Original Article

Robotic-assisted Laparoscopic Rectal Surgery: A Tertiary Center Experience

Yuan-Yao Tsai[1]
Ming-Hao Hsieh[1,2]
Chia-Lun Wu[1]
Sheng-Chi Chang[1]
Hua-Che Chiang[1]
Tao-Wei Ke[1]
William Tzu-Liang Chen[1]
[1]*Division of Colorectal Surgery, Department of Surgery, China Medical University Hospital,*
[2]*Division of Colon & Rectal Surgery, Department of Surgery, Taichung Armed Forces General Hospital, Taiwan*

Key Words
Robotic-assisted;
Laparoscopic rectal surgery;
Rectal cancer, rectal surgery;
Low anterior resection;
Total mesorectal excision

Purpose. The advantages of robotic-assisted surgery are the usage of multi-articulated instruments with superior dexterity and 3-dimensional visualization; it is thought to help overcome the limitations of laparoscopic rectal surgery in the narrow pelvis. This is a single center experience report of robotic-assisted laparoscopic surgery.
Methods. Between February 2012 and July 2013, all the patients who underwent robotic-assisted colorectal surgery were retrospectively evaluated in terms of demographics, surgical data, complications, duration of hospital stay, and histopathological data.
Result. Sixteen consecutive patients, 5 female and 11 male patients, underwent robotic-assisted laparoscopic rectal resection. Low anterior resection was performed in 3 patients. Sphincter-saving total mesorectal excision (TME) was performed in 12 patients and abdominoperineal resection (APR), in 1 patient. Of the 16 patients, 15 had adenocarcinoma, and 1, gastrointestinal stromal tumor. With regard to surgical technique, all the surgeries performed were hybrid robotic-assisted laparoscopic rectal operations. The average duration of surgery was 354 min. The average duration of postoperative hospital was 8.2 days. No operation was converted. One patient experienced port site infection, 2 experienced anastomotic leakage, 3 underwent nasal tube intubation for post-operation ileus, and 2 underwent urinary catheter reinsertion after removal. There was no mortality in our series. The median number of harvested lymph nodes was 15.5, and the distal resection margin was 2.81 cm.
Conclusion. Robotic-assisted rectal surgery was found to be a safe and feasible procedure. However, more evidence is needed regarding whether it is superior to convention laparoscopic colorectal surgery.
[*J Soc Colon Rectal Surgeon (Taiwan) 2015;26:45-50*]

Laparoscopic colorectal surgery (LCS) has many advantages,[1-5] including reduced postoperative pain and intraoperative blood loss, short hospital stay, and low risk of postoperative ileus. Oncologic surgery is possible using this novel technique with at least the same long-term results as that of the traditional open approach.[6,7] Some studies also suggest that LCS is associated with high rates of lymph node retrieval and oncological outcomes similar to those of open surgery.

Although laparoscopic surgery has become the

Received: June 16, 2014. Accepted: September 2, 2014.
Correspondence to: Dr. William Tzu-Liang Chen, Division of Colorectal Surgery, Department of Surgery, China Medical University Hospital, No. 2, Yu-Der Road, Taichung 404, Taiwan. Tel: +886-4-2205-2121 ext. 1638; Fax: +886-4-2202-9083; E-mail: golfoma22@gmail.com

mainstay in treatment of benign and malignant colorectal diseases, it does have some limitations, e.g., camera imaging, which is highly dependent on the assistant's experience, two-dimensional view, poor ergonomics, limited motion of instruments, and low chance of precision suturing. These drawbacks are more evident during rectal dissection of the pelvis. Fogging of the camera caused by fumes from energy sources in the confined spaces may also slow the procedure.[8]

Robotic surgery was developed in the early 1990s and the first robotic-assisted colorectal procedure was performed in July 2001 by Weber et al.[9] Robotic surgery provides tri-dimensional imaging under the surgeon's direct control and gives instruments 7 degrees of freedom and dexterity. These benefits may help surgeons enhance precision, control, and suturing and even eliminate hand tremors during surgery. Robotic-assisted colorectal surgery has been reported to be equivalent to laparoscopic surgery with regard to return of bowel function,[10,11] length of hospital stay,[10-12] postoperative quality of life,[13] and oncologic outcomes.[14,15] Several reports even highlight the possible advantages, especially for rectal surgery deep in the pelvis.[16,17] Here, we present a series of 16 cases of robotic-assisted colon and rectal resections.

Materials and Methods

Between February 2012 and July 2013, the patients who underwent robotic rectal surgery were retrospectively evaluated in terms of demographics, surgical data, complications, duration of hospital stay, and histopathological data. During left-side colonic and rectal surgery, we used conventional laparoscopy for mobilizing the left colon and splenic flexure as well as dividing the inferior mesenteric vessels; then, we used the robotic approach for the total mesorectal excision (TME) part of the surgery. Cefmetazole was the prophylaxis antibiotic administered to all the patients. All the patients were subjected to a "fast track recovery" protocol for improving surgical outcome and reduction of length of hospital stay. The details of the "fast track recovery" protocol are listed in Table 1.

Results

In all 16 patients, 5 females and 11 males, underwent robotic-assisted colorectal surgery from February 2012 to July 2013 (Table 2). The mean age was 59.2 years (range: 45 to 81 years). The ASA class distribution was as follows: 1 patient, ASA 1, 10 patients, ASA 2, and 5 patients, ASA 3. The mean body mass

Table 1. The details of the "fast track recovery" protocol

Preoperative stage
Patient education
Oral bowel preparation
No oral intake 8 hours before operation
Prophylactic antibiotics
Perioperative stage
Robotic surgery
Postoperative stage
No nasogastric tube placement
Analgesics use
Sipping water after surgery
Mobilization on POD 1
Begin oral food intake on POD 1
Removal of Foley catheter on POD 1
Removal of drain on POD 4
Discharge on POD 6

POD, Postoperative day.

Table 2. Clinical characteristics of patients, n = 16 (%)

Sex	
Male	11 (68.75)
Female	5 (31.25)
Age[a] (years)	59.25 (45-81)
BMI[a] (kg/m^2)	25.41 (22.5-31.6)
BMI ≥ 30 kg/m^2	2 (12.5)
ASA	
I-II	11 (68.75)
III	5 (31.25)
Co-morbidities	
Hypertension	9 (56.25)
Diabetes	3 (18.75)
Malignant disease	16
Upper rectum	2 (12.5)
Mid rectum	1 (6.25)
Low rectum	13 (81.25)
Neoadjuvant chemoradiotherapy	8 (50)
History of abdominal surgery	0

BMI, body mass index.
ASA, American Society of Anesthesiologists.
[a] Mean (range) value expressed.

index was 25.41 kg/m^2 (range: 22.5 to 31.6 kg/m^2). Three patients had diabetes mellitus and 9 patients, hypertension. We performed 12 TMEs, 3 low anterior resections (LAR), and 1 abdominoperineal resection (APR) (Table 3). The mean surgery duration was 354 min (range: 211 to 495 min). There was no conversion to laparotomy or any other intraoperative complication. With regard to postoperative complications, 4 patients had ileus or small bowel obstruction, 1 patient, port-site infection, and 2 patients, anastomotic leakages. No patient was admitted to the intensive care unit during hospital stay. The average duration of postoperative hospital stay was 8.2 days (range: 4 to 26 d) (Table 4).

Currently, 15 patients have adenocarcinoma, and 1 has low-third rectal gastrointestinal stromal tumor. In the adenocarcinoma group, 3 patients have stage 0, 3 patients, stage I, 1 patient, stage II, and 8 patients have stage III adenocarcinoma (4 have stage IIIA, 3, stage IIIB, and 1, stage IIIC adenocarcinoma). The mean number of lymph node retrievals in the adenocarcinoma group was 16.2 (range: 8 to 25). The mean length of distal resection margins was 2.81 cm (range: 1 to 5 cm) and histopathological evaluation revealed that the mesorectum resection was complete in patients who underwent TME.

Discussion

Robotic-assisted surgery may address the limitations of conventional laparoscopic surgery[18] while preserving all the advantages of the minimally invasive approach.[10] Three-dimensional visuals controlled by the operating surgeon could lead to improved pelvic dissection and preservation of the autonomic nerves during the TME. However, there are many limitations to the current robotic systems: it requires precise positioning for achieving optimal surgery space and avoiding arm collision, docking and repositioning of the robotic arm, and long surgery duration; in addition, many of the instruments (staplers and energy devices) used during laparoscopic surgery are currently not available with the robotic system.[19] In our series, 354 min, on average, were taken to perform this particular procedure, as compared with the time taken for conventional laparoscopic surgery;[20] therefore, robotic-assisted surgery is indeed a time-consuming procedure. In rectal cancer surgery, the operation field often involves 2 quadrants, and the splenic flexure needs to be mobilized to achieve an adequate length for anastomosis. Repeated docking and repositioning of a robotic cart may lengthen the porcedure.[21] Moreover, the time taken for undocking the robot could lead to a difficult situation when immediate conversion is needed.[21] However, with increased experience, the docking time may reduce.[10,22]

Lack of both tactile sensation and tensile feedback

Table 3. Types of operation, total 16 operations

LAR	3
TME	12
APR	1

LAR, Low anterior resection.
TME, Total mesorectal excision.
APR, Abdominoperineal resection.

Table 4. Outcomes of robotic-assisted laparoscopic rectal surgery, n = 16 (%)

Diverting stoma formation[a]	13 (86.6)
Conversion	0
EBL[b] (mL)	108 (20-400)
Operation time[b] (min)	354 (211-495)
AJCC stage [(y)pTMN]	
0	3 (18.75)
I	4 (25)
II	1 (6.25)
III	8 (50)
DRM[b] (cm)	2.81 (1-5)
Negative status of CRM	16 (100)
No. of harvested lymph nodes[b]	15.5 (4-25)
Postoperative hospital stay[b] (d)	8.2 (4-26)
Complications	
Ileus	4 (25)
Anastomotic leakage[a]	2 (13.3)
Urinary retention	1 (6.25)
Wound infection	1 (6.25)
Mortality	0

EBL, estimated blood loss; AJCC, American Joint Committee on Cancer TNM classification; DRM, distal resection margin; CRM, circumferential resection margin.
[a] Out of 15 patients with anastomosis.
[b] Mean values (range) expressed.

to the operating surgeon is another major drawback of the current robotic system.[19,21] Tissue damage can occur if excessive traction were applied by the robotic arms and during movement of the robotic instruments. This can explain why postoperative bleeding complications are higher among patients who undergo robotic-assisted colonic resections.[23] Bleeding complications are also high during robotic suturing,[21] as the thread can accidentally cut through tissues because no tensile feedback is received from the robotic instruments.

The intraoperative cost of LCS is higher than that of open colorectal surgery (OCS), but the overall cost of LCS is found to be comparable to that of OCS owing to reduction in the cost of postoperative care, leading to shorter postoperative hospital stay.[24] Therefore, the high capital and running costs of the currently available robotic system have limited its adoption in many hospitals. Regarding cost-effectiveness of the surgery, the capital cost of the robotic system and disposable instruments is a major issue.[21] Although a decrease in the capital and running costs of the robotic system is anticipated in the future, the overall cost of robotic colorectal surgery will still remain higher than that of O/LCS.[25]

There was no conversion to laparotomy in the rectal cancer group. The reported conversion rate ranged from 1% to 7.3% in the robotic group,[25] and it was 17% in laparoscopic group.[2,26]

Large prospective randomized controlled trials comparing robotic to laparoscopic resection for rectal cancer are still lacking, so the potential benefits of robotic-assisted colorectal surgery over laparoscopic surgery have yet to be shown. A recent systemic review failed to show clear, significant reduction in early postoperative complications when compared with standard laparoscopic surgery, with only potentially better short-term outcomes when applied in selected patients such as obese patients, male patients, and patients who have undergone preoperative radiotherapy, and those with tumors in the lower two-thirds of the rectum.[25]

In our report, 2 patients experienced anastomotic leakage, and 1 of these 2 male patients received neoadjuvant chemoradiotherapy. Anastomotic leakage is one of the most dreadful complications after rectal cancer surgery. Increased leakage rates were reported in lower rectal cancer and obese patients, especially if they had received neoadjuvant chemoradiotherapy prior to the surgery.[19,27-29] Overall, the reported median rate of anastomotic leakage was 7.6% for robotic procedures and that for standard laparoscopy procedures was 7.3%. There was no reported increase in anastomotic leakage in the robotic group even though a higher number of patients in this group received preoperative chemoradiotherapy.[25]

In the rectal cancer group, the mean number of lymph nodes harvested was 15.5 (range: 4 to 25), while that in the adenocarcinoma group was 16.2 lymph nodes (range: 8 to 25). In several studies, the number of lymph nodes harvested, ranged from 10.3 to 20 in the robotic group, with no significant difference compared to number of lymph nodes harvested in the laparoscopic group.[25]

The main limitation of our study lies in its retrospective nature and its small sample size. Autonomic nerve preservation, urinary retention, and fecal incontinence were not observed in our series.

Conclusion

Robotic-assisted colorectal surgery has been proven to be a safe modality with acceptable morbidity and mortality rates. However, robotic-assisted laparoscopic rectal surgery is not a well-established technique nowadays and more evidence is needed to determine whether it is preferable over convention LCS.

References

1. Lacy AM, García-Valdecasas JC, Delgado S, Castells A, Taurá P, Piqué JM, et al. Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomised trial. *Lancet* 2002;359:2224-9.
2. Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AMH, et al. Short-term endpoints of conventional versus laparoscopicassisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. *Lancet* 2005;365:1718-26.

3. Veldkamp R, Kuhry E, Hop WCJ, Jeekel J, Kazemier G, Bonjer HJ, et al. Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. *Lancet Oncol* 2005;6:477-84.
4. Abraham NS, Young JM, Solomon MJ. Meta-analysis of short-term outcomes after laparoscopic resection for colorectal cancer. *Br J Surg* 2004;91:1111-24.
5. Aly EH. Laparoscopic colorectal surgery: summary of the current evidence. *Ann R Coll Surg Engl* 2009;91:541-4.
6. Weeks JC, Nelson H, Gelber S, Sargent D, Schroeder G. Clinical Outcomes of Surgical Therapy (COST) Study Group. Short-term quality-of-life outcomes following laparoscopic-assisted colectomy vs open colectomy for colon cancer: a randomized trial. *JAMA* 2002;287:321-8.
7. The Clinical Outcomes of Surgical Therapy Study Group. A comparison of laparoscopically assisted and open colectomy for colon cancer. *N Engl J Med* 2004;350:2050-9.
8. Lee SW. Laparoscopic procedures for colon and rectal cancer surgery. *Clin Colon Rectal Surg* 2009;22:218-24.
9. Weber PA, Merola S, Wasielewski A, et al. Teleroboticassisted laparoscopic right and sigmoid colectomies for benign disease. *Dis Colon Rectum* 2002;45:1689-1694. discussion 1695-6.
10. Spinoglio G, Summa M, Priora F, et al. Robotic colorectal surgery: first 50 cases experience. *Dis Colon Rectum* 2008; 51:1627-32.
11. Baik SH, Kwon HY, Kim JS, et al. Robotic versus laparoscopic low anterior resection of rectal cancer: short-term outcome of a prospective comparative study. *Ann Surg Oncol* 2009;16:1480-7.
12. D'Annibale A, Morpurgo E, Fiscon V, et al. Robotic and laparoscopic surgery for treatment of colorectal diseases. *Dis Colon Rectum* 2004;47:2162-8.
13. Bertani E, Chiappa A, Biffi R, et al. Assessing appropriateness for elective colorectal cancer surgery: clinical, oncological and quality-of-life short-term outcomes employing different treatment approaches. *Int J Colorectal Dis* 2011;26:1317-27.
14. Park JS, Choi GS, Lim KH, et al. S052: a comparison of robot-assisted, laparoscopic and open surgery in the treatment of rectal cancer. *Surg Endosc* 2011;25:240-8.
15. Pigazzi A, Luca F, Patriti A, et al. Multicentric study on robotic tumor-specific mesorectal excision for the treatment of rectal cancer. *Ann Surg Oncol* 2010;17:1614-20.
16. Park IJ, You YN, Schlette E, et al. Reverse-hybrid robotic mesorectal excision for rectal cancer. *Dis Colon Rectum* 2012;55:228-33.
17. deSouza AL, Prasad LM, Marecik SJ, et al. Total mesorectal excision for rectal cancer: the potential advantage of robotic assistance. *Dis Colon Rectum* 2010;53:1611-7.
18. Ballantyne GH. The pitfalls of laparoscopic surgery: challenges for robotics and telerobotic surgery. *Surg Laparosc Endosc Percutan Tech* 2002;12:1-5.
19. Hellan M, Anderson C, Ellenhorn JDI, Paz B, Pigazzi A. Short-term outcomes after robotic-assisted total mesorectal excision for rectal cancer. *Ann Surg Oncol* 2007;14:3168-73.
20. Fung AK-Y, Aly EH. Robotic colonic surgery: is it advisable to commence a new learning curve? *Dis Colon Rectum* 2013; 56:786-96.
21. Baik SH. Robotic colorectal surgery. *Yonsei Med J* 2008;49: 891-6.
22. Ayav A, Bresler L, Brunaud L, et al. Early results of one year robotic surgery using the Da Vinci system to perform advanced laparoscopic procedures. *J Gastrointest Surg* 2004;8: 720-6.
23. Halabi WJ, Kang CY, Jafari MD, Nguyen VQ, Carmichael JC, Mills S, Stamos MJ, Pigazzi A. *World J Surg*. 2013;37: 2782-90.
24. Aly OE, Quayyum Z. Has laparoscopic colorectal surgery become more cost-effective over time? *Int J Colorectal Dis* 2012;27:855-60.
25. Scarpinata R, Aly EH. Does robotic rectal cancer surgery offer improved early postoperative outcomes? *Dis Colon Rectum* 2013;56:253-62.
26. Van der Pas MH, Haglind E, Cuesta MA, Fürst A, Lacy AM, Hop WC, et al. Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. *Lancet Oncol*. 2013.
27. Leong QM, Son DN, Cho JS, Baek SJ, Kwak JM, Amar AH, et al. Robot-assisted intersphincteric resection for low rectal cancer: technique and short-term outcome for 29 consecutive patients. *Surg Endosc* 2011;25:2987-92.
28. Leong QM, Kim SH. Robot-assisted rectal surgery for malignancy: a review of current literature. *Ann Acad Med Singapore* 2011;40:460-6.
29. Kwak JM, Kim SH, Kim J, Son DN, Baek SJ, Cho JS. (2011) Robotic vs laparoscopic resection of rectal cancer: short-term outcomes of a case–control study. *Dis Colon Rectum* 2011; 54:151-6.

原　著

機械手臂輔助腹腔鏡直腸切除的經驗報告

蔡元耀[1]　謝明浩[1,2]　吳嘉倫[1]　張伸吉[1]　江驊哲[1]　柯道維[1]　陳自諒[1]

[1]中國醫學大學附設醫院　外科部　大腸直腸外科

[2]國軍台中總醫院　外科部　大腸直腸外科

目的　機械手臂的好處在於多關節的器械及較立體視覺，在處理狹窄骨盆腔的直腸手術中被認為是可以克服某些腹腔鏡手術本身的限制。這是一篇來自於醫學中心的機械手臂輔助腹腔鏡直腸切除手術的經驗報告。

方法　從 2012 年 2 月至 2013 年 7 月，在單一醫院所有接受機械手臂輔助腹腔鏡直腸切除手術的病患，回溯性分析病患基本資料，手術中資料，術後併發症，住院天數及病理組織學報告。

結果　全部共 16 位病患，接受機械手臂輔助腹腔鏡直腸切除手術，其中 11 位男性、5 位女性。3 位接受低前位切除手術，12 位接受肛門保留全直腸繫膜切除手術，1 位接受經腹會陰直腸切除手術。15 位病患診斷為直腸線癌，1 位病患診斷為低位直腸腸胃道基質瘤。平均手術時間為 354 分鐘，術後平均住院天數為 8.2 天。全部病患皆未在術中轉換成傳統剖腹方式手術。1 位病患術後發生腹腔鏡套管穿刺孔傷口感染，2 位病患發生了腸吻合處滲漏，3 位病患臨床上出現術後腸麻痺並接受了鼻胃管置放來減壓，另有 2 位病患在尿管移除後因為尿滯留而再次接受了留置導尿。無患者因手術死亡。病理組織學部分，平均取下的淋巴結數目為 15.5 顆，遠端距離腫瘤平均為 2.81 公分。

結論　機械手臂輔助腹腔鏡直腸切除是安全及可行的方式。然需要更多的研究才能知道其是否優於傳統腹腔鏡直腸切除手術。

關鍵詞　機械手臂、腹腔鏡直腸切除、直腸惡性腫瘤、低前位切除手術、全直腸繫膜切除手術。