**Name of journal:** ***World Journal of Gastroenterology***

**ESPS Manuscript NO: 23790**

**Manuscript type: ORIGINAL ARTICLE**

***Retrospective Cohort Study***

**Total mesorectal excision for mid and low rectal cancer: laparoscopic *vs* robotic surgery**

Feroci F *et al*. Robotic *vs* laparoscopic total mesorectal excision

**Francesco Feroci, Andrea Vannucchi, Paolo Pietro Bianchi, Stefano Cantafio, Alessia Garzi, Giampaolo Formisano, Marco Scatizzi**

**Francesco Feroci, Andrea Vannucchi, Stefano Cantafio, Marco Scatizzi,** department of General and Oncological Surgery, Santo Stefano Hospital, 59100 Prato, Italy

**Paolo Pietro Bianchi, Giampaolo Formisano,** department of General and Minimally Invasive Surgery, Misericordia Hospital, Grosseto, Italy

**Author contribution:** Feroci F and Vannucchi A contributed equally to this work; Feroci F and Vannucchi A designed the research, analyzed the data and drafted the manuscript; Bianchi PP and Cantafio S made an important critical revision; Garzi A and Formisano G made the acquisition of data; Scatizzi M contributed to the conception and design of the study and made the final approval; all authors have approved the final version of the article.

**Institutional review board statement**: This study was reviewed and approved by the Ethics Committee of the Santo Stefano Hospital, Prato, Italy and of the Misericordia Hospital, Grosseto, Italy.

**Informed consent statement**: The IRB allowed us to waive the requirement for obtaining informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to have imaging study by written consent.

**Conflict-of-interest statement**: We have no financial relationships to disclose.

**Data sharing statement**: Statistical analysis and dataset are available from the corresponding author at fferoci@yahoo.it.

**Open-Access:** This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

**Correspondance to: Francesco Feroci, MD,** department of General and Oncological Surgery, Santo Stefano Hospital, Via Suor Niccolina 20, 59100 Prato (Po), Italy. fferoci@yahoo.it

**Telephone:** +39-57-4804612

**Received:** December 16, 2015

**Peer-review started:** December 19, 2015

**First decision:** January 13, 2016

**Revised:** January 27, 2016

**Accepted:** February 20, 2016

**Article in press:**

**Published online:**

**Abstract**

**Aim:** To compare the short- and long-term outcomes of laparoscopic and robotic surgery for middle and low rectal cancer.

**Methods:** This is a retrospective study on a prospectively collected database containing 111 patients who underwent minimally invasive rectal resection with total mesorectal excision (TME) with curative intent between January 2008 and December 2014 (robot, *n* = 53; laparoscopy, *n* = 58). The patients all had a diagnosis of middle and low rectal adenocarcinoma with stage I-III disease. The median follow-up period was 37.4 mo. Perioperative results, morbidity a pathological data were evaluated and compared. The 3-year overall survival and disease-free survival rates were calculated and compared.

**Results:** Patients were comparable in terms of preoperative and demographic parameters. The median surgery time was 192 minutes for laparoscopic TME (L-TME) and 342 minutes for robotic TME (R-TME) (*p* < 0.001). There were no differences found in the rates of conversion to open surgery and morbidity. The patients who underwent laparoscopic surgery stayed in the hospital two days longer than the robotic group patients (8 d for L-TME and 6 d for R-TME, *p* < 0.001). The pathologic evaluation showed a higher number of harvested lymph nodes in the robotic group (18 for R-TME; 11 for L-TME; *p* < 0.001) and a shorter distal resection margin for laparoscopic patients (1.5 cm for L-TME; 2.5 cm for R-TME; *p* < 0.001). The three-year overall survival and disease-free survival rates were similar between groups.

**Conclusion:** Both L-TME and R-TME achieved acceptable clinical and oncologic outcomes. The robotic technique showed some advantages in rectal surgery that should be validated by further studies.

**Key words:** Robotic surgery; laparoscopic surgery; rectal cancer; minimally invasive surgery; total mesorectal excision

**© The Author(s) 2016.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Core tip:** The aim of this retrospective study was to compare the short- and long-term outcomes of 111 patients who underwent minimally invasive rectal resection with total mesorectal excision (TME) with curative intent. The median surgery time was shorter for laparoscopic TME while there were no differences found in the rates of conversion to open surgery and morbidity. The pathologic evaluation showed a higher number of harvested lymph nodes in the robotic group and a shorter distal resection margin for laparoscopic patients but the three-year overall survival and disease-free survival rates were similar between groups.

Feroci F,Vannucchi A, Bianchi PP, Cantafio S, Formisano G, Garzi A, Scatizzi M. Total mesorectal excision for mid and low rectal cancer: laparoscopic *vs* robotic surgery. *World J Gastroenterol* 2016; In press

**INTRODUCTION**

Several randomized clinical trials have shown the long-term oncologic results of laparoscopic versus open surgery for colorectal cancer[1-3]. The recently published long-term results of the COLOR II trial state that laparoscopic surgery in patients with rectal cancer produces similar rates of locoregional recurrence, 3-year disease-free survival and 3-year overall survival as open surgery[4]. However, technical difficulties associated with laparoscopic resection and the extensive training required to perform the operation have limited its dissemination outside specialized centres[5-7]. A robot-assisted approach could potentially overcome some of the limitations of conventional laparoscopic rectal surgery. A robotic system enables the surgeon to control a three dimensional, high-definition, 10-fold magnification vision steady camera. It provides wrist motion for endoscopic instruments (7 degrees of freedom, 180 degrees of articulation and 540 degrees of rotation). The motion scaling feature reduces physiological tremors, provides superior dexterity, and increases ergonomic comfort[8]. Therefore, robotic systems can overcome several of the technical difficulties associated with traditional laparoscopic surgery and allow high-quality manoeuvres to be performed in narrow spaces such as the pelvic cavity. The additional third arm instrument is a fixed retractor used to improve vision and stability in restricted spaces. Robot-assisted operations have been used for years in other surgical specialties. However, it was not until 2002 that Weber *et al*[9] reported the first two cases of robot-assisted colectomies. Several meta-analyses have been published and they demonstrate the scientific community’s interest in this surgery[10-14]. The most relevant data resulting from these studies was that robotic surgery had reduced conversion to open surgery compared to the laparoscopic group. Additionally, the short-term clinical and oncologic outcomes were not significantly different between groups. The recently published 5-year results demonstrate that there are similar rates for overall survival, disease-free survival, and local recurrence between robotic and laparoscopic surgical procedures[15]. There are currently two ongoing multicentre randomized controlled trials comparing robotic versus laparoscopic surgery for rectal cancer: the ROLARR[16] and COLRAR[17] trials.

The aim of this study was to compare the feasibility and short-term and long-term outcomes of robotic surgery for middle and low rectal cancer with the results of conventional laparoscopic surgery in two different centres with high volume of colorectal minimally invasive surgery.

**MATERIAL AND METHODS**

***Study population and patient selection***

This is a retrospective study on a prospectively collected database containing 111 patients who underwent minimally invasive rectal resection with total mesorectal excision (TME) for curative intent. The patients all had a diagnosis of middle and low rectal adenocarcinoma (tumour located within 12 cm from the anal verge). The enrolled patients were from two Italian institutions; the Unit of General and Oncologic Surgery, Santo Stefano Hospital, Prato and the Unit of Minimally Invasive Surgery, Division of General and Laparoscopic Surgery, European Institute of Oncology, University of Milan. The Institutional Review Boards of both hospitals approved the study.

Patients considered for minimally invasive surgery were enrolled between January 1, 2008 and December 31, 2014. The exclusion criteria included emergency cases, patients with clinical T4 or metastatic disease, and those with contraindication for prolonged pneumoperitoneum. All surgeries were performed by the expert surgeons MS (Santo Stefano Hospital, Prato) and PPB (European Institute of Oncology, University of Milan). Both surgeons have performed more than 100 laparoscopic colorectal resections. The robotic resections were executed by a single surgeon (PPB).

***Data collection and evaluation parameters***

The preoperative data included the following: general patient characteristics, American Society of Anaesthesiologists (ASA) score, body mass index (BMI), previous neoadjuvant treatment, distance of the lesion from the anal verge, and tumour biomarkers.

The intraoperative data consisted of the following: surgical time including the docking of the robot, adjunct procedures, intraoperative complications, blood loss, ileostomy, and conversions to laparotomy.

The postoperative results included first bowel movement, hospital length of stay, postoperative surgical and non-surgical complications, and need for revision surgery. The postoperative complicationswere defined as adverse events that occurred within 30 d after surgery. All of the complications were diagnosed and categorized according to patient’s symptoms with the aid of laboratory and radiological evaluation to confirm clinical suspicions. The diagnosis of anastomotic leakage was based on clinical suspicion and required contrast radiography (radiograph or computed tomographic scan) or surgery to confirm the diagnosis. The signs of clinical leakage included abdominal pain or fever, discharge of pus or bowel contents through the indwelling drain, and local or generalized peritonitis. The total numbers of postoperative complications were counted for all cases related to morbidity. The postoperative surgical complications were also stratified by the Clavien-Dindo classification[18].

The tumour-node-metastasis (TNM) stage, resection margins, numbers of harvested lymph nodes, lymphovascular invasion, and circumferential resection margin (CRM) were evaluated for analysis of the pathologic outcomes. The involved CRM was defined when the tumour was located 1 mm or less from the CRM[19]. The pathologic analyses conducted after 2010 used the criteria of the American Joint Committee on Cancer seventh edition[20]. TNM stages evaluated before 2010[21] have been reviewed according to the newest edition.

All patients undergoing surgery were registered in our database and received close follow-up. We calculated the 3-year overall survival and disease-free survival rates. A local recurrence was defined as the relapse of the tumour at the primary site confirmed by radiological or histological evidence. Simultaneous local and systemic recurrences were counted as a local recurrence. A distant metastasis was considered a metastatic lesion diagnosed in other organs beyond the primary site.

***Clinical management***

The preoperative patient work-up included a colonoscopy with biopsy, standard blood testing, thoracic-abdominal computed tomography (CT), transrectal ultrasonography (US), and pelvic magnetic resonance imaging (MRI) if necessary. For locally advanced disease (clinical stage T3 N0 or any T N+) that was confirmed by MRI and/or US we considered neoadjuvant CRT. After neoadjuvant therapy, the patients received a thoracic-abdominal CT for restaging. A radical surgical treatment was proposed in all cases, including the patients with a pathological complete response[22]. Surgery was performed 8 wk after the completion of RT, when tumour regression was maximal[23].

Total mesorectal excision was the standard procedure for middle and low rectal cancer. The surgical techniques were performed as described in previous reports[24,25]. The tumour height and the absence of direct tumour invasion into the levator ani muscle or sphincter muscle were the primary considerations for sphincter-preserving procedures. Both institutions applied similar fast-track protocols and similar discharge criteria for the perioperative management of colorectal surgical patients[26]. Neoadjuvant and adjuvant therapies were administered according to the Italian National Institute of Health recommendations and the most current NCCN guideline for rectal cancer[27]. The discharged patients received a physical examination and tumour marker analysis at 1 mo, 3 mo, and then every 3 mo for the first 3 years. The patients were then evaluated every 6 mo until 5 years after surgery. Each patient was evaluated by colonoscopy at 1 year and 3 years after surgery and then every 5 years. We obtained chest and abdominopelvic computed tomography scans every 6 months for the first 3 years. We then obtained scans every 12 mo until 5 years after surgery to detect local recurrence or systemic metastasis during the follow-up period.

***Statistical analyses and measurement***

The differences in clinically important baseline characteristics, intraoperative outcomes, short-term (30-d) postoperative outcomes and long-term (3-year) outcomes were compared between the laparoscopic and robotic cohorts. A univariate analysis was performed using the Mann-Whitney U test for continuous variables. The *χ2* test was used for categorical variables. A *p* values < 0.05 was considered statistically significance for all analyses and all tests were two-sided. The univariate results are reported as median (interquartile range) or frequency (percent). The patient overall survival and disease free survival were calculated using the Kaplan–Meier method and were compared with the log-rank test. All data were analysed on an intention-to-treat basis. The data were tabulated using a Microsoft© Excel spreadsheet (Excel for Windows©; Microsoft Corporation, Redmond, WA, United States) and were processed with SPSS© 16.0 for Windows (SPSS, Chicago, IL, United States).

The overall survival for both groups was calculated as the interval from surgery to death and disease free survival was calculated as the interval from surgery to the first diagnosis of recurrence. Due to the current lack of a uniform consensus regarding the definition of conversion to laparotomic surgery, we defined a converted rectal resection as any interruption of the minimally invasive approach (laparoscopic or robotic) and subsequent use of a conventional abdominal incision for completion of the operation.

**RESULTS**

***Patient characteristics***

There were 58 laparoscopic rectal resections with TME (L-TME) and 53 robotic rectal resections with TME (R-TME).

There were no significant differences between groups for age and Body Mass Index. There were more males in the laparoscopic group (*p* = 0.031). The ASA score showed no signiﬁcant differences between the laparoscopic and robotic patients and a score of 2 was the most common value in both groups. The groups were similar with respect to tumour location, preoperative presence of tumour markers, and rate of patients who underwent preoperative CRT (Table 1).

***Perioperative clinical outcomes***

The median surgical time was 342 min (range 249-536 min) in the R-TME group, which includes time spent for the docking of the robot. The median surgical time was 192 minutes (range 90-335 min) in the L-TME group (*p* < 0.001). A transanal mechanical end to end anastomosis was performed in all the robotic procedures and in 54 laparoscopic patients. There was a manual coloanal anastomosis executed in the remaining four L-TME cases. There were eight adjunct procedures in the laparoscopic group that included the following: one prolonged lysis of visceral adhesions, one cholecystectomy, two urologic procedures, one left adrenalectomy, two liver biopsies, and one resection of jejunal gastro intestinal stromal tumour. There were the following five adjunct procedures performed in the robotic surgery group: two hysterectomy and salpingo-oopherectomy, two cholecystectomies and one urologic procedure. There were no intraoperative complications in either group. There were no signiﬁcant differences for intraoperative bleeding or diverting ileostomy. There was one conversion to laparotomy in the laparoscopic due to the presence of extensive visceral adhesions and there were two conversions in the robotic group (*p* = 0.605). The cause of conversion to laparotomy in both robotic procedures was the need to resect the anastomotic colon after the intraoperative identification of ischemia. The other robotic case was converted to conventional laparoscopy for the same reason. The day of first bowel movement, perioperative morbidity, and rate of revision surgery were similar between groups. However, patients who underwent laparoscopic surgery stayed at the hospital two days longer than the robotic group patients (8 d for L-TME and 6 d for R-TME, *p* < 0.001). There were no 30-d mortalities (Table 2).

***Postoperative pathologic assessment***

The tumour stage distribution and lymphovascular invasion did not differ between groups. The factors indicating the mesorectal excision quality such as invasion of distal resection margin (DRM) and positivity of CRM were not signiﬁcantly different. The CRM was less than 1 mm in one laparoscopic patient (*p* = 0.523) and the DRM was involved in one laparoscopic and one robotic patient (*p* = 0.729). The median number of harvested nodes was 11 (range 3-27) in the laparoscopic group and 18 (range 4-49) in the robotic group (*p* < 0.001). The median length of DRM was 1.5 cm (range 0.5-5 cm) for the L-TME and 2.5 cm (range 0.5-10 cm) cm for the R-TME (*p* < 0.001). A pathological complete response after neoadjuvant therapy was observed in 6 (10.3%) laparoscopic patients and in 5 (9.4%) robotic cases (*p* = 0.381). Our results are comparable with data reported in a recent meta-analysis[22] (Table 3).

***Oncologic long-term outcomes***

The median follow-up period for all cases was 37.4 mo (range 2–85 mo). There were no patients lost to follow-up. There was no significant difference in the administration of adjuvant chemotherapy between groups. There were local recurrences observed in three laparoscopic patients (5.2%) and one robotic case (1.9%, *p* = 0.618). There were distant metastasis in nine R-TME cases (17%) and five L-TME cases (8.6%, *p* = 0.265). The overall patient mortality rate was 10.3% (6 patients) for the laparoscopic group and 9.4% (5 patients) for the robotic group (*p* = 0.564). There were four patient deaths in each group due to the primary diagnosis of rectal cancer. The remaining deaths occurred for other reasons (Table 4).

The 3-year overall survival rate (figure 1A) was 90.2% in R-TME group and 90.0% in L-TME group (*p* = 0.956). The 3-year disease-free survival rate (figure 1B) was 79.2% in R-TME and 83.4% in L-TME (*p* = 0.268). There was no mortality or tumour recurrence in patients achieving a pathological complete response after neoadjuvant therapy in either group.

**DISCUSSION**

In this study, the robotic and laparoscopic patients were comparable with respect to intraoperative, short-term, and long-term results.

Robotic resections required a longer median surgical time, as reported in other series[28]. However, the similar rates of diverting ileostomy reflect the confidence of the robotic surgeon.

Although there were no differences in postoperative morbidity, the length of hospital stay was longer in the laparoscopic group for unclear reasons. This result is consistent with data from a pilot randomized trial comparing laparoscopic and robotic TME[29].

Our evaluation of CRM positivity and DRM involvement parameters accessed the quality of mesorectal excision and showed no significant differences between robotic and laparoscopic procedures. These results are oncologically acceptable and comparable to other reports[30-32]. The evidence of a longer median DRM in the robotic group (2.5 cm for R-TME; 1.5 cm for L-TME; *p* < 0.001) may be the result of technical advantages of the robotic approach because it allows the surgeon to perform high-quality manoeuvres in narrow spaces such as the pelvic cavity. Despite this consideration, a median DRM of 1.5 cm in the laparoscopic group was adequate and did not compromise the oncological outcome[33-35].

The total number of harvested lymph nodes was higher for the robotic group and this finding contrasts previously reported data[10-13,36]. The lower median number of resected lymph nodes for L-TME did not translate into higher rates of recurrence or mortality. This finding demonstrates the lymphadenectomy was accurate in both the laparoscopic and robotic procedures.

The 3-year survival rates of this study did not differ significantly between groups and is comparable with previously reported 3-year and 5-year outcomes[14,37-39].

The advantages of laparoscopic TME compared to the open approach have been examined in several studies[40-43]. The procedure has been described as oncologically safe and is associated with the standard benefits of minimally invasive techniques. Recent trials have reported long-term oncologic outcomes of laparoscopic TME and have shown survival rates similar to those obtained with open surgery[31,44-47]. The 3-year analysis of the CLASICC trial suggested there are improved outcomes for early stage rectal cancer excised laparoscopically compared with open surgery[48]. Despite these advantages, laparoscopic surgery for middle and low rectal cancers can be very challenging due to technical difficulties. Thus, the MRC CLASICC trial revealed high conversion rates, CRM involvement, and an increased incidence of urinary and sexual dysfunctions[49]. Although higher CRM infiltration did not result in increased local recurrence rates, the concerns regarding laparoscopic rectal cancer surgery led to decreased use in United Kingdom/ United States for rectal cancer[50,51]. The rate of conversion to open surgery is critical in minimally invasive rectal cancer surgery because the converted patients had higher complication rates than non- converted cases[45]. Additionally, one series reported the conversion patients had the worst oncological outcomes[52]. The COREAN trial revealed outcomes of the laparoscopic approach were comparable to open resection in middle and low rectal cancer after neoadjuvant therapy[53]. However, the low conversion rate of 1.5% and the excellent oncological outcomes achieved by a high volume skilled surgeon in low BMI patients may not be reproducible. All of the procedures in this trial have been performed by seven highly skilled laparoscopic specialists (each one performed more than 200 laparoscopic rectal resections). This suggests that excellent results in laparoscopic rectal cancer surgery can be achieved in expert surgeons. A recent study assessing the learning period for laparoscopic TME stated that 90 operations were required to achieve adequate oncological safety. However, fewer surgeries were needed to achieve operative safety[35].

Robot-assisted surgery may overcome several technical limitations of conventional laparoscopy such as a stable and high-definition 3D image, finer dissection with articulated tools, and better ergonomics for the surgeon. Several meta-analyses comparing robotic and laparoscopic TME[10-14] showed there was a lower percentage of conversion for robotic surgery. However, intraoperative reports indicate there are no significant differences in short-term and oncologic outcomes between the two approaches.

We did not evaluate the costs and preservation of genitourinary function in this study. One of the main concerns regarding robotic technology is the expense and maintenance of the equipment. Baek showed there are increased costs in robotic rectal resection compared to the standard laparoscopic procedure[54]. Conversely, recent studies have demonstrated a superiority of robotic rectal resection in recovery of urinary voiding and sexual function[55,56] due to improved visualization of the autonomic plexii in the pelvis. We are waiting for the results of the ROLARR and COLRAR trials to better define the optimal surgical approach in patients with advanced middle and low rectal cancer.

There are several aspects of our study that merit discussion. First, the patients were assigned to robotic surgery or laparoscopy in an uncontrolled and nonrandomized manner, which is a limitation. However, to reduce the margin of error the data were obtained independently by two authors. Additionally, the retrospective nature of this study is a limitation. However, both surgical centres followed similar perioperative and oncological protocols. Therefore, clinical differences were reduced. Furthermore, this study was limited by its small sample size.

In conclusion, our observations suggest that L-TME and R-TME can be safely performed at high volume centres for rectal cancer. Both procedures achieve acceptable clinical and oncologic outcomes. Moreover, the robotic technique shows some advantages in rectal surgery that should be validated by further studies.

**COMMENTS**

***Background***

Theshort- and long-term outcomes of laparoscopic total mesorectal excision (L-TME) were found to be acceptable in previous reports. However, the benefits of the robotic approach for treatment of rectal cancer (R-TME) have not been clearly described.

***Research frontiers***

There were no differences found in the rates of conversion to open surgery and morbidity. The patients who underwent laparoscopic surgery stayed in the hospital two days longer than the robotic group patients (8 d or L-TME and 6 d for R-TME, *p* < 0.001). The pathologic evaluation showed a higher number of harvested lymph nodes in the robotic group (18 for R-TME; 11 for L-TME; *p* < 0.001) and a shorter distal resection margin for laparoscopic patients (1.5 cm for L-TME; 2.5 cm for R-TME; *p* < 0.001). The three-year overall survival and disease-free survival rates were similar between groups.

***Innovations and breakthroughs***

Both procedures achieved acceptable clinical and oncologic outcomes. Moreover, the robotic technique showed some advantages in rectal surgery that should be validated by further studies.

***Applications***

Author’s observations suggested that L-TME and R-TME can be safely performed at high volume centres for rectal cancer.

***Peer-review***

This is a retrospective comparative study of a prospectively collected data of 111 patients who underwent minimally invasive TME (53 patients robotic assisted *vs* 58 patients laparoscopic assisted TME). The authors concluded that both techniques achieved acceptable similar clinical and oncologic outcomes. The manuscript is well written in clear English, and the authors addressed the study limitation such as the small study sample size, selection bias, and the retrospective nature of the study.

**REFERENCES**

1 **Fleshman J**, Sargent DJ, Green E, Anvari M, Stryker SJ, Beart RW, Hellinger M, Flanagan R, Peters W, Nelson H; Clinical Outcomes of Surgical Therapy Study Group. Laparoscopic colectomy for cancer is not inferior to open surgery based on 5-year data from the COST Study Group trial. *Ann Surg* 2007; **246**: 655-662; discussion 662-664 [PMID: 17893502 DOI: 10.1097/SLA.0b013e318155a762]

2 **Buunen M**, Veldkamp R, Hop WC, Kuhry E, Jeekel J, Haglind E, Påhlman L, Cuesta MA, Msika S, Morino M, Lacy A, Bonjer HJ; Colon Cancer Laparoscopic or Open Resection Study Group. Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. *Lancet Oncol* 2009; **10**: 44-52 [PMID: 19071061 DOI: 10.1016/S1470-2045(08)70310-3]

3 **Green BL**, Marshall HC, Collinson F, Quirke P, Guillou P, Jayne DG, Brown JM. Long-term follow-up of the Medical Research Council CLASICC trial of conventional versus laparoscopically assisted resection in colorectal cancer. *Br J Surg* 2013; **100**: 75-82 [PMID: 23132548 DOI: 10.1002/bjs.8945]

4 **Bonjer HJ**, Deijen CL, Abis GA, Cuesta MA, van der Pas MH, de Lange-de Klerk ES, Lacy AM, Bemelman WA, Andersson J, Angenete E, Rosenberg J, Fuerst A, Haglind E; COLOR II Study Group. A randomized trial of laparoscopic versus open surgery for rectal cancer. *N Engl J Med* 2015; **372**: 1324-1332 [PMID: 25830422 DOI: 10.1056/NEJMoa1414882]

5 **Jamali FR**, Soweid AM, Dimassi H, Bailey C, Leroy J, Marescaux J. Evaluating the degree of difficulty of laparoscopic colorectal surgery. *Arch Surg* 2008; **143**: 762-767; discussion 768 [PMID: 18711036 DOI: 10.1001/archsurg.143.8.762]

6 **Park IJ**, Choi GS, Lim KH, Kang BM, Jun SH. Multidimensional analysis of the learning curve for laparoscopic colorectal surgery: lessons from 1,000 cases of laparoscopic colorectal surgery. *Surg Endosc* 2009; **23**: 839-846 [PMID: 19116741 DOI: 10.1007/s00464-008-0259-4]

7 **Bianchi PP**, Rosati R, Bona S, Rottoli M, Elmore U, Ceriani C, Malesci A, Montorsi M. Laparoscopic surgery in rectal cancer: a prospective analysis of patient survival and outcomes. *Dis Colon Rectum* 2007; **50**: 2047-2053 [PMID: 17906896 DOI: 10.1007/s10350-007-9055-9]

8 **Lanfranco AR**, Castellanos AE, Desai JP, Meyers WC. Robotic surgery: a current perspective. *Ann Surg* 2004; **239**: 14-21 [PMID: 14685095 DOI: 10.1097/01.sla.0000103020.19595.7d]

9 **Weber PA**, Merola S, Wasielewski A, Ballantyne GH. Telerobotic-assisted laparoscopic right and sigmoid colectomies for benign disease. *Dis Colon Rectum* 2002; **45**: 1689-1694; discussion 1695-1696 [PMID: 12473897]

10 **Lin S**, Jiang HG, Chen ZH, Zhou SY, Liu XS, Yu JR. Meta-analysis of robotic and laparoscopic surgery for treatment of rectal cancer. *World J Gastroenterol* 2011; **17**: 5214-5220 [PMID: 22215947 DOI: 10.3748/wjg.v17.i47.5214]

11 **Trastulli S**, Farinella E, Cirocchi R, Cavaliere D, Avenia N, Sciannameo F, Gullà N, Noya G, Boselli C. Robotic resection compared with laparoscopic rectal resection for cancer: systematic review and meta-analysis of short-term outcome. *Colorectal Dis* 2012; **14**: e134-e156 [PMID: 22151033 DOI: 10.1111/j.1463-1318.2011.02907.x]

12 **Memon S**, Heriot AG, Murphy DG, Bressel M, Lynch AC. Robotic versus laparoscopic proctectomy for rectal cancer: a meta-analysis. *Ann Surg Oncol* 2012; **19**: 2095-2101 [PMID: 22350601 DOI: 10.1245/s10434-012-2270-1]

13 **Yang Y**, Wang F, Zhang P, Shi C, Zou Y, Qin H, Ma Y. Robot-assisted versus conventional laparoscopic surgery for colorectal disease, focusing on rectal cancer: a meta-analysis. *Ann Surg Oncol* 2012; **19**: 3727-3736 [PMID: 22752371 DOI: 10.1245/s10434-012-2429-9]

14 **Xiong B**, Ma L, Zhang C, Cheng Y. Robotic versus laparoscopic total mesorectal excision for rectal cancer: a meta-analysis. *J Surg Res* 2014; **188**: 404-414 [PMID: 24565506 DOI: 10.1016/j.jss.2014.01.027]

15 **Park EJ**, Cho MS, Baek SJ, Hur H, Min BS, Baik SH, Lee KY, Kim NK. Long-term oncologic outcomes of robotic low anterior resection for rectal cancer: a comparative study with laparoscopic surgery. *Ann Surg* 2015; **261**: 129-137 [PMID: 24662411 DOI: 10.1097/SLA.0000000000000613]

16 **Collinson FJ**, Jayne DG, Pigazzi A, Tsang C, Barrie JM, Edlin R, Garbett C, Guillou P, Holloway I, Howard H, Marshall H, McCabe C, Pavitt S, Quirke P, Rivers CS, Brown JM. An international, multicentre, prospective, randomised, controlled, unblinded, parallel-group trial of robotic-assisted versus standard laparoscopic surgery for the curative treatment of rectal cancer. *Int J Colorectal Dis* 2012; **27**: 233-241 [PMID: 21912876 DOI: 10.1007/s00384-011-1313-6]

17 Available from: URL: http: //www.clinicaltrials.gov/show/NCT01423214

18 **Dindo D**, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004; **240**: 205-213 [PMID: 15273542]

19 **Hwang MR**, Park JW, Park S, Yoon H, Kim DY, Chang HJ, Kim SY, Park SC, Choi HS, Oh JH, Jeong SY. Prognostic impact of circumferential resection margin in rectal cancer treated with preoperative chemoradiotherapy. *Ann Surg Oncol* 2014; **21**: 1345-1351 [PMID: 24468928 DOI: 10.1245/s10434-014-3484-1]

20 **Edge SB**, Compton CC. The American Joint Committee on Cancer: the 7th edition of the AJCC cancer staging manual and the future of TNM. *Ann Surg Oncol* 2010; **17**: 1471-1474 [PMID: 20180029 DOI: 10.1245/s10434-010-0985-4]

21 **Greene FL**, Page DL, Fleming ID (2002). AJCC Cancer Staging Manual. 6th ed. New York: Springer-Verlag, 99-106

22 **Monson JR**, Weiser MR, Buie WD, Chang GJ, Rafferty JF, Buie WD, Rafferty J; Standards Practice Task Force of the American Society of Colon and Rectal Surgeons. Practice parameters for the management of rectal cancer (revised). *Dis Colon Rectum* 2013; **56**: 535-550 [PMID: 23575392 DOI: 10.1097/DCR.0b013e31828cb66c]

23 **Pettersson D**, Glimelius B, Iversen H, Johansson H, Holm T, Martling A. Impaired postoperative leucocyte counts after preoperative radiotherapy for rectal cancer in the Stockholm III Trial. *Br J Surg* 2013; **100**: 969-975 [PMID: 23553796 DOI: 10.1002/bjs.9117]

24 **Feroci F**, Kröning KC, Lenzi E, Moraldi L, Cantafio S, Scatizzi M. Laparoscopy within a fast-track program enhances the short-term results after elective surgery for resectable colorectal cancer. *Surg Endosc* 2011; **25**: 2919-2925 [PMID: 21789649 DOI: 10.1007/s00464-011-1643-z]

25 **Bianchi PP**, Ceriani C, Locatelli A, Spinoglio G, Zampino MG, Sonzogni A, Crosta C, Andreoni B. Robotic versus laparoscopic total mesorectal excision for rectal cancer: a comparative analysis of oncological safety and short-term outcomes. *Surg Endosc* 2010; **24**: 2888-2894 [PMID: 20526623 DOI: 10.1007/s00464-010-1134-7]

26 **Feroci F**, Lenzi E, Baraghini M, Garzi A, Vannucchi A, Cantafio S, Scatizzi M. Fast-track colorectal surgery: protocol adherence influences postoperative outcomes. *Int J Colorectal Dis* 2013; **28**: 103-109 [PMID: 22941115 DOI: 10.1007/s00384-012-1569-5]

27 **Rottoli M**, Bona S, Rosati R, Elmore U, Bianchi PP, Spinelli A, Bartolucci C, Montorsi M. Laparoscopic rectal resection for cancer: effects of conversion on short-term outcome and survival. *Ann Surg Oncol* 2009; **16**: 1279-1286 [PMID: 19252948 DOI: 10.1245/s10434-009-0398-4]

28 **Hellan M**, Stein H, Pigazzi A. Totally robotic low anterior resection with total mesorectal excision and splenic flexure mobilization. *Surg Endosc* 2009; **23**: 447-451 [PMID: 19057962 DOI: 10.1007/s00464-008-0193-5]

29 **Baik SH**, Ko YT, Kang CM, Lee WJ, Kim NK, Sohn SK, Chi HS, Cho CH. Robotic tumor-specific mesorectal excision of rectal cancer: short-term outcome of a pilot randomized trial. *Surg Endosc* 2008; **22**: 1601-1608 [PMID: 18270772 DOI: 10.1007/s00464-008-9752-z]

30 **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 [PMID: 17763911]

31 **Laurent C**, Leblanc F, Wütrich P, Scheffler M, Rullier E. Laparoscopic versus open surgery for rectal cancer: long-term oncologic results. *Ann Surg* 2009; **250**: 54-61 [PMID: 19561481 DOI: 10.1097/SLA.0b013e3181ad6511]

32 **Jayne DG**, Thorpe HC, Copeland J, Quirke P, Brown JM, Guillou PJ. Five-year follow-up of the Medical Research Council CLASICC trial of laparoscopically assisted versus open surgery for colorectal cancer. *Br J Surg* 2010; **97**: 1638-1645 [PMID: 20629110 DOI: 10.1002/bjs.7160]

33 **Kuvshinoff B**, Maghfoor I, Miedema B, Bryer M, Westgate S, Wilkes J, Ota D. Distal margin requirements after preoperative chemoradiotherapy for distal rectal carcinomas: are & lt; or = 1 cm distal margins sufficient? *Ann Surg Oncol* 2001; **8**: 163-169 [PMID: 11258782]

34 **Moore HG**, Riedel E, Minsky BD, Saltz L, Paty P, Wong D, Cohen AM, Guillem JG. Adequacy of 1-cm distal margin after restorative rectal cancer resection with sharp mesorectal excision and preoperative combined-modality therapy. *Ann Surg Oncol* 2003; **10**: 80-85 [PMID: 12513965 DOI: 10.1245/ASO.2003.04.010]

35 **Park IJ**, Kim JC. Adequate length of the distal resection margin in rectal cancer: from the oncological point of view. *J Gastrointest Surg* 2010; **14**: 1331-1337 [PMID: 20143273 DOI: 10.1007/s11605-010-1165-3]

36 **Ghezzi TL**, Luca F, Valvo M, Corleta OC, Zuccaro M, Cenciarelli S, Biffi R. Robotic versus open total mesorectal excision for rectal cancer: comparative study of short and long-term outcomes. *Eur J Surg Oncol* 2014; **40**: 1072-1079 [PMID: 24646748 DOI: 10.1016/j.ejso.2014.02.235]

37 **Baik SH**, Kwon HY, Kim JS, Hur H, Sohn SK, Cho CH, Kim H. Robotic versus laparoscopic low anterior resection of rectal cancer: short-term outcome of a prospective comparative study. *Ann Surg Oncol* 2009; **16**: 1480-1487 [PMID: 19290486 DOI: 10.1245/s10434-009-0435-3]

38 **Choi DJ**, Kim SH, Lee PJ, Kim J, Woo SU. Single-stage totally robotic dissection for rectal cancer surgery: technique and short-term outcome in 50 consecutive patients. *Dis Colon Rectum* 2009; **52**: 1824-1830 [PMID: 19966627 DOI: 10.1007/DCR.0b013e3181b13536]

39 **Pahlman L**, Bujko K, Rutkowski A, Michalski W. Altering the therapeutic paradigm towards a distal bowel margin of & lt; 1 cm in patients with low-lying rectal cancer: a systematic review and commentary. *Colorectal Dis* 2013; **15**: e166-e174 [PMID: 23331717 DOI: 10.1111/codi.12120]

40 **Morino M**, Parini U, Giraudo G, Salval M, Brachet Contul R, Garrone C. Laparoscopic total mesorectal excision: a consecutive series of 100 patients. *Ann Surg* 2003; **237**: 335-342 [PMID: 12616116 DOI: 10.1097/01.SLA.0000055270.48242.D2]

41 **Breukink S**, Pierie J, Wiggers T. Laparoscopic versus open total mesorectal excision for rectal cancer. *Cochrane Database Syst Rev* 2006; **(4)**: CD005200 [PMID: 17054246 DOI: 10.1002/14651858.cd005200.pub2]

42 **Bärlehner E**, Benhidjeb T, Anders S, Schicke B. Laparoscopic resection for rectal cancer: outcomes in 194 patients and review of the literature. *Surg Endosc* 2005; **19**: 757-766 [PMID: 15868256 DOI: 10.1007/s00464-004-9134-0]

43 **Bretagnol F**, Lelong B, Laurent C, Moutardier V, Rullier A, Monges G, Delpero JR, Rullier E. The oncological safety of laparoscopic total mesorectal excision with sphincter preservation for rectal carcinoma. *Surg Endosc* 2005; **19**: 892-896 [PMID: 15920688 DOI: 10.1007/s00464-004-2228-x]

44 **Leroy J**, Jamali F, Forbes L, Smith M, Rubino F, Mutter D, Marescaux J. Laparoscopic total mesorectal excision (TME) for rectal cancer surgery: long-term outcomes. *Surg Endosc* 2004; **18**: 281-289 [PMID: 14691716 DOI: 10.1007/s00464-002-8877-8]

45 **Law WL**, Poon JT, Fan JK, Lo SH. Comparison of outcome of open and laparoscopic resection for stage II and stage III rectal cancer. *Ann Surg Oncol* 2009; **16**: 1488-1493 [PMID: 19290491 DOI: 10.1245/s10434-009-0418-4]

46 **Ng SS**, Leung KL, Lee JF, Yiu RY, Li JC, Hon SS. Long-term morbidity and oncologic outcomes of laparoscopic-assisted anterior resection for upper rectal cancer: ten-year results of a prospective, randomized trial. *Dis Colon Rectum* 2009; **52**: 558-566 [PMID: 19404053 DOI: 10.1007/DCR.0b013e31819ec20c]

47 **Lujan J**, Valero G, Hernandez Q, Sanchez A, Frutos MD, Parrilla P. Randomized clinical trial comparing laparoscopic and open surgery in patients with rectal cancer. *Br J Surg* 2009; **96**: 982-989 [PMID: 19644973 DOI: 10.1002/bjs.6662]

48 **Jayne DG**, Guillou PJ, Thorpe H, Quirke P, Copeland J, Smith AM, Heath RM, Brown JM; UK MRC CLASICC Trial Group. Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC CLASICC Trial Group. *J Clin Oncol* 2007; **25**: 3061-3068 [PMID: 17634484 DOI: 10.1200/JCO.2006.09.7758]

49 **Guillou PJ**, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM; UK MRC CLASICC Trial Group. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. *Lancet* 2005; **365**: 1718-1726 [PMID: 15894098 DOI: 10.1016/S0140-6736(05)66545-2]

50 **Rea JD**, Cone MM, Diggs BS, Deveney KE, Lu KC, Herzig DO. Utilization of laparoscopic colectomy in the United States before and after the clinical outcomes of surgical therapy study group trial. *Ann Surg* 2011; **254**: 281-288 [PMID: 21685791 DOI: 10.1097/SLA.0b013e3182251aa3]

51 The National Bowel Cancer Audit Annual Report 2011. Available from: URL: http: //www.ic.nhs.uk/bowelreports

52 NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines). Rectal Cancer. Version 3, 2012. Available from: URL: http: //www.nccn.org

53 **Kang SB**, Park JW, Jeong SY, Nam BH, Choi HS, Kim DW, Lim SB, Lee TG, Kim DY, Kim JS, Chang HJ, Lee HS, Kim SY, Jung KH, Hong YS, Kim JH, Sohn DK, Kim DH, Oh JH. Open versus laparoscopic surgery for mid or low rectal cancer after neoadjuvant chemoradiotherapy (COREAN trial): short-term outcomes of an open-label randomised controlled trial. *Lancet Oncol* 2010; **11**: 637-645 [PMID: 20610322 DOI: 10.1016/S1470-2045(10)70131-5]

54 **Baek SJ**, Al-Asari S, Jeong DH, Hur H, Min BS, Baik SH, Kim NK. Robotic versus laparoscopic coloanal anastomosis with or without intersphincteric resection for rectal cancer. *Surg Endosc* 2013; **27**: 4157-4163 [PMID: 23708725 DOI: 10.1007/s00464-013-3014-4]

55 **Baek SJ**, Kim SH, Cho JS, Shin JW, Kim J. Robotic versus conventional laparoscopic surgery for rectal cancer: a cost analysis from a single institute in Korea. *World J Surg* 2012; **36**: 2722-2729 [PMID: 22855217 DOI: 10.1007/s00268-012-1728-4]

56 **Kim JY**, Kim NK, Lee KY, Hur H, Min BS, Kim JH. A comparative study of voiding and sexual function after total mesorectal excision with autonomic nerve preservation for rectal cancer: laparoscopic versus robotic surgery. *Ann Surg Oncol* 2012; **19**: 2485-2493 [PMID: 22434245 DOI: 10.1245/s10434-012-2262-1]

**P-Reviewer:** Meshikhes AW **S-Editor:** Gong ZM

**L-Editor:** **E-Editor:**

**Table 1 Patient characteristics *n* (%)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **L-TME****(*n* = 58)** | **R-TME****(*n* = 53)** | ***p* value** |
| Age1 (yr) | 66 (33-80) | 66 (42-84) | 0.597 |
| Sex |  |  | 0.031 |
| Male | 42 (72.4) | 27 (50.9) |  |
|  Female | 16 (27.6) | 26 (49.1) |  |
| BMI1 (kg/m2) | 24.6 (19-37) | 24.6 (18-31) | 0.512 |
| ASA score |  |  | 0.082 |
|  1 | 7 (12.1) | 11 (20.8) |  |
|  2 | 31 (53.4) | 33 (62.3) |  |
|  3 | 20 (34.5) | 9 (16.9) |  |
| Neoadjuvant therapy | 25 (43.1) | 26 (49.1) | 0.571 |
| Tumour location from anal verge1 (cm) | 8 (3-12) | 8 (4-12) | 0.607 |
| CEA1 | 1.55 (0.6-51.6) | 1.65 (0.5-11.1) | 0.803 |
| Ca 19.91 | 7.85 (0.8-241) | 7.5 (2-905) | 0.896 |

1Median (range). L-TME: Laparoscopic total mesorectal excision; R-TME: Robotic total mesorectal excision; BMI: Body mass index; ASA: American Society of Anesthesiologists.

**Table 2 Perioperative outcomes *n* (%)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **L-TME****(*n* = 58)** | **R-TME****(*n* = 53)** | ***p* value** |
| Operative time1 (min) | 192 (90-335) | 342 (249-536) | < 0.001 |
| Anastomosis |  |  | 0.120 |
| Mechanical transanal | 54 (93.1) | 53 (100) |  |
| Manual coloanal | 4 (6.9) | 0 |  |
| Adjunctive procedure | 8 (13.8) | 5 (9.4) | 0.562 |
| Diverting ileostomy | 43 (74.1) | 41 (77.4) | 0.825 |
| Intraoperative blood loss2 (ml) | 47.4 (0-400) | 60.8 (0-400) | 0.510 |
| Conversion to laparotomy | 1 (1.7) | 2 (3.8) | 0.605 |
| Hospital stay1 (d) | 8 (5-53) | 6 (3-17) | < 0.001 |
| First bowel movement1 (postoperative day) | 1 (1-6) | 1 (1-6) | 0.904 |
| Total morbidity  | 26 (44.8) | 17 (32.1) | 0.122 |
| Surgical morbidity |  |  |  |
| Anastomotic leak | 8 (13.8) | 3 (5.7) | 0.208 |
| Peritoneal haemorrhage | 2 (3.4) | 1 (1.9) | 0.534 |
| Stomal stricture | 3 (5.2) | 1 (1.9) | 0.620 |
| Wound infection | 2 (3.4) | 0 | 0.496 |
| Ileus | 4 (6.8) | 3 (5.7) | 0.551 |
| Abdominal pain3 | 2 (3.4) | 3 (5.7) | 0.457 |
| Other surgical complications | 5 (8.6) | 3 (5.7) | 0.410 |
| Non surgical morbidity | 11 (19.0) | 6 (11.4) | 0.302 |
| Reoperation | 8 (13.8) | 3 (5.7) | 0.208 |
| Clavien-Dindo Classification |  |  | 0.297 |
| 0 | 32 (55.2) | 36 (67.9) |  |
| 1 | 9 (15.5) | 5 (9.4) |  |
| 2 | 7 (12.1) | 8 (15.1) |  |
| 3a | 2 (3.4) | 1 (1.9) |  |
| 3b | 4 (6.8) | 3 (5.7) |  |
| 4a | 2 (3.4) | 0 |  |
| 4b | 2 (3.4) | 0 |  |

1Median (range); 2Mean (range); 3without other causes. L-TME: Laparoscopic total mesorectal excision; R-TME: Robotic total mesorectal excision.

**Table 3 Pathologic evaluation *n* (%)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **L-TME****(*n* = 58)** | **R-TME****(*n* = 53)** | ***p* value** |
| TNM stage |  |  | 0.716 |
| Stage I | 28 (48.3) | 22 (41.5) |  |
| Stage II | 11 (19.0) | 8 (15.1) |  |
| Stage III | 13 (22.4) | 18 (34.0) |  |
| Pathological complete response | 6 (10.3) | 5 (9.4) | 0.381 |
| Total harvested lymph nodes1 | 11 (3-27) | 18 (4-49) | < 0.001 |
| DRM1 (cm) | 1.5 (0.5-5) | 2.5 (0.5-10) | < 0.001 |
| DRM |  |  | 0.729 |
| involved | 1 (1.7) | 1 (1.9) |  |
| non involved | 57 (98.3) | 52 (98.1) |  |
| CRM |  |  | 0.523 |
| involved | 1 (1.7) | 0 |  |
| non involved | 57 (98.3) | 53 (100) |  |
| Lymphovascular invasion | 10 (17.2) | 5 (9.4) | 0.087 |

1Median (range). L-TME: Laparoscopic total mesorectal excision; R-TME: Robotic total mesorectal excision; DRM: Distal resection margin; CRM: Circumferential resection margin.

**Table 4 Long-term outcomes *n* (%)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **L-TME****(*n* = 58)** | **R-TME****(*n* = 53)** | ***p* value** |
| Adjuvant chemotherapy | 25 (43.1) | 27 (50.9) | 0.700 |
| Distant recurrence | 5 (8.6) | 9 (17.0) | 0.265 |
| Local recurrence | 3 (5.2) | 1 (1.9) | 0.618 |
| Overall mortalit | 6 (10.3) | 5 (9.4) | 0.564 |
| Mortality for rectal cancer | 4 (6.9) | 4 (7.5) | 0.491 |
| 3-yr overall survival (%) | 90.0 | 90.2 | 0.956 |
| 3-yr disease-free survival (%) | 83.4 | 79.2 | 0.268 |

L-TME: Laparoscopic total mesorectal excision; R-TME: Robotic total mesorectal excision.



**A**

**B**

**Figure 1 The 3-year overall (A) and disease-free (B) survival rate between robotic and laparoscopic total mesorectal excision surgical procedures.** DTS: disease-free survival; OS: overall survival; L-TME: Laparoscopic total mesorectal excision; R-TME: Robotic total mesorectal excision.