young and old patients [54].

Robotic surgery has higher costs than the laparoscopic approach, but it is likely that in the future newer, portable, and cheaper robotic systems will be developed. In combination with the clinical advantage of improved function the somewhat higher costs may be outweighed [55].

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Chapter 13
Minimally Invasive Surgery for Rectal Prolapse: Robotic Procedures

Joseph C. Carmichael and Zhobin Moghadamyeghaneh

Introduction

Since 1899, when the first report of rectal prolapse surgery was introduced by Edmond Delorme, there has been controversy regarding the best surgical technique for the treatment of rectal prolapse [1]. While innumerable rectal prolapse procedures have been introduced, virtually all procedures fall into two basic categories: transabdominal and perineal approaches. The abdominal and perineal approaches each have their own advantages and disadvantages. The abdominal approaches tend to be longer, have a higher cost, and a lower recurrence rate while perineal approach tends to be safer with a higher recurrence rate [2]. The transabdominal approach has emerged as the procedure of choice for treatment of full-thickness rectal prolapse in patients without significant comorbidities. In addition, transabdominal approaches can be combined with uteropexy or colpopexy in patients with multicompartment pelvic organ prolapse [3, 4].

The role of abdominal rectopexy was expanded with the introduction of minimally invasive techniques in 1993 [4]. The laparoscopic technique has been reported to be as effective as open surgery with a faster recovery time, less blood loss, less postoperative pain, and fewer procedure-related complications [5–7]. Therefore, many authors have recommended the laparoscopic approach as the preferred technique [5, 6, 8].

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Robotic surgery was introduced to overcome some of the challenges of laparoscopic surgery in 1998 [9]. Robotic surgery has the advantages of both laparoscopic and open procedures with high-quality three-dimensional vision, restoration of the eye–hand–target axis, faster recovery time, and less postoperative pain [10–12]. Three-dimensional vision provides better depth perception and a better definition of tissue planes compared to standard two-dimensional laparoscopic images. Robotic surgery allows for more accurate identification of anatomic structures, easier suturing in the pelvis, tremor elimination, more precise dissection, fewer conversions to open surgery, and lower blood loss compared to the laparoscopic surgery [11, 13]. The disadvantages of robotic surgery clearly are longer procedures and greater hospital costs. As surgeons become more experienced in robotic techniques, the length of the procedure decreases significantly; however, the high cost of robotic procedures is still an important issue [14]. In order to confirm the role of robotic surgery in the treatment of rectal prolapse, further prospective clinical trials are needed.

Outcomes of Robotic Surgery for Rectal Prolapse

The surgical literature regarding robotic rectal prolapse is very limited at this time. However, in this section, the literature available is reviewed.

There are now case-series and case–control data that reveal robotic-assisted rectal prolapse surgery has equivalent safety and short-term outcomes compared with laparoscopic surgery. In 2002, the first case series of robotic rectal prolapse patients was published. Six patients underwent robotic suture rectopexy with no major complications [12]. In 2005, a larger case series with 18 consecutive patients who underwent robotic treatment of pelvic organ prolapse was published. The authors noted that robotic surgery was feasible, safe, and effective [11]. Robotic surgery for rectal prolapse also appears to be safe in the elderly population. Overall, the morbidity rate of patients undergoing various types of robotic rectal prolapse repair has been reported as 1.7 % for patients older than 75 years of age [15] In a case–control series comparing robotic, laparoscopic, and open rectal prolapse techniques, the length of stay was 2.6 days, 3.5 days, and 5.7 days respectively [16]. In a case series of 77 robotic rectal surgery patients, 8 major complications requiring intervention were noted—two urinary tract infections, two presacral fluid collections, three rectal injuries, and one hemorrhage [17]. Further studies are needed to evaluate if the robotic approach will decrease complications of the surgery compared to the laparoscopic approach.

While short-term outcomes for robotic rectal prolapse seem on par with laparoscopic and open techniques, the functional outcomes are also critically important. In a case–control study comparing open, laparoscopic, and robotic techniques in 82 patients, all groups showed an improvement in the Cleveland Clinic Fecal Incontinence (CCF) score without a significant difference between the three groups [16]. Similar results were seen in a series of 77 patients in which the CCF score fell from a mean of 10.5 to 5.1 in the postoperative period [17].

Constipation resolved in 50 % of patients who were preoperatively constipated, but appeared in 24 % of patients who were not. Sigmoid colectomy was used selectively in this series and the authors did not specify if it was associated with less postoperative constipation.

Although the short-term outcomes of robotic surgery for rectal prolapse have been observed by some studies, the long-term outcomes of robotic colon resection remain relatively unknown, and there is a controversy regarding the long-term rate of recurrence. De Hoog et al., with a study of long-term outcomes of 20 patients who underwent robotic rectal prolapse procedures reported a 20 % recurrence rate for robotic procedures which was significantly higher than open abdominal procedures [16]. At first blush, this recurrence rate is alarming, however, in more recent studies, the rate of recurrence has not been so high. Perrenot and colleagues followed 77 patients for a mean of 52.5 months and found a 12.8 % risk of recurrence [17]. Haahr et al. reported a postoperative rectal prolapse recurrence rate of 11 % in 24 patients followed for an average of 10 months [18].

Ventral Rectopexy

There are a multitude of different abdominal and perineal operations that have been described for the treatment of rectal prolapse. Much like other areas of abdominal surgery, the integration of the robot can be used to mimic the previously described laparoscopic and open procedures. However, given the expense of robotic surgery [14], it should be employed in situations where it imparts some specific advantage over existing techniques. While robotics can play a role in posterior rectopexy with or without sigmoid colectomy, ventral rectopexy with mesh is an excellent example of how the robot can be used to a specific advantage. The majority of patients, who have undergone robotic rectopexy in published series, underwent ventral rectopexy in some form [14–17]. This procedure requires deep pelvic dissection and a moderate amount of intracorporeal suturing that are both facilitated with robotic techniques. This chapter will focus primarily on robotic ventral rectopexy as it has emerged as the procedure of choice in the robotic rectal prolapse surgery literature.

Ventral rectopexy was first described by Dr. Thomas Orr at the University of Kansas in 1947 [19]. Orr supported the theory that rectal prolapse was primarily due to an "abnormally attached rectosigmoid" and a deep cul-de-sac and that the correction of these two abnormalities would provide the most effective treatment. He felt that the evidence suggested the anterior rectum was usually the lead point of the prolapse and this should be the focus of the operation [19]. Like Edmonde Delorme before him [3], his descriptive case series involved primarily male patients with rectal prolapse; which is interesting considering that modern published studies on rectal prolapse involve far more female patients [20].

The Orr ventral rectopexy involved no rectal mobilization. The rectum was suspended, under tension with fascia lata to the sacral promontory. The fascia lata, harvested from the patient during the operation, was sutured to each anterior–lateral side of the rectum with a double row of interrupted silk sutures. Obliteration of the pouch of Douglas was emphasized.

The ventral rectopexy operation did not gain popularity in the United States, but became the focus of study of Dr. Jean Loygue at Hopital Saint-Antoine, Paris, France who made two significant modifications to the operation. Dr. Loygue theorized that simple rectopexy without any dissection of the rectum was not sufficient and he proposed that the rectum be completely mobilized to the pelvic floor anteriorly and posteriorly and that the pouch of Douglas peritoneum be resected [21, 22]. In addition, he employed the use of two nylon strips to suspend the anterior–lateral rectum to the sacral promontory rather than fascia lata. The Orr-Loygue ventral rectopexy series of 257 patients remains the largest published series to date. Ninety-six percent of patients had an uneventful postoperative course and the recurrence rate was 4.3 % [20].

Other authors have supported the theory that mobilization of the rectum is the most critical step in prevention of recurrent rectal prolapse. In a small case series of thirteen patients, full posterior mobilization of the rectum alone with sham sacral sutures was performed. With a mean follow-up of 33.4 months, ten patients remained recurrence-free. The authors concluded that rectal mobilization alone produces results similar to more extensive operations and may be the major component of operative success [23]. Little else has been published on mobilization of the rectum without rectopexy, but this has given support to the idea that recurrence is “due to inadequate mobilization”.

A Cochrane meta-analysis of surgery for complete rectal prolapse was completed in 2008. It involved 12 randomized controlled trials with 380 patients. The authors determined that the meta-analysis was hindered by the heterogeneity of the various trials and comparison was difficult. There was no detectable difference between the fixation methods used during rectopexy. Division of the lateral rectal “stalks” was associated with less recurrent prolapse, but more postoperative constipation. Laparoscopic rectopexy was associated with fewer postoperative complications and shorter length of hospital stay. Colectomy during rectopexy was associated with lower rates of constipation [24].

Given the limited meta-analysis data, is ventral rectopexy without sigmoid colectomy prone to constipation? The existing ventral rectopexy data would suggest it is not a constipation-inducing procedure. In a series of 73 patients who underwent open and laparoscopic Orr-Loygue rectopexy with a mean follow-up of 28.6 months, postoperative constipation was not a significant problem. 5.5 % of preoperatively non-constipated patients (2 of 36) became constipated and 5.4 % of preoperatively constipated patients (2 of 37) remained constipated after surgery [25].

The final major iteration of ventral rectopexy that has been described is the D’Hoore ventral rectopexy. Described in 2004 by Dr. Andre D’Hoore, this minimally invasive method of rectopexy involves anterior mobilization of the rectum only [26]. A single Marlex™ mesh measuring 3 × 17 cm is used to fix the anterior rectum to the sacrum without tension. This approach was advocated to minimize autonomic denervation that may occur with posterior mobilization. It is also significantly simpler to perform, but can still correct concomitant enterocele and rectocele that are present in many patients with pelvic organ prolapse. In a 109-patient series, the authors noted a low recurrence rate of 3.66 % [27].

Indications and Contraindications

Choosing the appropriate approach for treatment of rectal prolapse involves consideration of the patients' surgical risk assessment and preexisting bowel and anal sphincter functions [14, 16]. The choice between abdominal and perineal procedures is multifaceted. In general, patients who do not have significant comorbidities should be offered abdominal procedures, especially laparoscopic or robotic techniques due to lower recurrence rates and a greater chance for functional improvements in these techniques [28]. Robotic surgery is also a good choice for patients with other abdominal pathologies requiring surgery (e.g., enterocele, rectocele, vaginal vault prolapse). Additionally, trends in treatment of recurrent rectal prolapse in patients who were previously poor candidates for abdominal treatment is abdominal repair with laparoscopic or robotic approaches [29].

Contraindications to robotic surgery are similar to the contraindications of laparoscopic surgery and are divided into physiologic contraindications and anatomic contraindications of surgery. Physiologic contraindications of laparoscopic/robotic surgery include: pregnancy, coagulopathy, increased intracranial pressure, low cardiac output, severe pulmonary disease, and chronic liver disease [30]. The above mentioned conditions are not absolute contraindications for surgery and the risk of the robotic surgery should be estimated for each case separately [31].

There are not any specific anatomic contraindications to robotic surgery; however, anatomic limitations in certain conditions can potentially make the operation more challenging to perform (i.e., the hostile abdomen with severe adhesions) [14].

Preoperative Workup

The evaluation of patients with rectal prolapse should start with a complete history and physical exam. Frequently, patients present with complaint of fecal incontinence or hemorrhoids without mentioning concerns for a large prolapsing rectal mass. However, the most common symptom in patients with rectal prolapse is the prolapse itself and patients usually provide a history of a mass protruding from the anus on defecation or with walking [32]. Other common symptoms of rectal prolapse include: soiling of the undergarments, mucus discharge, constipation, fecal urgency, change in the bowel habit, and poor anal control. Therefore, a careful history of anal function and bowel habits should be taken. In the lateral or prone position, it is very hard for patients to reproduce rectal prolapse; frequently, the only thing identified in these positions is a patulous anus. To reproduce the prolapse in the office, it is best to have the patient sit on a toilet and Valsalva. If prolapse cannot be demonstrated, a defecography may be helpful. Defecography may also be helpful in patients suspected of internal prolapse or intussusception as a cause of obstructive defecation syndrome.

After diagnosis of the rectal prolapse some additional workup is necessary. If the patient has concomitant constipation, a Sitzmarks® study may be needed to evaluate for slow-transit constipation. The anal sphincter and resting procedures may be evaluated subjectively with digital exam, or objectively with anorectal manometry. When planning surgery, it is important to ensure the patient is up to date with routine colorectal cancer screening with recent colonoscopy, barium enema, or an alternative is indicated.

The patient is usually instructed to take a clear liquid diet on the day prior to surgery. Also, limited bowel preparation and evacuation of the rectum with an enema before surgery are suggested by some surgeons [33]. Single dose broad spectrum antibiotic should be administrated within an hour before the incision. Thrombosis prophylaxis should start prior to the operation and should be continued during hospitalization [34].

Operative Details

In this section, we will specifically address ventral rectopexy; however, the positioning of the robot, instrumentation, and approach could also be used to perform suture rectopexy with sigmoid colectomy or posterior mesh rectopexy if the operative surgeon feels that these are indicated.

Positioning

The patient is positioned in a low lithotomy position with Allen® Surgical Stirrups (Allen Medical Systems, Acton, MA, USA). The surgical table is covered with soft foam or egg crate that is fixed to the table. The patient lies directly on the foam or egg crate to create a “friction hold” and minimize any movement during steep Trendelenburg positioning. The arms are tucked at the sides with adequate padding to minimize pressure points where nerve injury could occur. A padded strap is placed across the patient’s chest to prevent lateral movement. A Bair Hugger® blanket or alternative is placed over the patient’s chest to minimize intraoperative hypothermia. A vaginal prep is performed as a vaginal elevator will be used during surgery.

Port Placement and Robotic Docking

Some authors have described docking the four-armed da Vinci® surgical system robot between the legs [16], but we advocate a left-sided docking procedure to allow for easier intraoperative access for vaginal elevators and rectal exam. This is the same positioning we use for all of our rectal dissections and the consistency helps facilitate a quick setup for robotic procedures. Figure 13.1 shows the port placement for this procedure.

All port placements are based on the location of the robotic camera, and this port should be placed first. After insufflation of the abdomen with a Veress needle, the 12 mm camera port is placed 15 cm cephalad to the pubis. Placement of this port too high on the abdominal wall will result in inability to reach the deep pelvis at the end of the procedure. A line is drawn from the camera port to the anterior superior iliac spines on both sides. Additional robotic ports are placed 8–10cm from the camera port along this line. An additional left lateral robotic port is placed 6 cm lateral to the left lower quadrant port for robotic Arm number 3. It may be necessary to mobilize a small portion of the sigmoid colon to place this lateral port. A 12 mm assistant port is placed in the right upper quadrant, and a 5 mm assistant port is placed in the epigastric area.

After port placement, the patient is placed in steep Trendelenburg position and the small bowel is swept out of the pelvis. The robot is docked with Arm 1 in the right lower quadrant, Arm 2 in the left lower quadrant and Arm 3 in the left lateral abdomen. The Arm 1 instrument is a monopolar scissors, the Arm 2 instrument is a fenestrated bipolar grasper, and the Arm 3 instrument is an atraumatic grasper. A 0-degree robotic camera is used in the beginning of the procedure.

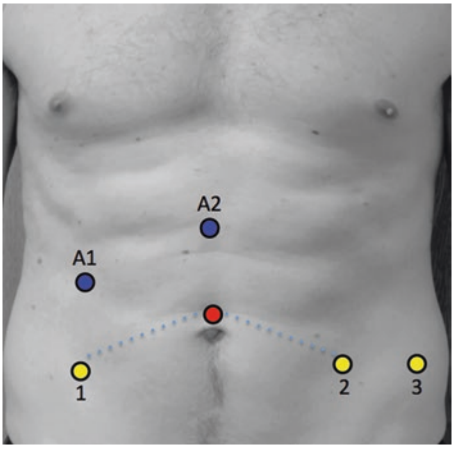

Fig. 13.1 Port placement. Yellow ports are robotic ports with numbers corresponding to the robotic arm in the port. The blue ports are assistant ports. The red port is the camera port

Rectal Mobilization

The rectosigmoid is grasped and elevated by the assistant via the epigastric port. The peritoneum overlying the base of the rectosigmoid mesentery is sharply opened with scissors. And the upper rectal mesentery is elevated off the sacral promontory. Care should be taken to identify and preserve the hypogastric nerves during the maneuver. The entire posterior mesorectum is not mobilized. The peritoneum along the right side of the rectum is opened up to the rectovaginal septum. A 0-Prolene suture is passed through the lower abdominal wall on a straight Keith Needle and passed once through the Uterus and back through the abdominal wall. The suture is used to elevate the uterus with gentle traction to the abdominal wall during the surgery and can easily be removed prior to abdominal closure. A vaginal manipulator or sound is used to elevate the posterior vaginal and facilitate the anterior dissection. Some colon and rectal surgeons have used rectal dilators for this purpose because they are usually present in the operating room. However, we advocate the use of a flat acrylic vaginal manipulator for much better retraction.

While the vagina is elevated, the assistant pulls the rectum up and out of the pelvis with an atraumatic grasper. The surgeon enters the rectovaginal plane by incising the peritoneum at that level. This can be a challenging maneuver as the rectovaginal septum can and is usually much attenuated in rectal prolapse patients. The peritoneum incision is carried to the left lower rectum to complete an inverted "J-"shaped peritoneal incision that began at the right sacral promontory. The rectovaginal septum is opened to the pelvic floor. It is important to perform digital rectal exam as the dissection approaches the pelvic floor as it is easy to dissect up too far into the intersphincteric space with the exceptional robotic visualization. The right anterior and left anterior pelvic floor is exposed, but the lateral stalks of the rectum are completely preserved. For deep pelvic dissection, it may be necessary to change the 0-degree camera lens out for a 30-degree camera lens with an "up" view.

Mesh Placement

Unfortunately, there is little evidence to guide the surgeon as to the appropriate choice of mesh for this procedure. We have routinely used a lightweight, macroporous polypropylene mesh in our practice. The mesh is cut 18 cm long and it is 3 cm wide on the side intended to attach to the anterior rectum and tapered to 2 cm in width on the side intended to attach to the sacral promontory. The mesh is rolled and delivered through the 12 mm assistant port into the abdomen. The mesh is sutured to the anterior, extraperitoneal surface of the rectum with 2-0 Ethibond® suture. Usually six sutures are placed (Fig. 13.2). The mesh is placed along the right side of the rectum and brought to the sacral promontory. The overlying presacral fascia is opened to expose the bare periosteum of the sacral promontory and presacral veins are avoided. The position of the right ureter and iliac vessels is confirmed prior to suture placement. Two 0-Ethibond® sutures are placed in a mattress fashion to fix the mesh to the sacral promontory (Figs. 13.3a, b and 13.4). The peritoneum is

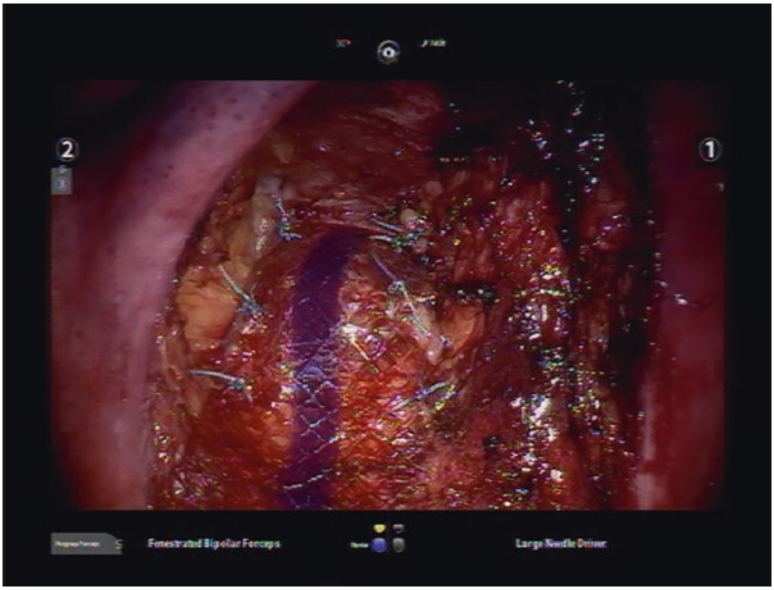

Fig. 13.2 Polypropylene mesh sutured to anterior, extraperitoneal surface of the rectum

closed over the mesh with 3-0 Vicryl® suture and Lapra-Ty® suture clips (Fig. 13.5). We do not routinely excise a portion of the peritoneum anteriorly as originally described by Loygue [22] as we find the cul-de-sac is adequately obliterated with suture closure.

Postoperative Care

Mobilization of the patent should start the following day after surgery. Diet is advanced rapidly as tolerated and the urinary catheter is removed when the patient is adequately mobile. Patients are usually discharged after resuming bowel function on the second or third day after surgery. After discharge, patients should be discouraged from lifting greater than 15 lbs for 6 weeks [34].

Possible Complications

Recurrent Prolapse

Robotic-assisted rectopexy is a safe procedure with a lower postoperative recurrence rate compared to the perineal procedures [15, 17]. Long-term recurrence of prolapse in patients with robotic surgery has been reported at 11–13 % [15, 17] and it is lower than the 25 % recurrent rate for conventional perineal procedures [35].

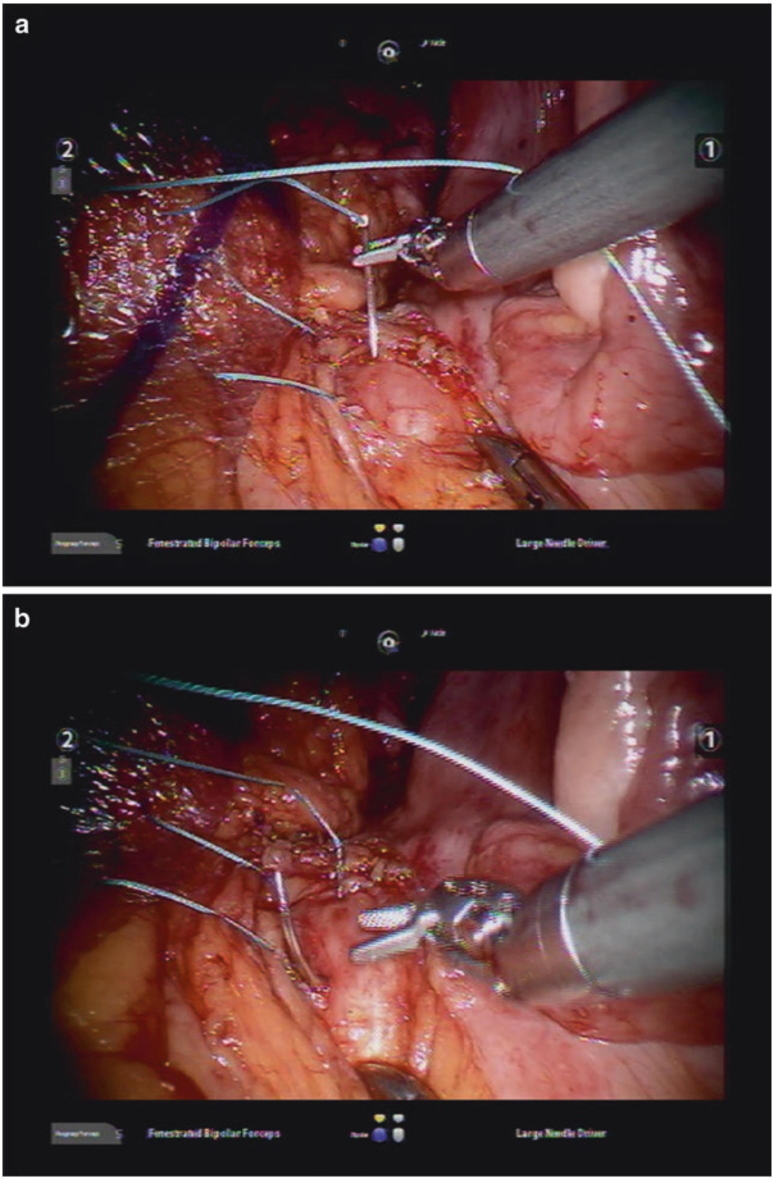

Fig. 13.3 (**a**) The periosteum of the sacral promontory is exposed in preparation for suturing. (**b**) The needle is passed through the periosteum of the sacrum

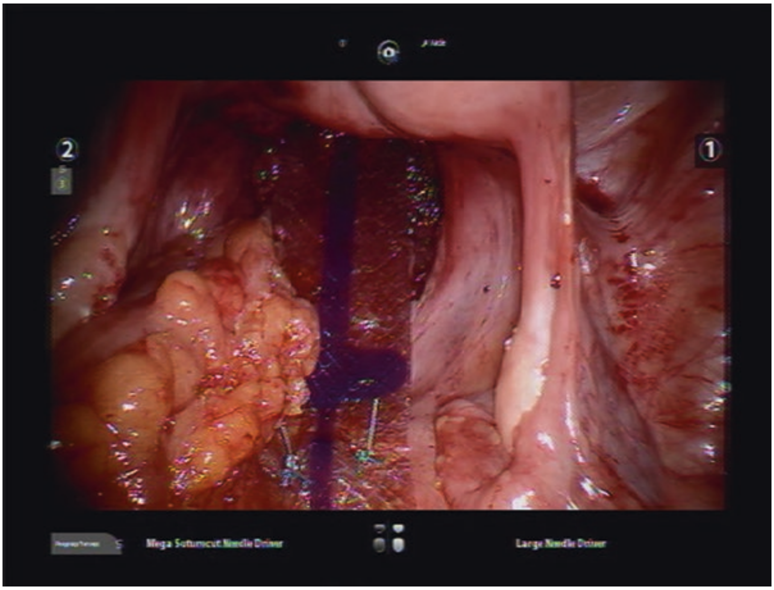

Fig. 13.4 Polypropylene mesh sutured to the sacrum

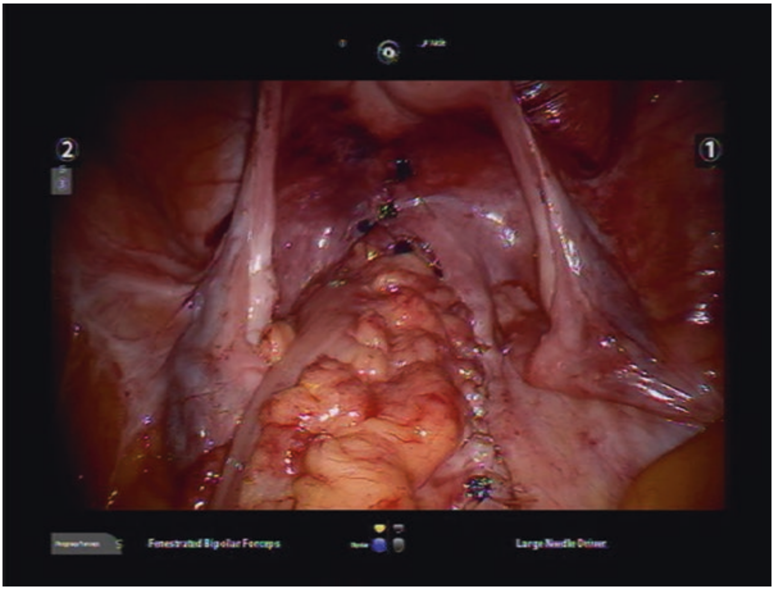

Fig. 13.5 Peritoneum closed over mesh. Note that the deep Pouch of Douglas has been obliterated and the enterocele repaired

Among abdominal procedures, there is not any significant difference between recurrence rates in laparoscopic and robotic procedures [7, 16]. A meta-analysis of the published articles between 1995 and 2003 reported that there is no significant difference in recurrence between open and laparoscopic abdominal rectopexy [7]. If recurrence does occur, robotics can be used again in a similar fashion as pelvic adhesions are likely minimal.

Mesh Complications

The use of mesh in rectopexy has been supported as a technique which decreases recurrence of prolapse [36]; however, complications of the mesh can result in significant morbidity for patients [36]. There are multiple case reports regarding complications of rectopexy with synthetic mesh in the literature and the risk of mesh complications is noted to increase in the presence of a synchronous rectal anastomosis [37, 38]. The rate of pelvic sepsis associated with the use of prosthetic mesh in rectopexy ranges from 2 to 16 %; however, the higher rates of pelvic sepsis were associated with the use of the polyvinyl alcohol sponge, a practice that has largely been abandoned [28]. While some of these percentages seem alarming, it is important to remember that several large studies of laparoscopic ventral rectopexy show mesh erosion rates from 0 to 1 % [25, 27, 39–41]. Some of the other complications of mesh include: fistula and dyspareunia [42, 43].

The treatment of mesh complications is challenging. Mesh erosion into the vaginal or rectum has been treated with simple transvaginal or transanal excision [25, 39] without significant sequela. In the largest study of complications to date after *laparoscopic* ventral rectopexy, four patients presented with rectal stricture and were treated with laparoscopic resection [44]. All strictures were associated with the tail of the mesh being stapled too low to the midsacrum rather than the promontory. Mesh erosion into the rectum (2), vagina (8) and bladder (1), were treated with laparoscopic excision and primary repair.

Many authors are now evaluating biologic meshes in colorectal [45, 46] and gynecological procedures [47] for pelvic organ prolapse; however, current studies have not demonstrated any significant decrease in mesh complications with the use of biologic mesh in rectal prolapse procedures [42]. Overall, the use of mesh rectopexy in patients without resection appears to be reasonable with an acceptable rate of morbidity and without significant increase in mortality. However, some authors have noted a high rate of recurrence with biologic mesh after laparoscopic ventral rectopexy [44].

Constipation

Constipation can be found in more than 40 % of rectal prolapse patients [48]. The treatment of constipation in conjunction with rectal prolapse is an important challenge. Overall, posterior rectopexy without resection is less efficient in the treatment of constipation compared to posterior rectopexy with resection. In theory, postoperative constipation is explained by kinking the rectosigmoid junction between the redundant sigmoid colon and the rectum in patients with suture rectopexy [49]. Another theory is that denervation of the rectum during division of lateral ligaments can cause postoperative constipation [50].

Overall, there is not a significant difference between open, laparoscopic, and robotic approaches in the treatment of constipation. The effect of the surgery on constipation depends on the type of procedure rather than the technique (open vs. laparoscopic vs. robotic). Recent studies show that ventral rectopexy with limited rectal dissection and preservation of the rectal lateral ligaments leads to diminished postoperative constipation [25]. Portier, in a study of abdominal ventral rectopexy with limited dissection and preservation of rectal lateral ligaments, reported an incidence of only 5 % postoperative constipation [25]. Similar results were reported by D'Hoore [26]. In a systematic review of ventral rectopexy, Samaranayke and colleagues found that there is a greater reduction in postoperative constipation if ventral rectopexy is used without posterior rectal mobilization [51]. Therefore, robotic or laparoscopic ventral rectopexy with limited dissection and preservation of the lateral rectal stalks seems suited for patients with a history of constipation.

Fecal Incontinence

Fecal incontinence has been reported in more than 50 % of patients with rectal prolapse [28, 32]. The possible pathophysiology may be sphincter injury, pudendal neuropathy, or impaired rectal adaptation to distention in patients with chronic rectal prolapse [28, 52]. In terms of treatment of these patients, overall perineal procedures are less efficient in treatment of incontinence compared to the abdominal procedures as they can worsen the previous incontinence. Abdominal procedures have been reported to improve incontinence in more than 62 % of patients within 3 months after surgery [53, 54].

Treatment of Recurrent Rectal Prolapse

Recurrence of rectal prolapse after surgical treatment is quite frequent. The recurrence rate varies depending on the type of procedure and it may be as high as 50 % in some perineal procedures. Overall, the higher recurrence rate of perineal procedures compared to abdominal procedures has been reported [55]. Usually the first step is to evaluate the patient and review the previous operative records. Obviously, a patient who previously underwent a perineal rectosigmoidectomy, or Altemeier procedure, would not be a candidate for sigmoid colectomy as the rectal vascular supply is now dependent on the inferior mesenteric artery. Consideration of the existing blood supply is critical when planning reoperative rectal prolapse surgery. The treatment of such patients remains an unresolved problem; however, generally in patients without significant comorbidities, the treatment is the abdominal approach with or without sigmoidectomy. Recurrent rectal prolapse is not a contraindication to robotic surgery as adhesions are usually minimal.

For patients with significant comorbidities, the perineal approach is feasible but re-recurrence is as high as 39 % compared to the re-recurrence rate of 13 % in the abdominal approach [56]. Steele et al., with a study of 78 patients who presented with recurrent rectal prolapse, reported a significantly lower rate of second recurrence following abdominal procedures compared to perineal procedures (39 % vs. 13 %, $p < 0.001$) [56]. Among abdominal approaches to recurrent rectal prolapse, more and more studies seem to favor a laparoscopic or robotic technique [55, 57]. However, there is limited data examining such patients and a study of long-term outcomes of laparoscopic or robotic techniques is needed.

Conclusions

Robotic techniques safely facilitate minimally invasive treatment of rectal prolapse with improved visualization in the deep pelvis and ease of suturing. A significant body of evidence is developing in support of ventral rectopexy, and robotic techniques seem to facilitate the implementation of this technically challenging procedure. The surgical literature supporting a specific robotic approach is still limited and more research is needed to better understand if the increased cost is justified by the improvement in outcomes.

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Chapter 14
Minimally Invasive Procedures for Rare Rectal Conditions: Complex Rectourethral Fistulas and Retrorectal Tumors

Alessio Vinci, Mark H. Hanna, and Alessio Pigazzi

Introduction

The surgical treatment of rectourethral fistulas (RUF) and retrorectal tumors (RRT) represent challenging cases even for an experienced minimally invasive surgeon.

The diseases' rarity and the often complete distortion of the normal anatomy force surgeons to deal with situations they have not enough experience with, laying the basis for future new complications.

Aim of this chapter is to go through the key features of RUF and RRT, from the diagnostic workup to the postoperative care, explaining the possible role for robotic surgery in the treatment of these two rare rectal diseases.

Indications and Contraindications

Rectourethral Fistula

RUF is a devastating and not uncommon condition that usually occurs as a complication of prostatic cancer treatment with ablative or resective procedures. It can also be seen in patients with prostate benign pathology, Fournier's gangrene and inflammatory bowel disease. RUF represents a challenge for the surgeon

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Table 14.1 List of publications describing different techniques to treat rectourethral fistulas

Different surgical techniques for Rectourethral fistula (RUF) repair			
Investigator	Year	Procedure	Patients (*n*)
Ryan et al. [21]	1979	Perineal	1
Trippitelli et al. [22]	1985	Abdominoperineal	9
Pieretti et al. [23]	1995	Combined	1
Stephenson et al. [24]	1996	York-Mason	16
Wilbert et al. [25]	1996	Combined	2
Noldus et al. [5]	1999	Latzko	7
Youssef et al. [26]	1999	Dartos muscle flap	12
Garofalo et al. [4]	2003	Rectal advancement flap	12
Zmora et al. [2]	2003	Perineal	12
Moreira Jr et al. [27]	2004	Omental flap	7
Gözen et al. [28]	2005	Laparoscopic transvesical	1
Sotelo et al. [3]	2007	Laparoscopic transperitoneal	2
Wexner et al. [29]	2008	Gracilis muscle flap	36
Abdalla MA [30]	2008	Gluteus Maximum flap	1
Atallah S et al. [31]	2013	Transanal laparoscopic	1
Lee et al. [32]	2013	Transanal, laparoscopic and robotic	2

because spontaneous closure is a rare event [1]. The diversity of treatments, combined with limited reported success rates, makes the disease management difficult [2].

Conservative management consisting of urinary diversion, broad-spectrum antibiotics, and parenteral nutrition is often attempted initially [3]. The type of conservative therapy and the duration of treatment are highly variable among surgeons. Success rates as great as 25–50 % have been reported [4, 5], but conservative measures often fail and, if the fistula has not closed within 3–6 months, it is unlikely to do so [6]. More than 40 surgical techniques for the management of RUF have been described, and no data are available clearly favoring one approach [7] (Table 14.1). Among the several different surgical approaches, the basic principles are: excision and debridement of the fistula tract, closure of the rectal and urethral openings with or without interposition of vital tissue. Transanal and perineal approaches are first-line surgical treatments but in cases of recurrent fistulas or in cases of heavy radiation damage a more radical surgical approach may be necessary, and this will be the focus of this chapter. Urinary diversion with a Foley catheter is effective for the fistula treatment, while fecal diversion is necessary only in some specific cases: previous failed repairs, complex fistulas, and previous radiotherapy treatment.

Retrorectal Tumors

Pararectal tumors are rare lesions that comprise a multitude of histological types, according to the numerous embryologic remnants contained in the retrorectal space. Most lesions are benign, but malignant neoplasms are not uncommon [8]. Reports are limited to small single institution case series and recommendations on the ideal surgical approaches are lacking. Because of this, some confusion is associated with their diagnosis and management.

Most retrorectal tumors require surgical resection, usually without preoperative biopsy [9]. Choosing a suitable approach is key to a successful operation and may help provide optimal exposure, minimize damage, and reduce complications. Complete surgical resection is the cornerstone in the management of retrorectal tumors and minimally invasive robotic surgery may offer the needed tools to obtain an en bloc excision.

Preoperative Workup (Includes Imaging)

Rectourethral Fistula

If the fistula is small, the diagnosis may be delayed and the patient will present with recurrent urinary tract infections [9].

All the patients must undertake a complete physical examination as part of the diagnostic process with identification of previous incisions, medications, immunosuppression, nutritional status, and comorbidities. The history of relevant coexisting disorders such as diverticular disease, inflammatory bowel disease, pelvic malignancies, and operations is important [1, 7].

The diagnosis is suggested by clinical features like recurrent cystitis, pneumaturia, fecaluria, and urine leakage per rectum. Sometimes, gastrointestinal symptoms such as abdominal pain and diarrhea, are associated.

Identification of the exact site of the fistula is critical for the operative plan.

Cystourethrography, colonoscopy, endoscopic ultrasound (EUS), pelvic magnetic resonance imaging (MRI), and intravenous pyelography are usually used during the RUF workup. Cystoscopy is the reference standard for the diagnosis, with a sensitivity of 80–100 % [7] helping to rule out a uretheral stricture, if present. Colonoscopy is used to assess vascularity and pliability of tissues and to localize the rectal fistula orifice (whenever it is possible).

Both EUS and MRI have shown to be more accurate than computer tomography and are the diagnostic imaging techniques of choice for the assessment of the perianal tract [10].

According to Buchanan [11], surgery guided by MRI reduces further recurrence of fistula by 75 % and should be done in all patients with recurrent fistula.

The preoperative management must also include bowel preparation and antibiotic prophylaxis administered before the operation.

Retrorectal Tumors

Symptoms of retrorectal tumors are often nonspecific and are related to the location and size of the lesion. Most benign lesions are asymptomatic. Pain or constipation occurs occasionally and are more often related to the presence of large masses

Fig. 14.1 Preoperative CT scan of a patient with a complex retrorectal cystic mass measuring 7.4×6 cm

(cystic or solid). A careful rectal examination is essential to establish the diagnosis in >90 % of the patients [12, 13]. Most lesions are soft and easily missed if the physician does not maintain a high index of suspicion [14, 15].

Flexible colonoscopy is useful for detecting the involvement of rectal mucosa and may help confirm the level of proximal extension of the tumor [14].

Glasgow et al. reported that transrectal ultrasonography (TRUS), combined with proctoscopy, had a sensitivity of 100 % and provided information on the size, consistency of the mass, and evidence of local invasion [16].

Computed tomographic scan has been used extensively (Fig. 14.1), is able to distinguish a cystic lesion from a solid lesion, and to reveal sacral involvement or invasion of adjacent structures. MRI is particularly useful in delineating soft tissue planes and evaluating the presence or absence of bony invasion and nerve involvement.

The role of biopsy is controversial [8]. As cases of contamination and tumor spread have been reported, biopsy is usually not indicated, and surgical resection is the best diagnostic option. A biopsy should be performed when the lesion appears to be unresectable and if a tissue diagnosis is required to guide adjuvant therapy (imaging suspicious of Ewing sarcoma, osteogenic sarcoma, neurofibrosarcomas, and desmoid tumors) [17].

Operative Details (with Photos)

Rectourethral Fistula

The patient is positioned in the prone jackknife position and the perineal area is draped in a sterile fashion. After placing a LoneStar (TM) retractor® (Lone Star Retractor System, Cooper Surgical) to dilate the anus, the transanal dissection has

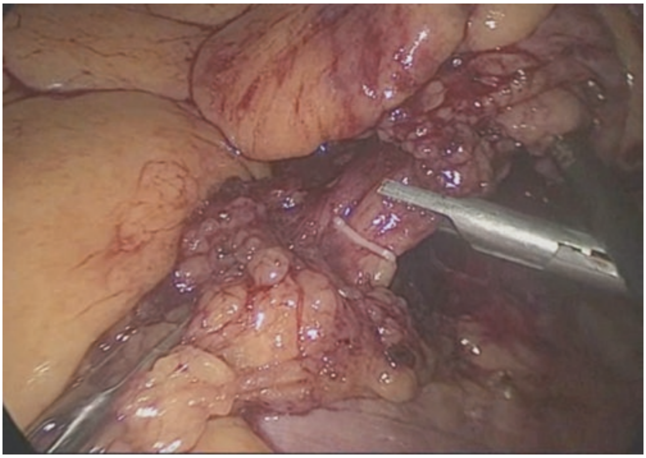

Fig. 14.2 Identification, dissection, and division of inferior mesenteric vein and superior rectal artery

begun starting about 1 cm distal to the level of the fistula in the intersphincteric plane. The area around the fistula is dissected and debrided to achieve an adequate view of the opening of the fistula, afterwards the urethral opening is approximated with 4/0 vicryl interrupted sutures.

The patient is therefore repositioned in a modified lithotomy position. Draping and pneumoperitoneum are obtained in the usual fashion. After positioning a total of six ports, the laparoscopic part of the procedure is started. Using a medial-to-lateral approach, the descending and sigmoid colon are mobilized. The inferior mesenteric vein and superior rectal artery were identified (Fig. 14.2), skeletonized and divided between Hem-o-lok clips (Weck Teleflex Medical), after identifying and preserving the left ureter and gonadal vessels. Then, the entire descending and sigmoid colon were medialized above Toldt's fascia.

At this point, the four-arm da Vinci® Si HD robot (Intuitive Surgical, Inc., Sunnyvale, CA, USA) is docked over the left hip. Total mesorectal dissection and autonomic nerve preservation is carried out posteriorly, laterally, and finally anteriorly (Fig. 14.3). The dissection of the rectum is continued all the way down until the transanal intersphincteric plane is met, freeing the distal rectum from its attachments around the anal hiatus. The port sites were closed.

The patient is repositioned in the prone jackknife position. The perineal area is draped in a sterile fashion. A wound protector was introduced through the anus enabling the specimen extraction (Figs. 14.4 and 14.5). After the segmental resection of the diseased rectum and a handsewn rectoanal anastomosis (Fig. 14.6), a Penrose drain was left in between the anastomotic sutures, draining the pelvic cavity.

If not previously performed, and depending on the clinical signs and symptoms, an ostomy is considered at this point of the operation.

Fig. 14.3 The rectal dissection is carried out posteriorly, laterally, and anteriorly, taking care of the hypogastric plexus until the intersphinteric dissection plane is met

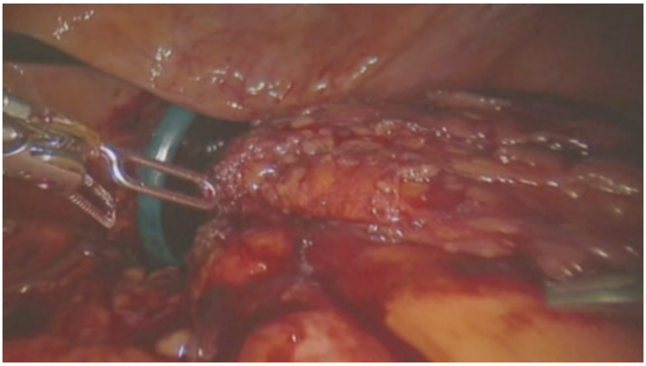

Fig. 14.4 A wound protector is entered through the anus and the specimen is extracted (internal view)

Retrorectal Tumors

The narrow space of the pelvis and the anatomical complexity of the pararectal region can be challenging in the surgical approach to this kind of tumors. The extent of surgery is determined by the characteristics of the tumor: position, involvement of the sacrum, pelvic sidewall or adjacent viscera. Benign pararectal tumors require complete gross resection, whereas malignant tumors will require radical resection, including en bloc resection of adjacent organs [18].

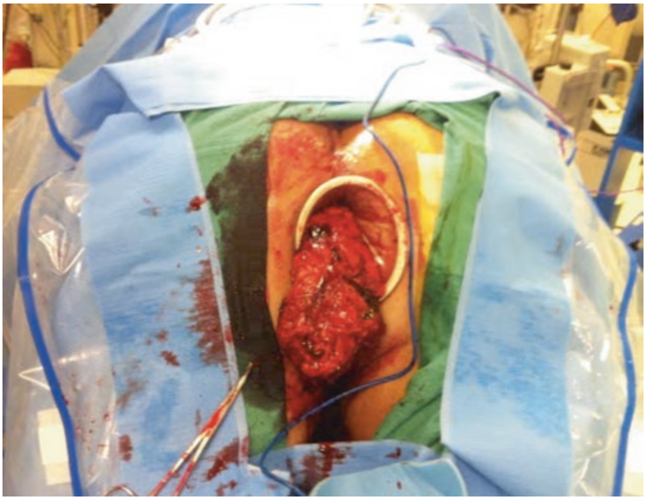

Fig. 14.5 The specimen is extracted through the anus (external view)

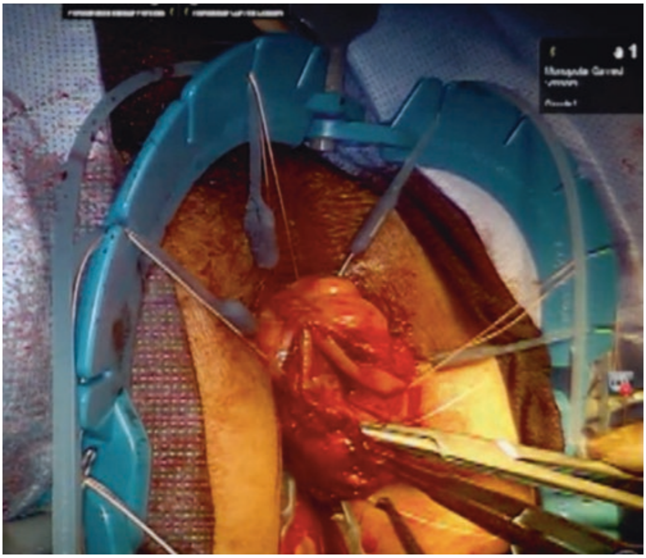

Fig. 14.6 Handsewn rectoanal anastomosis

Compared to other techniques, the advantages of the abdominal approach include good access to the pelvis, pelvic viscera, and pelvic sidewall. This permits proximal vascular control and mobilization of the rectum and other viscera [19].

Thanks to the three-dimensional view, superior dexterity, and multi-articulated instruments, robotic surgery can facilitate precise dissection and structural identification in the narrow pelvic space and pelvic floor.

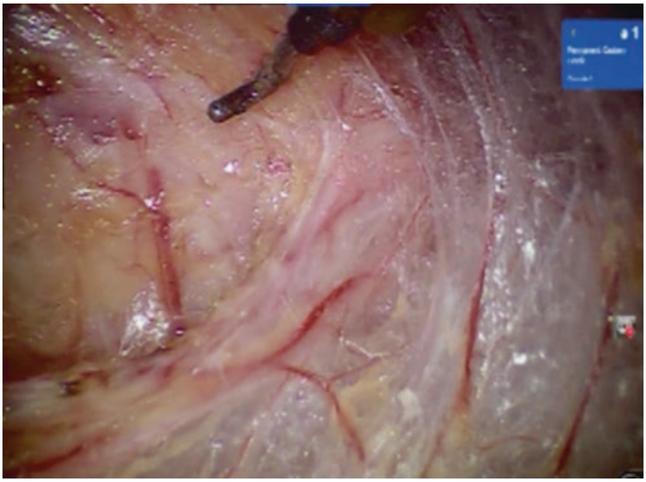

Fig. 14.7 During the rectal dissection the hypogastric nerve is identified and preserved

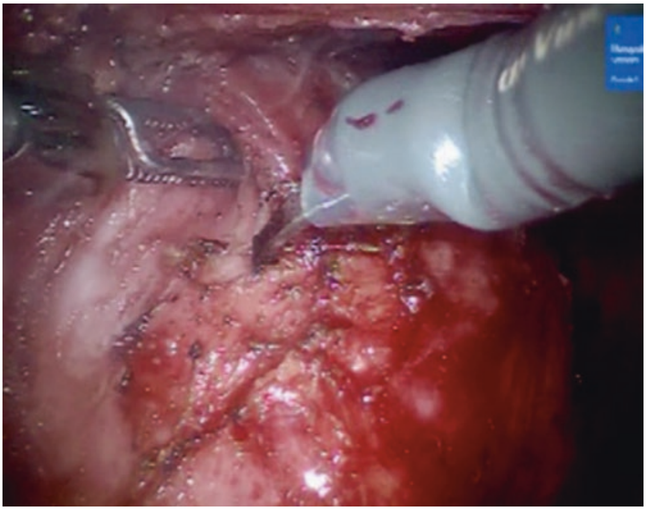

Fig. 14.8 The large bulging mass extends from the elevator plane to the level of the coccyx. Care is taken not to divide the levator fibers

The patient is placed in a modified lithotomy position. A total of six ports are placed in the patient's abdomen under direct vision: one 12-mm trocar for the camera, three 8-mm robotic trocars, and two 5-mm trocars for the assistant. The da Vinci® Si HD robot is therefore docked via a left hip approach. The dissection is carried out posteriorly in the avascular presacral plane to the pelvic floor. Pitfalls are the median sacral vessels, and, when moving laterally, the ureters, iliac vessels, and hypogastric plexus (Figs. 14.7 and 14.8). Care must be taken to avoid injury to the rectum.

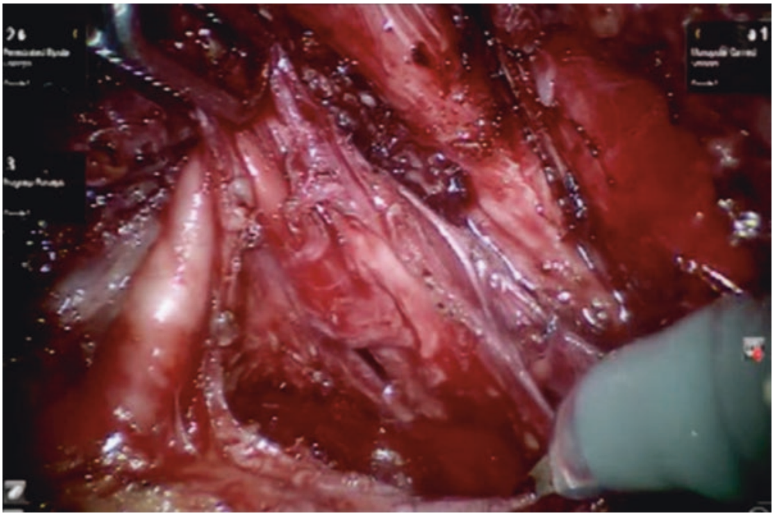

Fig. 14.9 The decompressed mass is opened and dissected off the external sphincter

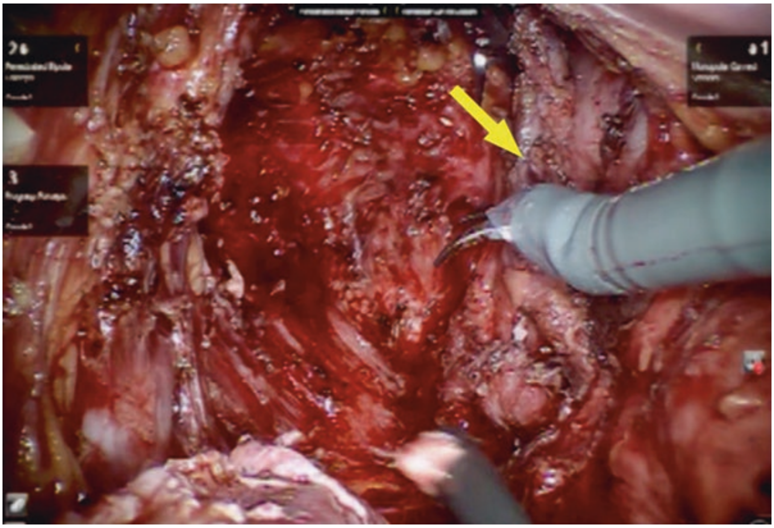

Fig. 14.10 The external sphincter is preserved in its entirety as shown by the arrow

During dissection the tumor is carefully separated from its attachments to the adjacent structures, achieving macroscopically negative margins (Figs. 14.9 and 14.10).

Tumor is then extracted via a Pfannenstiel incision and or port site using a laparoscopic bag and or wound protector.

Postoperative Care

Rectourethral Fistula

In patients with a previous fecal diversion a liquid diet can be started in 1st POD. Patients are discharged on 3rd or 4th postoperative day. The urethral catheter is usually removed around 4 weeks after the operation, and the colostomy may be taken down after the 8th postoperative week if appropriate healing has been documented during contrast and/or endoscopic studies.

Retrorectal Tumors

Pain can initially be controlled with an epidural catheter or a PCA, and the diet is advanced with the return of bowel function. Foley catheter can be removed usually on postoperative day 2.

Possible Complications

Rectourethral Fistula

Short-term complications are pelvic nerve lesions and pelvic abscess. Thanks to the high-definition 3D view offered by the robotic technology, a nerve-sparing technique is usually achievable. The possible pelvic abscess may be treated with transanal or percutaneous drainage and germ-specific antibiotic therapy.

Long-term rectal anastomotic stricture can be managed before the colostomy reversal procedure, with digital dilation or endoscopic balloon dilation.

Retrorectal Tumors

Traditionally, as the retrorectal tumor surgical approach is widely variable, the postoperative complication rate has been described as high as 45 % [13]. According to the same study the most common complications are, in order of frequency: bleeding (28 %), neurogenic bladder (23 %), other neurologic complications (18 %), wound infection (15 %). Surprisingly, rectal injury has been reported to occur only in 5 % of cases.

Even if extensive data about postoperative complication rate are lacking, bleeding has been reported to be the most common postoperative complication in different studies [16, 20], making effective hemostasis control the first goal needed to be fully reached after specimen retrieval.

Follow-Up

Rectourethral Fistula

Patients are seen in the outpatient clinic 2 weeks postoperatively and then at approximately 4 months after stoma closure. Bladder training before urinary catheter removal is highly recommended to avoid acute urinary retention. If dilation of rectal stricture is needed, it can be offered as 1-day surgery.

Retrorectal Tumors

As reported by Glasgow [16], while the recurrence rate for benign tumor is essentially nil, most patients with malignancy show recurrence or recrudescence. In particular the median disease-free survival was 38 months and the overall survival was 61 months. On the basis of these observations we encourage a strict follow-up for the first 3 years with CT or MRI.

Tips and Tricks

Rectourethral Fistula

– Acquire enough information about the exact location of the fistula through the preoperative diagnostic imaging
– Plan the right timing for the surgical approach after the conservative approach failed
– Order a urine culture and antibiogram and begin a specific antibiotic treatment before the operation
– Check for rectal stricture before colostomy reversal procedure is performed

Retrorectal Tumors

– Obtain preoperative MRI of the pelvis to determine the surgical approach by documenting the position of the tumor with respect to the sacrum
– Biopsy performed by experienced radiologists may be considered in unresectable tumors and with patients suffering from significant medical comorbidity that precludes pelvic surgery. It can also be carried out when preoperative imaging poses the suspect of tumor that can benefit from neoadjuvant chemotherapy
– Place ureteral stents when ureter infiltration is found on preoperative imaging
– When rectal and sacral invasion are present, a multidisciplinary team (colorectal, urology, plastic, orthopedic, neurosurgeon) approach may be necessary

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Chapter 15
Minimally Invasive Procedures for Rare Rectal Conditions: Endometriosis

Vladimir Schraibman, Antonio Luiz de Vasconcellos Macedo, Marina Gabrielle Epstein, and Camila Campos Padovese

Introduction

Endometriosis is defined as the appearance of endometriotic tissue outside the uterus.

The most affected parts are the reproductive organs (ovaries, uterus and surrounding region, tubes) and other organs, including intestine. Intestinal involvement occurs in 8–12 % of the patients affected by this pathology. The most affected sites in the intestinal region are: rectosigmoidjunction (65 %), the ileocecal area (20 %) and the rectum (15 %) [1].

When it affects the rectum, it can cause rectal bleeding, diarrhea or obstructive symptoms, making it more difficult to differentiate a malignant from an inflammatory disease.

Robotic surgery is a revolutionary minimally invasive approach, with several advantages compared to traditional laparoscopic surgery, due to the high-definition 3D vision system and to the specific instrument articulation, with greater precision, absence of tremor, and excellent outcomes.

These key features may allow complex minimally invasive procedures to be performed more easily than with conventional laparoscopic surgery [1].

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Indications and Contraindications

As endometriosis is a benign disease, the basic treatment follows the principles of relief of pain, bleeding, obstruction, fertility improvement, and prevention of disease recurrence or progression [2].

The asymptomatic infiltrative intestinal disease is rare and can be treated in a conservative way, provided that there is no obstruction, hemorrhage, difficulty in differentiating a malignant disease or disease progression occurrence [2].

Preoperative Workup

Magnetic resonance imaging (MRI) and endoscopic ultrasonography are used to help out in diagnosis and to estimate the disease extension, but the gold standard for diagnosis is direct lesion visualization (through laparoscopy, laparotomy, or robotic surgery).

Transvaginal ultrasonography has been classicaly indicated for ovarian endometriosis cases and has currently been much used for the appraisal of deep endometriosis. With intestinal preparation, providing for fecal contents removal, a better visualization of the region gets possible as a better identification of the affected intestinal layers [3].

Endometriosis rarely involves the mucosa. Colonoscopy maybe sometimes used to exclude other pathologies as colorectal cancer, inflammatory intestinal disease, and to evaluate the mucosa. And it can show an extrinsic compression or a stenotic area which can suggest involvement of the rectum or colon due to endometriosis [4].

Operative details: rectosigmoid resection for endometriosis.

In our practice, the da Vinci robotic surgical system (Intuitive Surgical, Sunnyvale, CA, USA) is used in all cases. All patients are placed in the modified lithotomy position.

After pneumoperitoneum induction, a 12-mm trocar in the umbilical incision, two 8-mm trocars in the right and left iliac fossa, a 15-mm trocar in the median suprapubic area, and a 5-mm trocar in the upper right iliac fossa are introduced. At this time, robotic-assisted laparoscopic surgery is initiated. After the extension of endometriosis in the pélvis is determined, the pararectal spaces are opened to obtain mobilization of the bowel. Total or partial mesorectal excision is performed depending on the location of the endometriotic lesion. During the procedure, the exposed bowel is transected caudal to the endometriotic lesions with one or two Echelon Golden cartridges (Ethicon Endo surgery). A mini-laparotomy just above the pubic triangle (approximately 4 cm) is carried out to remove the intestine, assess the endometriotic lesion, and divide the proximal bowel. After closure of the laparotomy, pneumoperitoneum is created again. The procedure is completed using an end-to-end anastomosis with a circular stapler.

Fig. 15.1 shows trocar size and positions for robotic rectosigmoidectomy

Fig. 15.2 shows pelvic site with uterine manipulator elevating the uterus and presenting a complex endometriotic lesion comprising the vagina and the rectum

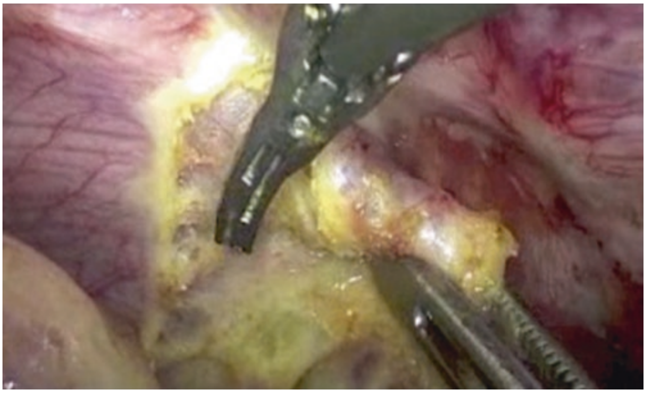

Fig. 15.3 shows dissection and resection of the left uterosacral ligament compromised with endometriosis just before colonic dissection

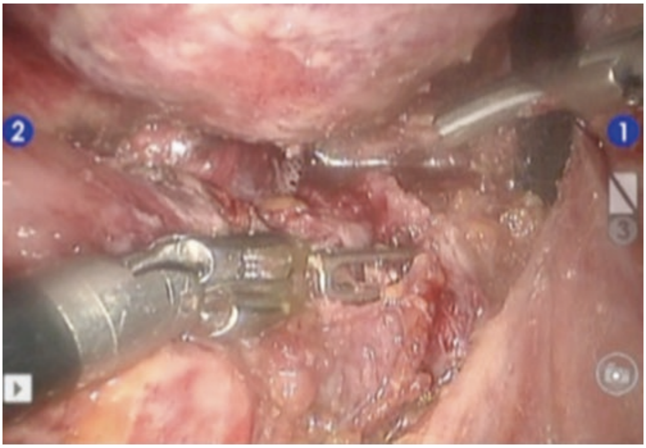

Fig. 15.4 shows a complex case with endometriosis comprising the uterus, vagina, and rectum being dissected and separated during a robotic dissection

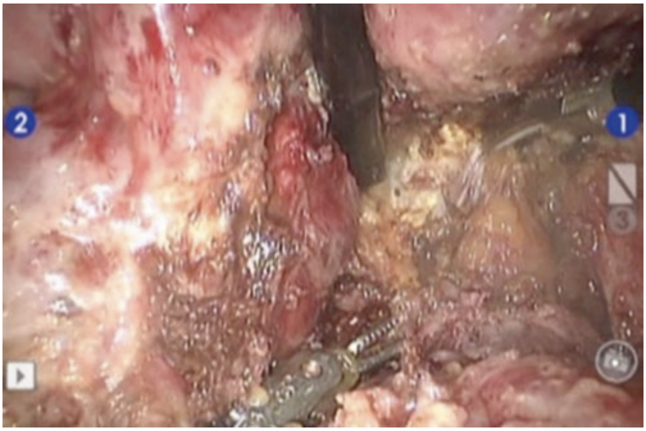

Fig. 15.5 shows a complex case with encasement of the left ureter, uterus, vagina, and rectum by endometriosis during a robotic dissection

Normally during surgery we use a harmonic scalpel and two bowel graspers. Margins are normally assessed after specimen removal during surgery.

A liquid diet is started on the second postoperative day if flatus is present. Patients are normally discharged on the third postoperative day [5].

Postoperative Care

Normally in the 1st PO day a liquid diet with no lactose and probiotics is started. On the second day antibiotics and IV saline infusion are discontinued.

If the patient has bowel movements on the 2nd or 3rd PO day he is dismissed.

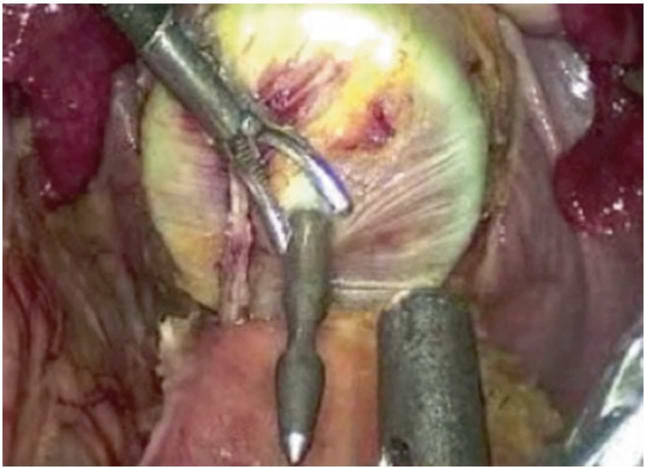

Fig. 15.6 shows the rectal stump with a 33 mm circular stapler just before the connection for the anastomosis

Possible Complications

Short-term complications are related to rectosigmoid surgery such as anastomotic bleeding, fistulas, adhesions, ureter injury, and pelvic nerve lesions. Long-term complications are reported in the medical literature and linked to huge pelvic dissections with nerve injury leading to urinary retention, fecal incontinence or intermittent urinary catheterization [6]. Long-term rectal anastomotic stricture can be managed with digital dilation or endoscopic balloon dilation [7].

Follow-Up

Symptoms including dysmenorrhea, dyspareunia, intestinal cramping, diarrhea, and constipation normally disappear in over 95 % of the women after colorectal resection after 3 months of follow-up.

Women with infertility before surgery, diagnosed as a mean infertility time of 2 years, got pregnant in 66 % in our series [5].

Tips and Tricks

– Complete clinical history and physical examination are mandatory.
– Transvaginal ultrasound with intestinal preparation or magnetic resonance imaging is the key for the diagnosis of intestinal endometriosis and surgical planning.

– Uterine manipulator allows better pelvic evaluation and complete resection of the endometriotic lesions
– Start surgery detecting the left ureter.
– In most of the cases, a 33 mm circular stapler can be used.

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Index

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