Seminars in Colon and Rectal Surgery 30 (2019) 75–78

Contents lists available at ScienceDirect

Seminars in Colon and Rectal Surgery

journal homepage: www.elsevier.com/locate/yscrs

# Proctectomy for rectal cancer – What is the data for open, laparoscopy and robotics?

Sonia L. Ramamoorthy, MD[a,*], Sarah B. Stringfield, MS, MD[b]

[a] Division of Colorectal Surgery, Rebecca and John Moores' Cancer Center, UCSD San Diego Health System, 3855 Health Sciences Drive MC 0987, San Diego, California, United States
[b] Department of Surgery, UCSD Health System, San Diego, California, United States

A B S T R A C T

Since the first reported radical resection by Miles in 1908, innovation in the field of rectal cancer surgery has continued at a steady pace. Improved preoperative staging, chemoradiation therapy for local advanced disease and pelvic MRI have drastically changed the course of disease for rectal cancer patients. Despite these important advances, surgical resection remains the cornerstone of treatment for rectal cancer. Surgical approaches to rectal cancer have also evolved to improve oncologic outcomes and reduced associated morbidity. Greater attention to pathologic assessment, total mesorectal excision, minimal invasive approaches, and minimizing the impact of sexual, bladder and bowel dysfunction have become the focus of modern-day rectal cancer surgeons. This chapter focuses on proctectomy for rectal cancer, current approaches and the high-level data to support their use.

Published by Elsevier Inc.

## Introduction

Although the incidence of colorectal cancer is decreasing in the United States, approximately 44,000 new patients are diagnosed with rectal cancer each year, with the average age of diagnosis decreasing in the last decade.[1] Surgical resection, chemoradiation therapy, and systemic chemotherapy are the cornerstones of treatment for rectal cancer, and the indication for these treatments depends on accurate clinical staging. Advances in these areas as well as a multidisciplinary approach have led to improved oncologic outcomes for rectal cancer patients.

Advances in surgical resection for rectal cancer have had a profound impact on the oncologic outcomes of patients. Innovations in surgical approaches, including total mesorectal excision (TME), and attention to radial and distal resection margins have resulted in lower rates of local recurrence.[2,3] Additionally, minimal invasive surgery techniques such as laparoscopic and robotic approaches offer the possibility of shorter recovery times, sphincter preservation and less morbidity.[4,5]

## Open surgery

### *Proctectomy*

The history of rectal cancer surgery is notable for the evolution of techniques and technologies over the years, with the goal of optimizing both oncological outcomes and quality of life for patients. The first rectal cancer operation with curative intent was believed to be performed by RJ Miles in 1908. Prior to this, most surgery for cancer of the rectum was done with palliative intent. The first rectal resections combining the abdominal and perineal approaches had already been described in 1884 and 1904, respectively, by Czerny and Mayo, however Miles' understanding of lymphatic spread of cancer and the need to remove this tissue was revolutionary at the time.[6,7] Miles' management of rectal cancer resulted in what would be considered high mortality and morbidity, but also a one-year survival rate of 58%.[6] Miles' approach became the gold standard for rectal cancer surgery until 1921, when the French surgeon Henri Albert Hartmann introduced the anterior resection of the rectum with preservation of its distal third and sphincters and creation of a sigmoid colostomy with the aim of reducing complications and mortality rates.[8] In 1910 Balfour, and in 1948 Claude F. Dixon at the Mayo Clinic, introduced the concept of a restorative anterior resection for tumors of the proximal rectum and the distal sigmoid colon and his published data showed a five-year survival rate of 64%.[9] Subsequently, the work of Golligher et al. showed that local tumor spread in rectal cancer did not exceed 2 cm from tumor margins in most cases and the authors considered that a 5 cm margin of clearance would have ensured a reasonable tumor clearance.[10] In the following years, contributions from Nichols and others proved the oncologic safety of a 2 cm margin and in more recent years a <1cm margin was shown to be similarly adequate, thus paving the way for more sphincter preservation.[11,12]

* Corresponding author.
*E-mail address:* sramamoorthy@ucsd.edu (S.L. Ramamoorthy).

https://doi.org/10.1053/j.scrs.2019.04.006
1043-1489/Published by Elsevier Inc.

*Total mesorectal excision*

The importance of total mesorectal excision (TME) and negative radial margins were first identified as critical to oncologic outcomes in 1982 by RJ Heald.[13–15] His work constitutes a major milestone of modern rectal cancer surgery. Prior to this, rectal cancer surgery was largely performed with blunt dissection of the rectum and minimal attention to radial margins. As a result, disease-free five-year survival rate for all stages treated with curative intent did not exceed 50% with local recurrence rates of up to 20%. Heald pointed out that this was due to defects created in the mesorectal fascia and the mesorectum itself during the blunt rectal dissection. In Heald's original study, positive radial margins are found in up to 85% of local recurrences.[3] Heald's theory was that rectal cancer spread through lymphovascular invasion within the mesorectum. A surgical plane is a "potential space between contiguous organs which can be reproducibly created by dissection".[14] In rectal surgery the "holy plane" develops between the mesorectum and the surrounding somatic structures (Fig. 1). Dissection along this plane should be sharp, under direct vision and gentle continuous traction.[14] Heald reported 80% five-year disease-free survivals with a local recurrence rate that dropped down to 4% after TME.[15] Heald's contributions were critical and changed the practice of rectal cancer surgery. Following Heald's work, many more conformational studies followed including a study from Sweden showing the adoption of the TME technique resulted in a 20% improvement in the 4-year survival, and the Norwegian Rectal Cancer Group showed a greater than 20% reduction in local recurrence.[16] Shortly after, Nagtegaal et al. demonstrated the importance of assessing the circumferential resection margin (CRM), showing that margins <2 mm were associated with a 16% LR rate vs 5.8% for >2 mm. Further, they showed the prognostic value of CRM involvement independent of TNM staging (Table 1).[17]

In modern times, open resection for rectal cancer remains the gold standard by which many other surgical techniques are compared including laparoscopic, robotic, and transanal approaches. Ongoing trials and early results of trials comparing these techniques have yet to demonstrate oncologic superiority over open surgery for rectal cancer. Despite these findings, surgeons continue to push forward with surgical innovations in the area of minimal invasive surgery with the eye towards improving Quality of Life (QOL) and reducing surgical morbidity.

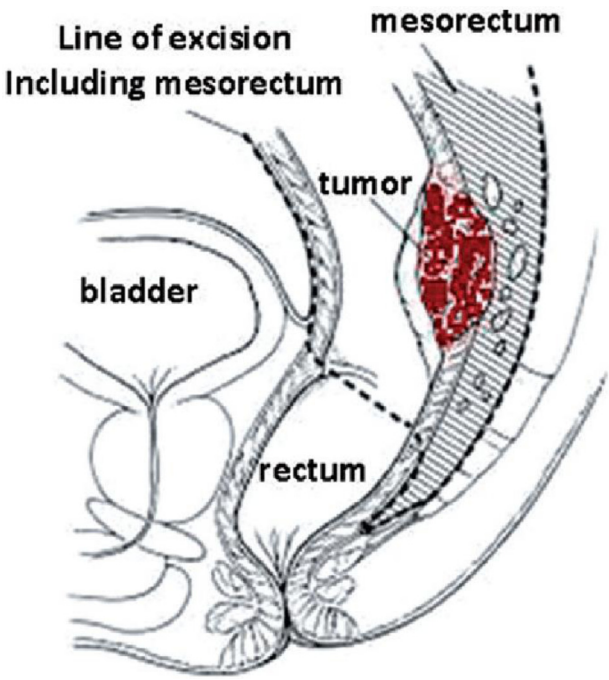


**Fig. 1.** Diagrammatic representation of the TME "Holy Plane", as published in the British Journal of Surgery in 1982 by RJ Heald.

**Table 1**
Milestones in radical proctectomy for rectal cancer.

| Author | Year | Contribution |
|---|---|---|
| Miles[6] | 1907–1923 | Abdominoperineal resection (APR) for rectal cancer |
| Hartman[8] | 1921 | Low anterior resection (LAR) with end colostomy |
| Dixon[9] | 1948 | Restorative LAR |
| Golligher[10], Nicholls[11,12] | 1951, 1983 | Oncologic safety of 2–5 cm distal margin |
| Heald[13–15] | 1982 | TME reduces local recurrence |
| Wibe[16] Norwegian Trial | 2002 | TME 50% reduction in LR |
| Nagtegaal[17] | 2002 | CRM < 2 mm associated with increased risk of LR |

*Quality of life*

One of the many challenges with rectal cancer surgery is the impact on quality of life. Preservation of both sexual and bladder function, stoma free survival, and minimizing bowel dysfunction has been a focus of rectal cancer surgeons for decades. Long-term follow-up data from the Dutch TME trial showed that 46% of patients still endure major low anterior resection syndrome (LARS) symptoms as far out as 14 years after TME surgery.[18] Rate of sexual and bladder dysfunction has been reported to be as high as 30%–60% in patients who have undergone radical resection for rectal cancer.[19] Only in recent years was it thought possible to "lessen" the morbidity of radical proctectomy with careful TME, attention to neurovascular structures, and minimal invasive techniques. It is believed that the advent of minimal invasive surgery has created greater awareness of the importance of autonomic nerve identification and preservation during rectal dissection and has had a positive impact on the patients' postoperative quality of life. Similarly, enhanced visualization in the pelvis and deeper access to the pelvic floor has provided greater opportunity for sphincter preservation in traditionally challenging patients such as those patients with high BMI. Poor quality of life following rectal cancer surgery is hard to attribute to surgery alone as in many cases patients have undergone chemoradiation therapy and have suffered structural and neurologic insults from the neoplastic process prior to resection. Nevertheless, the myriad of symptoms such as "low anterior syndrome" can be directly attributed to rectal resection suggesting that surgical intervention plays a major role in QOL following cancer treatment. More recent oncologic trials such as the AlaCart and ROLARR failed to show a substantial benefit from minimal invasive surgery over open procedures with regards to postop bladder and sexual dysfunction.[20,21] A more recent study by Helbach et al., comparing laparoscopic TME and a newer transanal TME (TaTME) technique demonstrated comparable functional and QOL outcomes regardless of technique.[22] As newer technologies are developed that provide better identification of critical structures such as neurovascular bundles, and tumor margins, the reality of an excellent oncologic outcome can go hand in hand with the preservation of bowel, bladder and sexual function.

## Laparoscopic surgery

Minimal invasive surgery challenged the notion that to have a successful oncologic surgery, it must be done thru an open technique. Increasingly, in the late 80s and early 90s surgeons were applying minimal invasive techniques to colorectal surgery. The COST trial published in 2004 demonstrated the short- and long-term oncologic safety of laparoscopic resection of colon cancer.[23] Since that landmark trial, several landmark studies including the COLOR, CLASICC, and Barcelona trial have

demonstrated both oncologic safety, improved QOL and reduced morbidity with a minimal invasive approach.[24–26] Similar questions regarding the safety and efficacy of laparoscopy for rectal cancer emerged. Analysis from the CLASICC trial showed that in the cohort of rectal cancer cases the most common reason for conversion was "uncertainty of tumor clearance, obesity, inaccessibility of tumor and anatomic uncertainty".[25] As a result, a higher CRM positivity rate was seen in the laparoscopic rectal cancer group and a higher complication rate was seen in those rectal cancer cases that were converted. This was felt to be due to the anatomical difficulties and technical challenges of a TME for rectal cancer surgery, but the authors stopped short of making recommendations, instead opting to encourage future studies focused on comparing laparoscopic rectal cancer surgery to open approaches. In subsequent years, short- and long-term results of several randomized clinical trials have been published and have demonstrated the variable safety of a laparoscopic approach to TME, with short-term QOL benefits and similar oncological outcomes. However, four randomized trials reported controversial results adding to the debate of the safety of laparoscopic procedures over standard open rectal cancer surgery. The COLOR II, COREAN, ALaCaRT, and ACSOG 6051 trials were designed to assess the oncologic safety of laparoscopic rectal cancer surgery.[20,27–29] The results of these studies are shown in Table 2, demonstrating conflicting results. The COLOR II and COREAN trials demonstrated oncologic equivalency between the laparoscopic and open groups, and clear advantages to the laparoscopic group when considering enhanced recovery.[28,29] Two studies, ALaCaRT (Australasian Laparoscopic Cancer of the Rectum) and ACOSOG (American College of Surgeons Oncology Groups) Z6051 were similarly designed non-inferiority trials that demonstrated that laparoscopic resection failed to meet with criterion for noninferiority for pathologic outcomes compared with open resection.[20,27] The studies showed no difference in outcomes between the two groups when comparing CRM, completeness of TME and distal margins, but when using a novel composite marker, "z score", the studies failed to show non-inferiority. The findings while surprising, highlight the challenges of rectal resection; limited work space, tight angles, instrumentation challenges, visualization difficulties and variable anatomy of patients. Interestingly, long term follow-up of oncologic outcomes from both trials have shown no significant difference in disease free survival (DFS) or overall survival (OS) between laparoscopic and open groups.[27,30] As in the COST trial, the reported advantages of minimal invasive rectal cancer surgery including early mobilization, less pain and improved quality of life were hypothesized to be further augmented by the theoretical advantages of a magnified view allowing improved dissection, leading to the possibility of better oncologic outcomes. Despite early results showing concern for pathologic markers of recurrence, long term follow-up data shows no difference thus suggesting that a minimal invasive surgical approach in experienced hands may still provide benefit to rectal cancer patients. Although these results were encouraging, many experienced minimal invasive surgeons still felt the technical challenges of laparoscopic pelvic surgery were insurmountable and they desired an alternative approach which has ushered in the era of robotics and transanal surgery.

## Robotic surgery

Surgical robots were initially designed for cardiac surgery. The benefits were not realized until urologic surgeons adopted the technology for prostate surgery. Like rectal cancer surgeons, many urologists found the challenges of laparoscopic pelvic surgery insurmountable. Urologist were the earliest adopters of robotic pelvic surgery citing its stable platform for dissection in narrow spaces, enhanced visualization, and increased dexterity as the major advantage over laparoscopy. Rectal cancer surgeons came to appreciate the benefits of this minimal invasive approach as it offered similar advantages when performing TME. Over time, the addition of select instrumentation, fluorescent imaging and smaller more flexible robotic platforms have made robotic surgery the preferred MIS approach for many rectal cancer surgeons.

The first cases of robotic assisted proctectomy were reported in 2004 by D'Annabale et al.[31] Shortly after this publication, several single institutional studies followed most notably from Korea, and the Prasad group in the US.[32–35] A recent systematic review of 27 studies and over 5547 patients comparing robotic proctectomy for rectal cancer to laparoscopy showed a benefit for robotics with passage of early flatus, and lower conversion rates, cost however was significantly higher for robotics.[36] There was no difference in oncologic or surgical outcomes.

The ROLLAR trial completed in 2014 was the first randomized control trial to evaluate the oncologic and QOL benefits of robotic surgery versus laparoscopy.[19] ROLLAR was designed as a multi-institutional international trial with a primary endpoint of conversion to open laparotomy and secondary endpoints that examined oncologic and QOL outcomes. It should be noted that during the trial period (2011–2014), the majority of rectal cancer surgery in the US was being performed with an open technique making the data less informative when focusing on current practice trends. Like previous laparoscopic trials for rectal cancer, ROLLAR failed to show a benefit of robotics over traditional laparoscopy when considering both primary and secondary endpoints. Despite these findings, and issues related to cost and training, robotic rectal cancer surgery has been widely adopted in the US and increasingly in Europe. Surgeons continue to cite the technical advantages of robotics over other minimal invasive approaches and with a paucity of data demonstrating oncologic non-inferiority, it is likely robotics remains a viable surgical approach for rectal cancer surgery in the foreseeable future.

**Table 2**
Laparoscopic vs. open rectal cancer surgery trials and oncologic outcomes.

| Trial | Year | N | Difference in oncologic outcomes?* | Conversion |
|---|---|---|---|---|
| COLOR II | 2004–2010 | 1103 | No | 17% |
| ACOSOG 6051 | 2008–2013 | 486 | Yes favor open | 11% |
| COREAN | 2006–2009 | 340 | No | 1.2% |
| A la CaRT | 2010–2014 | 450 | Yes favor open | 9% |

* Circumferential margins (CRM), TME completeness, Distal margin

## Transanal TME

Newer approaches to rectal cancer have evolved in recent years. Building on previous experience of using transanal approaches for local excision, APR and rectal prolapse procedures, a new "bottom up" approach to TME was developed by various modern-day pioneers.[37,38] TaTME has since become a preferred technique for many when approaching challenging pelvises, or low rectal tumors. In institutions where robotics may not be an option due to cost or training, taTME has emerged as a potential alternative. TaTME is in the early phases of study with two randomized control trials ongoing in the US and Europe. Early reports suggest that taTME is a viable option in experienced hands but may not confer any additional benefit over current approaches.[39]

## Conclusion

Regardless of the approach used for rectal cancer surgery, the tenets of an intact TME, >1–2 cm distal margin and >2 mm CRM are critical to reducing risk of local recurrence and conferring long team DFS and OS. Minimal invasive approaches are more common now than in previous eras and despite the reported benefits of reduced pain and early recovery, there has been no recent data to show there is an oncologic advantage.

## References


1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2017. *CA Cancer J Clin*. 2017;67:7–30.
2. Heald RJ, Ryall RDH. Recurrence and survival after total mesorectal excision for rectal cancer. *Lancet*. 1986;327:1479–1482.
3. Heald RJ, Husband EM, Ryall RDH. The mesorectum in rectal cancer surgery–the clue to pelvic recurrence? *Br J Surg*. 1982;69:613–616.
4. Arbman G, Nilsson E, Hallbook O, Sjodahl R. Local recurrence following total mesorectal excision for rectal cancer. *Br J Surg*. 1993;83(3):375–379.
5. Wibe A, Moller B, Norstein J, et al. A national strategic change in treatment policy for rectal cancer- implementation of total mesorectal excision as routine treatment in Norway. A national audit. *Dis Colon Rectum*. 2002;45(7):857–866.
6. Miles WE. A method of performing abdomino-perineal excision for carcinoma of the rectum and of the terminal portion of the pelvic colon. *CA Cancer J Clin*. 1971;21:361–364.
7. Lirici MM, Huscher C. Techniques and technology evolution of rectal cancer surgery: a history of more than a hundred years. *Min Invas Thera Allied Tech*. 2016;25(5):226–233.
8. Ronel D, Hardy M. Henri Albert Hartmann: labor and discipline. *Curr Surg*. 2002;59:59–64.
9. Dixon CL. Anterior resection for malignant lesions of the upper part of the rectum and lower part of the sigmoid. *Ann Surg*. 1948;128:425–442.
10. Golligher JC, Dukes CE, Bussey HJR. Local recurrences after sphincter saving excisions for carcinoma of the rectum and rectosigmoid. *Br J Surg*. 1951;39:199–211.
11. Pollett WG, Nicholls RJ. The relationship between the extent of distal clearance and survival and local recurrence rates after curative anterior resection for carcinoma of the rectum. *Ann Surg*. 1983;198:159–163.
12. Reguero JL, Longo WE. The evolving treatment of rectal cancer. In: Longo WEM, Reddy V, Audisio RA, eds. *Modern management of cancer of the rectum*. New York: Springer; 2015:1–12.
13. Heald RJ, Husband EM, Ryall RD. The mesorectum in rectal cancer surgery-the clue to pelvic recurrence? *Br J Surg*. 1982;69:613–616.
14. Heald RJ. The 'Holy Plane' of rectal surgery. *J R Soc Med*. 1988;81:503–508 17.
15. Heald RJ, Moran BJ, Ryall RD, Sexton R, MacFarlane JK. Rectal cancer: the Basingstoke experience of total mesorectal excision, 1978–1997. *Arch Surg*. 1998;133:894–899.
16. The Norwegian Rectal Cancer Group. Total mesorectal excision (TME) in Norway: a national rectal cancer project. *Dis Colon Rectum*. 1999;42:A26.
17. Nagtegaal ID, Marjinen CA, Kranenberg EK, et al. Circumferential margin involvement is still an important predictor of local recurrence in rectal carcinoma: not one millimeter but two millimeters is the limit. *Am J Surg Pathol*. 2002;26(3):350–357.
18. Chen TYT, Wiltink LM, Nout RA, Kranenbarg EMK, Laurberg S, Marijnen CAM, et al. Bowel function 14 years after preoperative short-course radiotherapy and total mesorectal excision for rectal cancer: report of a multicenter randomized trial. *Clin Colorectal Canc*. 2004;14:106–114.
19. Ho VP, Lee Y, Stein SL, et al. Sexual function after treatment for rectal cancer: a review. *Diseas Colon Rectum*. 2011;54(1):113–125.
20. Stevenson AR, Solomon MJ, Brown CS, et al. Effect of laparoscopic-assisted resection versus open resection on pathologic outcomes in rectal cancer. *JAMA*. 2015;314(13):1356–1363.
21. Jayne D, Pigazzi A, Marshall H, et al. Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer. The ROLARR randomized clinical trial. *JAMA*. 2017;318(16):1569–1580.
22. Helbach MV, Koedam TW, Knol JJ, et al. Quality of life after rectal cancer surgery: differences between laparoscopic and transanal total mesorectal excision. *Surg Endosc*. 2017;33(1):79–87.
23. Nelson H, Sargent DJ, Wieand HS. A comparison of laparoscopically assisted and open colectomy for colon cancer. *NJEM*. 2004;350(20):2050–2059.
24. Veldkamp R, Kuhry E, Hop WC, et al. Colon cancer laparoscopic or open resection study group (COLOR). *Lancet Oncol*. 2005;6(7):477–484.
25. Guillou PJ, Quirke P, Thorpe H, et al. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial); a multicenter randomized controlled trial. *Lancet*. 2005;365(9472):1718–1726 May 14-20.
26. Lacy AM, Garcia-Valdecasas JC, Delgado S, et al. Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomized trial. *Lancet*. 2002;359(9325):2224–2229.
27. Fleshman J, Branda ME, Sargent DJ. Disease-free survival and local recurrence for laparoscopic resection compared with open resection for stage II to III rectal cancer: follow-up results of the ACOSOG Z6051 randomized controlled trial. *Ann Surg*. 2019;269(4):589–595.
28. van der Pas MH, Haglind E, Cuesta MA, Fürst A, Lacy AM, Hop WC. COlorectal Cancer Laparoscopic or Open Resection II (COLOR II) Study Group. Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomized, phase 3 trial. *Lancet Oncol*. 2014;14:210–218.
29. Jeong SY, Park JW, Nam BH. Open versus laparoscopic surgery for mid-rectal or low-rectal cancer after neoadjuvant chemoradiotherapy (COREAN trial): survival outcomes of an open-label, non-inferiority, randomized controlled trial. *Lancet Oncol*. 2014;15:767–774.
30. Stevenson AR, Solomon MJ, Brown CS. Disease-free survival and local recurrence after laparoscopic-assisted resection or open resection for rectal cancer. *Ann Surg*. 2019;269(4):596–602.
31. D'Annibale A, Morpurgo E, Fiscon V. Robotic and laparoscopic surgery for treatment of colorectal diseases. *Dis Colon Rectum*. 2004;47:2162–2168.
32. Hellan M, Anderson C, Ellenhorn JD, Paz B, Pigazzi A. Short term outcomes after robotic-assisted total mesorectal excision for rectal cancer. *Ann Surg Oncol*. 2007;14:3168–3173.
33. Choi DJ, Kim SH, Lee PJ. Single-stage totally robotic dissection for rectal cancer surgery: Technique and short-term outcome in 50 consecutive patients. *Dis Colon Rec*. 2009;52(11):1824–1830.
34. deSouza AL, Prasad LM, Ricci J. A comparison of open and robotic total mesorectal excision for rectal adenocarcinoma. *Dis Colon Rectum*. 2011;54(3):275–282.
35. Baik SH, Ko YT, Kang CM. Robotic tumor-specific mesorectal excision of rectal cancer: short-term outcome of a pilot randomized trial. *Surg Endosc*. 2008;22:1601–1608.
36. Jones K, Qassem MG, Sains P. Robotic total meso-rectal excision for rectal cancer: a systematic review following the publication of the ROLARR trial. *World J Gastrointest Oncol*. 2018;10(11):449–464.
37. Sylla P, Rattner DW, Delgado S, Lacy AM. NOTES transanal rectal cancer resection using transanal endoscopic microsurgery and laparoscopic assistance. *Surg Endosc*. 2010;24:1205–1210.
38. Atallah S, Martin-Perez B, Albert M. Transanal minimally invasive surgery for total mesorectal excision (TAMIS-TME): results and experience with the first 20 patients undergoing curative-intent rectal cancer surgery at a single institution. *Tech Coloproctol*. 2014;18:473–480.
39. Lee L, de Lacy B, Gomez Ruiz M. A multicenter matched comparison of transanal and robotic total mesorectal excision for mid and low-rectal adenocarcinoma. *Ann Surg*. 2018. [Epub ahead of print].