Original Article

A Comparative Study of Short-term Clinical Outcome of Robotic vs. Laparoscopic Surgery for Rectal Cancer

Chih-Wei Lin
Xuan-Yuan Huang
Yu-Yao Chang
Division of Colon and Rectal Surgery, Department of Surgery, Changhua Christian Hospital, Changhua, Taiwan

Key Words
Robotic;
Laparoscopic;
Rectal cancer;
Outcome

Purpose. In this study, we aimed to compare surgical parameters and short-term postoperative clinical outcomes of robotic vs. laparoscopic rectal cancer surgery.
Methods. From May 2016 to Nov 2018, we retrospectively reviewed 46 patients who underwent robotic and laparoscopic rectal cancer surgery at our institution by a single surgeon. Patient characteristics and perioperative demographic data were collected and short-term clinical outcomes were compared, including TNM stage, preoperative chemoradiotherapy, postoperative radiotherapy, surgical parameters and postoperative outcomes.
Results. Of 46 total patients, 21 underwent robotic surgery and the remaining 25 underwent laparoscopic rectal cancer surgery. There was no significant difference in patient characteristics between surgical groups. Mean operative time was longer in robotic surgery than laparoscopic surgery (robotic: 301.4 vs. laparoscopic: 206 min, $p < 0.001$); mean estimated blood loss was not statistically different (robotic" 101.9 vs. 72.8 ml, $p = 0.334$). No significant difference was detected with regard to pathological outcome or postoperative complications.
Conclusion. Robotic rectal cancer surgery had greater operative time but made no difference in postoperative short-term complication and outcome compared with laparoscopic rectal cancer surgery, which offers another safe, operative method.
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According to the 2017 Statistics of Causes of Death from Ministry of Health and Welfare of Taiwan, malignant neoplasms were still the major cause of death over the past four decades, with a standardized death rate of colorectal cancer of 14%;[1] the proportion of colorectal cancer incidence in 2015 was 43%.[2] For those who did not have locally advanced colon cancer, surgical excision was the optimal treatment according to clinical staging. Minimally invasive surgery has an advantage over conventional open surgery with its smaller wound size, reduced postoperative pain, and shorter hospitalization time. Several studies have shown that laparoscopic resection had fewer complications compared to open surgery.[3-7] Rectal cancer surgery has its own technical challenges, due to the limitation of the pelvic operation field and difficulty in instrument application. Robotic rectal surgery (RRS) has the same benefits as laparoscopy

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Correspondence to: Dr. Yu-Yao Chang, Division of Colon and Rectal Surgery, Department of Surgery, Changhua Christian Hospital, No. 135, Nanxiao St., Changhua City, Changhua County 500, Taiwan. Tel: 886-4-723-8595; Fax: 886-4-723-2942; E-mail: 177176@cch.org.tw

with three-dimensional vision and precise instrument application, a clearer operation image experience, and similar short-term perioperative outcomes compare with laparoscopic rectal surgery (LRS). However, the increased cost and longer operation time has been cited as disadvantages of RRS.[14,17-19,30] The aim of this study was to compare robotic to laparoscopic rectal cancer surgery performed by a single surgeon at a single-center hospital with regard to short-term clinical outcomes.

Materials and Methods

Patient selection

This was a retrospective study of data collected from the medical database of Changhua Christian Hospital between May 2016 and Nov 2018. We studied a total of 46 patients with rectal cancer underwent primary RRS and LRS by a single experienced surgeon (experience with > 100 laparoscopic surgeries). Among them, 21 underwent RRS and the remaining 25 underwent LRS. The operation method included low anterior resection, abdomino-perineal resection, and Hartmann's operation, depending on the location of the tumor. Patients who had recurrent cancer, multiple-organ cancer, or multiple procedures were excluded from our study. The preoperative work-up included colonoscopy, preoperative carcinoembryonic antigen, and imaging study with abdomen computed tomography scan, positron emission tomography, or magnetic resonance imaging. Patients with advanced clinical stage received neoadjuvant chemoradiation (5,600 cGy administered in 28 fractions with 5-fluorouracil based chemotherapy) were followed up by surgical resection within 8 weeks. Patients were staged according to the American Joint Committee on Cancer staging manual (7th edition). Two groups based on robotic or laparoscopic surgery were compared for perioperative short-term outcome.

We collected data of patient characteristics, including sex, age, body mass index, comorbidities (hypertension, diabetes mellitus, end stage renal disease, and coronary artery disease), preoperative concurrent chemoradiotherapy (CCRT), postoperative radiotherapy (RT), diverting stoma, pre-operation carcinoembryonic antigen (CEA), and pre-operation carbohydrate antigen 19-9 (CA19-9). Patients whose circumferential resection margin (CRM) was involved with the tumor were treated with postoperative radiotherapy. The operation outcomes included operation method (low anterior resection, abdomino-perineal resection, and Hartmann's procedure) performed according to tumor location, estimated blood loss, number of lymph node harvested, diverting stoma, CRM positive, tumor size, total hospital stay, day of intake, and readmission within 30 days. Operative time was defined as the duration of time between the first skin incision and closure. Tumor location was defined as the distance of the tumor from the anal verge and classified into upper (11-15 cm), middle (6-10 cm), and lower (0-5 cm). Pathological outcomes were defined with TNM stage, according to the American Joint Committee on Cancer staging manual (7th edition). Surgical complications were anastomosis leakage (major or minor), ileus, wound infection, chylous leakage, and mortality. Anastomosis leakage was defined as bowel content detected through a drainage tube or wound, or via imaging study. Minor leakage was defined as anastomosis leakage and was treated with nothing by mouth, antibiotics, drainage, and peripheral parenteral nutrition without surgical intervention; major leakage was defined as anastomotic leakage that required surgical intervention. Ileus was defined as no flatus or no stool passage with abdominal distension or vomiting persisting on the fifth postoperative day and the need for nasogastric tube decompression with peripheral parenteral nutrition treatment.

Surgical technique

All RRS and LRS were performed by a single experienced surgeon (over 100 laparoscopic surgeries) at our institution. The RRS was performed using the da Vinci Si Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) to perform surgery. The initial procedure to create a pneumoperitoneum was similar between the two groups with the open Hasson technique. The RRS had one 12-mm supra-umbilical cam-

era port, another four 8-mm robotic working ports over the epigastrium, right flank, left flank, and suprapubic region, and one 5-mm assistant port over right flank. The LRS had one 12-mm supra-umbilical camera port, two working ports (5-mm and 12-mm) over the right flank, and one 5-mm assistant port over the left flank. The technique to mobilize the colon, pelvic dissection, rectal anastomosis, and ileostomy creation was similar between groups. Hem-o-lok was used for inferior mesenteric artery ligation in RRS and endoscopic linear stapler or endoscopic hemoclip was applied during LRS. Energy device with LigaSure™ was used only in LRS.

Statistical analysis

Categorical variables were recorded as number of cases and percentage, whereas continuous variables were showed as mean ± standard deviation. The chi-squared test was used to compare categorical variables and Fisher's exact test was used when the minimum expected value was less than five. Continuous variables were compared by independent samples Student's *t*-test or the Mann-Whitney *U* test. A two-sided p value < 0.05 was considered statistically significant. All analyzes were performed using SPSS statistical software version 12 (SPSS Inc, Chicago, IL, USA).

Results

In this study, a total of 46 patients underwent minimally invasive surgery for rectal cancer, of which 21 underwent RRS and 25 underwent LRS. Demographic characteristics are shown in Table 1. No significant differences were found with regard to sex, age, body mass index, hypertension, diabetes mellitus, end stage renal disease and coronary artery disease, preoperative CCRT, postoperative RT. There were also no significant differences in the preoperative CEA, pre-

Table 1. Patient characteristics

	Robotic (n = 21)	Laparoscopic (n = 25)	*p* value
Sex			0.22
Male	15 (72%)	14 (56%)	
Female	6 (28%)	11 (44%)	
Age			
< 65 y	13 (62%)	15 (60%)	0.569
≥ 65 y	8 (38%)	10 (40%)	
Body mass index (kg/m^2)	24.8 ± 4.1	22.7 ± 4.5	0.108
Comorbidities			
Hypertension	11 (52%)	12 (48%)	0.5
Diabetes mellitus	5 (24%)	1 (4%)	0.079
End stage renal disease	1 (5%)	1 (4%)	1
Coronary artery disease	1 (5%)	1 (4%)	1
Pre-operation CCRT	5 (24%)	7 (28%)	0.508
Post-operation RT	1 (5%)	1 (4%)	1
Pre-operation CEA (ng/mL)	5.7 ± 4.7	34.9 ± 72.3	0.066
Pre-operation CA19-9 (U/mL)	24.8 ± 38.4	533.9 ± 2235.2	0.773
TNM Stage			0.152
0	3 (14%)	2 (8%)	
I	8 (38%)	3 (12%)	
II	3 (14%)	5 (20%)	
III	7 (34%)	12 (48%)	
IV	0	3 (12%)	

Data are represented as mean ± standard deviation and (ratio).
CCRT: concurrent chemoradiotherapy; RT: radiotherapy; CEA: carcinoembryonic antigen; CA19-9: carbohydrate antigen 19-9.
According to AJCC/UICC TNM staging.

operation CA 19-9. More patients who underwent LRS had advanced stage (≥ stage III; 15 vs. 7; p = 0.152), but this was not significantly different.

Perioperative outcomes

The perioperative outcomes showed in Table 2. The operative method (p = 0.198) was performed as low anterior resection (RRS: 20 vs. LRS: 19 patient), abdomino-perineal resection (RRS: 1 vs. LRS:5 patient) and Hartmann's procedure (RRS: 0 vs. LRS: 1 patient), but no significant difference between was found between groups. Operative time was significantly longer in RRS than in LRS (RRS: 301.4 vs. LRS: 206 mins; $p < 0.001$). Estimated blood loss was similar (RRS: 101.9 vs. LRS: 72.8 ml; p = 0.334). There were no significant difference with regard to diverting stoma (RRS: 16 vs. LRS: 17; p = 0.539), lymph node retrieval (RRS: 17.6 vs. LRS: 17.7; p = 0.973), tumor size (RRS: 35.21 vs. LRS: 30 cm^3; p = 0.707), CRM positive (RRS: 1 vs. LRS: 1; p = 1), total hospital stay (RRS: 10.8 vs. LRS: 10.5 days; p = 0.858), day of intake (RRS: 3.1 vs. LRS: 2.2 days; p = 0.755).

Table 2. Operation outcomes

	Robotic (n = 21)	Laparoscopic (n = 25)	p value
Operation method			0.198
Low anterior resection	20 (95%)	19 (76%)	
APR	1 (5%)	5 (20%)	
Hartmann's procedure	0	1 (4%)	
Operative time (mins)	301.4 ± 56.9	206 ± 63.5	< 0.001
Estimated blood loss (ml)	101.9 ± 127.3	72.8 ± 71.2	0.334
Diverting stoma	16 (76%)	17 (68%)	0.539
Lymph node retrieval	17.6 ± 7.8	17.7 ± 11.4	0.973
Tumor size (cm^3)	35.21 ± 43.5	30 ± 47.5	0.707
Tumor location (cm)			0.742
Upper (11-15 cm)	4 (19%)	5 (20%)	
Middle (6-10 cm)	6 (29%)	10 (40%)	
Low (0-5 cm)	11 (52%)	10 (40%)	
CRM positive	1 (5%)	1 (4%)	1
Total hospital stay (day)	10.8 ± 4.8	10.5 ± 4.3	0.858
Day of intake	3.1 ± 3.7	2.2 ± 0.7	0.755

Data are represented as mean ± standard deviation and ratio.
CRM: circumferential resection margin; APR: abdomino-perineal resection.

Postoperative complications are showed in Table 3. There were no significant difference in postoperative complications (p = 0.611), including minor leakage (RRS: 0 vs. LRS: 2), major leakage (RRS: 1 vs. LRS: 1) (p = 0.614), ileus (RRS: 2 vs. LRS: 5; p = 0.428), wound infection (RRS: 2 vs. LRS: 2; p = 1), chylous leakage (RRS: 2 vs. LRS: 1; p = 0.585), mortality (RRS: 1 vs. LRS: 0; p = 0.457), readmission within 30 days (RRS: 1 vs. LRS: 3; p = 0.614) between RRS and LRS. One patient with major leakage in RRS underwent diverting stoma, and one patient in LRS suffered from ileostomy obstruction with colon anastomosis site necrosis and subsequently underwent ileostomy revision and drainage of intra-abdominal abscess. One patient with end stage renal disease in RRS encountered mortality because of pneumonia and pulmonary edema. One patient in RRS encountered iatrogenic bladder injury because of adhesion. One patient in RRS had to be readmitted within 30 days because of partial intestinal obstruction, high output stoma with dehydration, and electrolyte imbalance. Two patients in LRS were readmitted due to urinary tract infection and persistent ileus.

Discussion

The aim of this study was to compare short-term outcome of RRS with LRS. In our study, all surgery were performed by single surgeon, operative time was significant longer in RRS than LRS. There were no significant differences in demographic characteristics, perioperative outcomes, or complications between the

Table 3. Postoperative complications

	Robotic (n = 21)	Laparoscopic (n = 25)	p value
Complication	6 (28.6%)	7 (28%)	0.611
Leakage	1 (4.8%)	3 (12%)	0.614
Minor	0	2 (8%)†	
Major	1 (4.8%)*	1 (4%)*	
Ileus	2 (9.5%)	5 (20%)	0.428
Wound infection	2 (9.5%)	2 (8%)	1
Chylous leakage	2 (9.5%)	1 (4%)	0.585
Mortality	1 (4.8%)	0	0.457
Readmission within 30 days	1 (5%)	2 (8%)	1

RRS and LRS groups.

Several studies have reported that robotic surgery operative time was longer than laparoscopic surgery.[8-12] Min et al. studied 278 rectal cancer patients who underwent robotic surgery among 1029 total patients, finding that robotic surgery had a longer operative time than the laparoscopic group (361.6 ± 91.9 vs. 272.4 ± 83.8 mins; $p < 0.001$)[13] similar with our study. In our study, the two groups had the same procedure after distal rectum transection and we determined two factors which accounted for the difference in operative time. First was the robotic instrument docking times, with the main factor being a lack of energy source device with LigaSure™ blunt tip laparoscopic sealer in RRS; this added time to the dissection with Da Vinci Maryland bipolar forceps. The other factor was the different method used for inferior mesenteric artery ligation; RRS used Hem-o-lok was used in RRS and LRS utilized the endoscopic hemoclip or endoscopic linear cutter stapler. The estimated blood loss was similar between two groups, consistent with most previous studies. Interestingly, some studies have actually reported less blood loss in robotic surgery.[14-16]

Our finding of similar clinical and pathological outcomes between RRS and LRS are similar with previous reports.[11-14,17-20] Four patients in the RRS group and two patients in LRS did not have diverting stoma performed according to the surgeon's decision regarding location, tension, and perfusion over the anastomosis site. Those who did not have diverting stoma underwent preoperative CCRT that had a greater risk of anastomosis leakage.[21,22] One patient in RRS encountered major leakage without diverting stoma and received a second operation with diverting stoma. One patient with end stage renal disease occurred mortality within postoperative 30 days in RRS encountered with pneumonia and pulmonary edema, but the family refused advanced respiratory intubation support. There are several meta-analyses reporting that robotic surgery had a lower conversion rate to open surgery compared to laparoscopy.[23-29] Seon et al. reported robotic group had a shorter time to first flatus and better recovery in voiding and sexual function.[25] Binghong et al. reported that the positive rate of CRMs ($p = 0.04$) and incidence of erectile dysfunction ($p = 0.002$) were lower in the robotic group compared with the laparoscopic group.[29] However, cost analysis in several studies showed that robotic surgery was more expensive than laparoscopic surgery.[14,17-19,30]

There were several limitations in our study which warrant discussion. First, this was a retrospective study without randomization and with a small sample size. Second, all surgeries were performed by a single surgeon, which may have led to a selection bias. Third, the oncological outcomes were not analyzed; long-term oncological outcomes need further analysis.

Conclusions

Robotic rectal cancer surgery had longer operative time but no significant difference in postoperative short-term complication or outcomes compared with laparoscopic rectal cancer surgery, offering another safe operative method.

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原　著

對於直腸癌使用機器人手臂輔助與腹腔鏡輔助手術兩者比較：短期經驗分享

林志衛　黃玄遠　張譽耀

彰化基督教醫院　外科部　大腸直腸外科

目的　對於機器人手臂輔助及腹腔鏡輔助手術切除直腸癌，術中與術後預後比較。

方法　自 2016 年 5 月至 2018 年 11 月，共 46 位直腸癌患者接受單一手術醫師進行機器人手臂及腹腔鏡手術的回顧性研究。

結果　共 46 位直腸癌患者納入研究，21 位施行機器人手臂輔助手術，25 位施行腹腔鏡輔助手術。平均手術時間機器人手臂組對比腹腔鏡組較長 (301.4 vs. 206 分鐘，$p < 0.001$)，術中出血量沒有顯著差異 (101.9 vs. 72.8 毫升，$p = 0.334$)。病患基本資料，合併症，術前腫瘤指數，術中淋巴結摘除數量，術後併發症，病理結果，住院天數，術後進食時間及術後 30 天內再住院率及死亡率兩組沒有差異。

結論　機器人手臂輔助直腸癌手術相較腹腔鏡手術的花費的手術時間較長，但對於術中及術後併發症及預後並無顯著差異，因此相較腹腔鏡手術，仍是一個安全的手術方式。

關鍵詞　機器人手臂、腹腔鏡、直腸癌、預後。