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Robotic-assisted total mesorectal excision in low-lying rectal cancer

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Abstract

Aim: To evaluate the feasibility, safety, and short-term oncological outcomes of robotic-assisted total mesorectal excision (TME) in patients with low-lying rectal cancer (≤ 5 cm from anal verge).

Methods: We enrolled 60 patients with stages I-III low-lying rectal cancer who underwent robotic-assisted TME at a single institution between July 2013 and April 2017.

Results: Of the 60 patients enrolled, 49 (81.6%) underwent preoperative concurrent chemoradiotherapy. Furthermore, among these 49 patients, 18 (36.7%) achieved a pathologic complete response. R0 resection was performed in 57

(95%) patients. Circumferential and distal resection margins were positive in 3 (5%) and 1 (1.6%) patients, respectively. The sphincter preservation rate was 93.3% (56/60). The overall complication rate was 21.7% (13/60), with an anastomotic leakage rate of 3.3% (2/60); most of these instances were mild and the patient recovered uneventfully.

Conclusion: The results demonstrate that robotic-assisted TME is safe and feasible for patients with low-lying rectal cancer.

Keywords: Robotic-assisted total mesorectal excision, low-lying rectal cancer, R0 resection, circumferential resection margin

INTRODUCTION

In 2014, approximately 15,000 new cases of colorectal cancer were diagnosed in Taiwan, and in approximately 5,600 of cases, the patient died. Total mesolectal excision (TME) surgery, reported by Heald *et al.*[1] in 1982, has resulted in decreased 5-year local and overall recurrence rates. MacFarlane *et al.*[2] reported the importance of identifying the "holy plane", that is, the surgeon's dissection that will encompass the malignancy and yet preserve autonomic neural function. Radiation therapy offers noteworthy benefits to many patients with rectal cancer; preoperative radiation is superior to postoperative radiation. Preoperative radiation combined with chemotherapy (chemoradiotherapy) is used for locally advanced rectal cancer. A German study suggested that compared with postoperative chemoradiotherapy, preoperative chemoradiotherapy improved local control and was associated with reduced toxicity, but did not improve overall survival[3,4]. We achieved similar results from other studies[5-7].

Laparoscopic rectal surgery was as safe as open surgery and resulted in improved recovery rates[8,9]. However, the robotic system has several advantages over laparoscopic surgery, such as a high-definition three-dimensional vision, smooth movement of instruments, and absence of surgeon tremor. Thus, this robotic system can be anticipated to assist with dissections in the narrow pelvic cavity. Since the first robotic colon surgery in 2002[10], it is believed to have the potential to improve compliance with minimal invasive surgery. For rectal cancers, robotic surgery has been demonstrated to be as safe and feasible as laparoscopic and open surgical procedures[11-14].

The unique anatomy of the rectum, with its retroperitoneal location in the narrow pelvis, makes surgical access relatively difficult. The visceral endopelvic fascia, also known as fascia propria, is identified by a loose areolar tissue that circumferentially separates the rectum and mesorectum from surrounding pelvic structures. Removal of the rectum with the mesoretum intact ensures the complete removal of all lymph nodes and lymphatics from the diseased rectum and thus prevents oncologic contamination of the pelvis during surgery. In this study, we present the short-term oncological outcomes of patients with low-lying rectal cancer who underwent complete robotic-assisted TME.

METHODS

Patients

The data included 60 patients with low-lying rectal cancer (adenocarcinoma) stages I-III who underwent complete robotic-assisted TME with the da Vinci® surgical system at a single institution between July 2013 and April 2017. The study was approved by the institutional review board of our hospital. Informed consent was obtained from each patient before performing the robotic surgery. All patients underwent routine preoperative colonoscopy and abdominal and pelvic computed tomography (CT) or magnetic resonance imaging for preoperative staging. Low-lying rectal cancer was defined as a tumor located at or less than 5 cm from the anal verge. Patients with T3, T4, or N+ rectal cancer received preoperative concurrent chemoradiotherapy (CCRT). Furthermore, a 5-fluorouracil, leucovorin, and oxaliplatin (FOLFOX) regimen

or a fluoropyrimidine-based regimen was prescribed. Long-course radiotherapy (total of 5000 cGy in 25 fractions) was concurrently administered. The median time interval between radiotherapy completion and robotic surgery was 91 (range, 47-363) days.

We thoroughly evaluated the surgical outcomes, including the operation time (with operation, console, and docking times), blood loss, complication rates, and pathologic clearance, including the positive circumferential resection margin (CRM) and distal resection margin (DRM) rates. Docking time was defined as the time taken to position the robot and mount the robotic arms. Postoperative follow-up studies included physical examination and serum CEA assay every 3 months for the first 2 years and thereafter every 6 months. Chest radiograph was taken every 6 months and abdominopelvic CT was taken annually in the following years. Colonoscopy was performed annually.

Surgical procedure

The single-docking technique with five or six ports was used as the docking method[15]. The da Vinci® Si Surgical System was docked over the left flank of the patient. The second arm was engaged at the right upper trocar, and the first and third arms worked at the left medial and lateral trocars, respectively [Figure 1A and B]. An assistant on the right side of the patient used one or two ports for suctioning and additional retraction. High dissection and low ligation of the inferior mesenteric vessel and mobilization of the left colon was done but splenic flexure was not taken down regularly[16]. The inferior mesenteric vein was also identified but was not ligated immediately. The intraoperative view of robotic-assisted total mesorectal excision compared with laparoscopic total mesorectal excision showed more clear obviously [Figure 1C and D]. Complete robotic-assisted TME with single-docking technique was performed in all patients.

After complete mobilization of the sigmoid or descending colon, mesocolon, and entire rectum after TME, low anterior resection (LAR) with the double-staple technique, intersphincteric resection (ISR) with coloanal anastomosis [Figure 1E and F] and loop colostomy, or abdominoperineal resection was accordingly performed[16]. For the ISR of the perineal part, we used the Lone Star Retractor System® to assist operation. The specimen was then extracted and resected transanally (natural orifice specimen extraction, Figure 1G). Coloanal anastomosis was performed using the hand-sewn method. A loop colostomy of the transverse colon was created. A drain tube was placed into the pelvic cavity through laparoscopic assistance.

Statistical analysis

All data were statistically analyzed using SPSS Version 19.0 (SPSS Inc., Chicago, IL, USA). All patients were followed up until their death, last follow-up, or 30 April 2017. The operation time was defined as the time between the initial skin incision and wound closure completion. A P value of < 0.05 denoted statistical significance. Overall survival was defined as the time from surgery to death or to the last date the patient was known to be alive. Disease-free survival was defined as the time from surgery to recurrence of cancer or to the last date the patient was known to be disease free. Overall survival and disease-free survival were obtained using the Kaplan-Meier method.

RESULTS

Patients' characteristics and perioperative outcomes

Of the enrolled patients, 36 were men and 24 were women. The median age was 62 years (range, 24-92). Forty-nine (81.7%) patients had neoadjuvant chemoradiotherapy. The details of patient characteristics are presented in Table 1.

The most frequent surgical procedure performed was ISR (37/60, 61.7%). ISR with coloanal anastomosis was performed in 37 patients, and abdominoperineal resection was performed in 4 patients. Protective di-

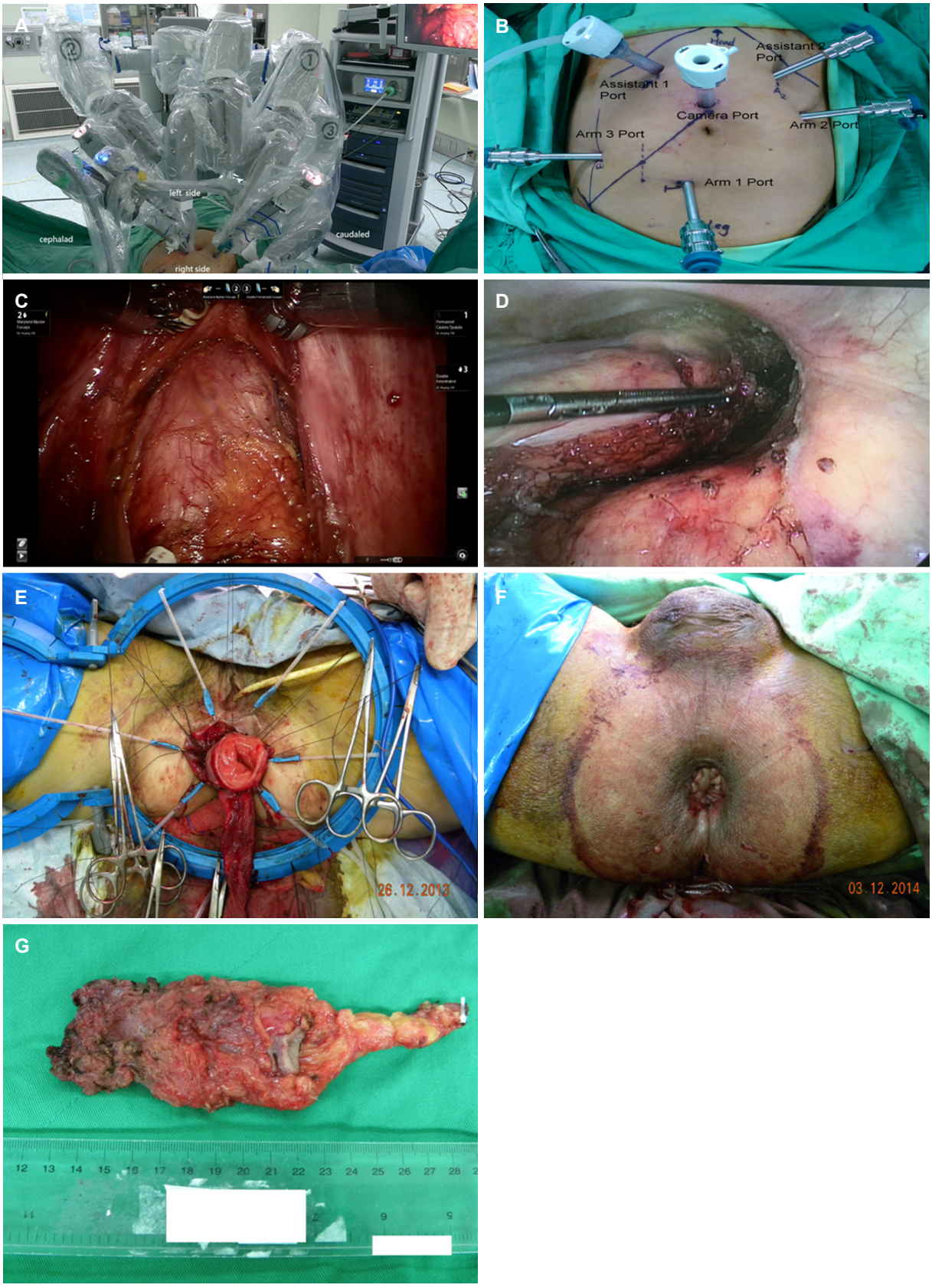

Figure 1. A: Da Vinci docked from patient's left side; B: port positions during single docking; C: intraoperative view of the distal rectum, Da Vinci view; D: intraoperative view of the distal rectum, laparoscopic view; E: intersphincteric resection with long-star retractor; F: coloanal anastomosis done; G: total mesorectal excision specimen

Table 1. Baseline characteristics and perioperative outcomes of 60 patients with low-lying rectal cancer who underwent robotic-assisted total mesorectal excision

Characteristics	Value/number
Age (years, median) (range)	62 (32-87)
Gender	
Female	24 (40%)
Male	36 (60%)
Distance from anal verge (cm, median) (range)	3.5 (1-5)
Pre-operation CCRT	
Yes	49 (81.7%)
No	11 (18.3%)
Pre-operation chemotherapy regimen	49
FOLFOX	36 (73.5%)
Fluoropyrimidine-based	13 (26.5%)
Time interval between radiotherapy completion and robotic surgery (day, median) (range) (49 patients undergoing pre-operation chemotherapy)	91 (47-363)
ASA classification	
II	36 (60%)
III	24 (40%)
BMI kg/m^2 (median) (range)	23.07 (17.50-30.9)
Procedure	
LAR	19 (31.7%)
ISR	37 (61.7%)
APR	4 (6.6%)
Protective diverting colostomy	
Yes	45 (75%)
No	15 (25%)
Docking time (min, median) (range)	5 (3-10)
Console time (min, median) (range)	215 (150-527)
Operation time (min, median) (range)	320 (240-710)
Estimated blood loss (mL, median)	95 (15-450)
Time of first flatus passage (day) (median, range)	2 (1-10)
Time of resuming soft diet (day) (median, range)	4 (2-13)
Postoperative hospital stay (day) (median, range)	6 (5-30)
Postoperative first day VAS pain score (median, range)	3 (1-7)

CCRT: concurrent chemoradiotherapy; ASA: American Society of Anesthesiologists; BMI: body mass index; LAR: low anterior resection; ISR: intersphincteric resection; APR: abdominoperineal resection; VAS: visual analog scale

verting loop transverse colostomy was performed in 45 patients, including 37 patients and 8 patients who underwent ISR and LAR, respectively. The median operating time was 320 min (range, 240-710), with a median blood loss of 95 mL (range, 15-450). Median length of stay was 6 days (range 5-30). No mortality was observed within 30 days following the procedure. Furthermore, no intraoperative complications or conversion to open surgery were noted.

Postoperative complications

Table 2 presents postoperative complications. Three patients required reoperation within 30 days following the procedure, two for anastomotic leak, and one for postoperative bleeding. Transverse loop colostomy was performed for anastomotic leak, and we monitored postoperative bleeding through laparotomy. Other complications included prolonged ileus (n = 3), urethral injury (n = 1), and coloanal anastomosis stenosis (n = 2). We used colonfiberoscope dilation for the two patients with coloanal anastomosis stenosis. The others morbidities recovered uneventfully after conservative treatment.

Pathological and oncological outcomes

The pathological characteristics and oncological outcomes of all 60 patients are listed in Table 3. Preoperative clinical staging demonstrated that the majority of the patients had locally advanced rectal cancer: T3,

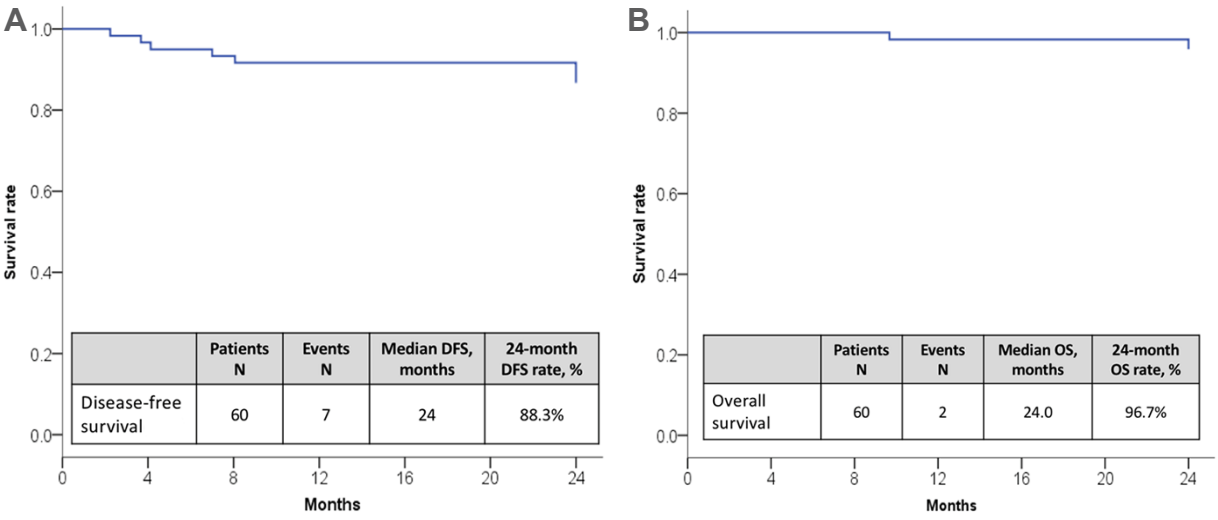

Figure 2. Kaplan-Meier survival curves. A: Disease-free survival; B: overall survival

Table 2. Postoperative complications in 60 patients with low-lying rectal cancer who underwent robotic-assisted total mesorectal excision

Complications	Number (%)	Management
Post-operative bleeding	1 (1.7%)	Laparotomy
Intra-abdominal infection/abscess	2 (3.3%)	1: conservative treatment 1: CT-guided pig-tail drainage
Coloanal anastomosis stenosis	2 (3.3%)	Colonoscopic dilation
Ileus	3 (5%)	Conservative treatment
Anastomosis leakage	2 (3.3%)	Loop transverse colostomy
Urethral injury	1 (1.7%)	Conservative treatment
Pulmonary complication	2 (3.3%)	Conservative treatment
Total	13 (21.7%)	

T4, and N+ in 42 (70%), 8 (13.3%), and 36 (55.8%) patients, respectively. Therefore, preoperative CCRT was performed in 49 patients - the FOLFOX regimen in 36 (73.5%) patients and fluoropyrimidine-based regimen in 13 (26.5%) patients. The median numbers of harvested lymph nodes and apical lymph nodes were 8 (range, 0-36) and 1 (range, 0-6), respectively. However, positive apical lymph node metastasis was observed in only three (5%) patients. The median distances of the DRM and CRM were 1.9 and 1.1 cm, respectively. CRM and DRM were positive in three patients (5%) and one (1.7%) patient, respectively. R0 resection for primary rectal cancer was performed in 57 (95%) patients. Of the 49 patients who received preoperative CCRT, pathologic complete response (pCR) of the primary tumor was observed in 18 patients (18/49 = 36.7%). In total, 19 (38.8%), 17 (34.7%), 10 (20.4%), and 3 (6.1%) patients exhibited complete response [tumor regression grade (TRG) 0], moderate response (TRG 1), minimal response (TRG 2), and poor response (TRG 3), respectively.

During the postoperative follow-up period, 7 patients (11.7%) exhibited cancer recurrence. The median follow-up duration was 28 months (range, 12-53 months). Distant metastasis was observed in 5 patients (1 in the lung, 2 in the liver, 1 in both the lung and liver, and 1 with peritoneal seeding), whereas local recurrence was observed in 2 patients. The overall survival rate at 2 years was 96.7%, whereas the disease-free survival rate at 2 years was 88.3% [Figure 2].

DISCUSSION

Minimal invasive surgery has become the gold standard for colorectal cancer; however, laparoscopy has some limitations. Therefore, a robotic approach to rectal cancer surgery seems appealing. Studies have

Table 3. Clinicopathologic characteristics and oncological outcomes of 60 patients with low-lying rectal cancer who underwent robotic-assisted total mesorectal excision

Preoperative clinical staging	Value/number
Tumor depth	
T1	3 (5%)
T2	7 (11.7%)
T3	42 (70%)
T4	8 (13.3%)
Lymph node metastasis	
N0	24 (40%)
N1	24 (40%)
N2	12 (20%)
AJCC stage (clinical)	
I	7 (11.7%)
II	17 (28.3%)
III	36 (60%)
Postoperative pathological outcomes	
Histology	
Well differentiation	12 (20%)
Moderate differentiation	45 (75%)
Poor differentiation	3 (5%)
Tumor size	
< 5 cm	56 (93.3%)
≥ 5 cm	4 (6.7%)
Tumor size (cm, mean ± SD) (range)	2.11 ± 1.62 (0-8)
Tumor depth	
T0	20 (33.3%)
Tis	1 (1.7%)
T1	9 (15%)
T2	13 (21.7%)
T3	16 (26.7%)
T4	1 (1.7%)
Lymph node metastasis	
N0	46 (76.7%)
N1	12 (20%)
N2	2 (3.3%)
AJCC stage (pathologic)	
0	18 (30%)
I	18 (30%)
II	10 (16.7%)
III	14 (23.3%)
Tumor regression grade (49 patients with preoperative CCRT)	
0	19 (38.8%)
1	17 (34.7%)
2	10 (20.4%)
3	3 (6.1%)
Harvested lymph node (median) (range)	8 (0-36)
Harvested apical node (median) (range)	1 (0-6)
Distance of distal resection margin (cm, median) (range)	1.9 (1.0-4.0)
Distance of circumferential resection margin (cm, median) (range)	1.1 (0.1-3.5)
Distal resection margin	
Free	59 (98.3%)
Positive	1 (1.7%)
Circumferential resection margin	
Free	57 (95%)
Positive	3 (5%)
Resection degree of primary tumor	
R0	57 (95%)
R1	3 (5%)
Oncological outcomes	
Follow-up periods (months, median) (range)	28 (12-53)

R0 resection	57
Locoregional recurrence	2 (3.5%)
Distant metastasis	5 (8.8%)
Lung	1 (1.75%)
Liver	2 (3.5%)
Liver + Lung	1 (1.75%)
Peritoneal carcinomatosis	1 (1.75%)
R1 resection	3
Local recurrence	1 (33.3%)
Lung	1 (33.3%)
Peritoneum	1 (33.3%)

AJCC: American Joint Commission on Cancer; CCRT: concurrent chemoradiotherapy

shown that the robotic approach to colorectal surgery is safe and feasible[16]. Most crucially, favorable short-term clinical and oncological outcomes can be achieved by combining complete robotic-assisted TME with appropriate preoperative CCRT. At least 12 lymph nodes should be examined for each surgical specimen of colorectal cancer, as recommended in the American Joint Commission on Cancer/Union for International Cancer Control guidelines. However, this recommendation was mainly based on studies of colon cancers. Chou *et al.*[17] reported that patients with rectal cancers and older patients who had distally located, early colon cancer were less likely to meet the recommended lymph node yield of 12. Besides, Persiani *et al.*[18] showed that a low lymph node count after neoadjuvant chemoradiotherapy for rectal cancer does not signify inadequate resection or understaging but represents increased sensitivity to the treatment. Additionally, preoperative chemotherapy significantly reduces the number of lymph nodes that can be harvested, with the mean number of detected nodes ranging between 4 and 14 per specimen. In this study, the median number of harvested lymph nodes was 8 (range, 0-36), which is consistent with the literature[18].

The results of this study were consistent with those of a meta-analysis conducted by Scarpinata and Aly[19]. The selection criteria for robotic surgery in this meta-analysis were obesity, male sex, preoperative radiotherapy, and tumors in the lower two-thirds of the rectum. The pCR rate after CCRT observed in our study was 36.7%, which is slightly higher than in previous studies[20,21]. The introduction of oxaliplatin-based chemotherapy and a longer interval may be the major reasons for the higher pCR rate as in our previous study[22]. The sphincter preservation rate achieved in our study was 93.3% (56/60), which is comparable with that reported by Kim *et al.*[23] and Saklani *et al.*[24].

Two pathological assessments appear to be crucial in judging the standard of surgery: CRM involvement and the gross appearance of the surgically resected specimen. Moreover, CRM involvement has been reported as a prognostic factor for local recurrence and survival[25-28]. In this study, the rate of CRM involvement was 5%, with a median distance of 1.1 cm, which is comparable with that reported in other studies (0%-16.1%) [Table 4]. Moreover, the rate of DRM involvement was 1.7%, with a median distance of 1.9 cm, which is also comparable with that reported in previous studies [Table 4]. R0 resection for primary rectal cancer was performed in 57 (95%) patients, 2 of whom developed local recurrence and 5 of whom developed distant metastasis. We attempted to perform R0 resection in all patients, but R1 resection was performed in three patients. One such patient was a 59-year-old woman at clinical stage cT4bN2bM0 with uterus invasion. Neoadjuvant chemotherapy was performed first, followed by robotic ISR 55 days later. The pathology report showed positive CRM, but the DRM was free. During follow up period, she died of intraabdominal infection 2 years and 10 months after operation. The second patient was a 61-year-old man at clinical stage cT4aN2bM0 with visceral peritoneum invasion. Neoadjuvant chemotherapy was performed first, followed by robotic ISR 85 days later. The pathology report showed positive CRM, but DRM was free. During follow up period, he died of pneumonia 9 months after operation. The third patient was a 53-year-old woman at clinical stage cT4bN2bM0 with posterior vaginal wall invasion. Neoadjuvant chemotherapy

Table 4. Comparison of clinical and perioperative outcomes of robotic-assisted total mesorectal excision

Study	Country (year)	Sample size	Lower rectum (%)	Preoperative CCRT (%)	Conversion Rate (%)	Estimated blood loss (mL)	Overall complications (%)	Anastomotic leakage (%)	Rate of sphincter preservation (%)	DRM (cm)	Positive CRM (%)
Present study	Taiwan (2018)	60 (yp Stage 0-III)	100	81.7	0	95	21.7	3.3	93.3	1.9 (1-4)	5
Baek *et al.*[11]	Korea (2011)	41 (yp Stage 0-III)	36.6*	80.5	7.3	200 (20-2000)	22.0	7.3	85.4	3.6 (0.4-10)	2.4
Park *et al.*[12]	Korea (2011)	52 (yp Stage 0-III)	60.4#	23.1	0	NA	19.2	9.6	100	2.8	1.9
Hellan *et al.*[14]	USA (2015)	425 (yp Stage I-IV)	31.3	51.3	5.9	119 ± 164	40.2	8.7	NA	3.0 ± 2.0	0.9
Kim *et al.*[23]	Korea (2016)	33 (yp Stage 0-III)	NA	100	6.1	232.0 ± 180.0	45.6	NA	93.9	2.2 ± 1.5	16.1
Saklani *et al.*[24]	Korea (2013)	74 (yp Stage 0-III)	NA	100	1.4	180 ± 28.1 (0-1100)	16.2	5.4	97.3	1.7 ± 1.4 (0.1-6.0)	4
Pai *et al.*[29]	USA (2015)	101 (yp Stage 0-IV)	28.7	74.3	4	190 ± 128	28.7	6.3	79.2	3.5 ± 2.7 (0.1-16.3)	5
Kim *et al.*[30]	Korea (2016)	60 (yp Stage 0-IV)	56.7*	36.7	0	74.2 ± 50	15	5	93.4	3.1 ± 1.7	11.7
Feroci *et al.*[31]	Italy (2016)	53 (yp Stage (yp 0-III)	NA	49.1	3.8	60.8 (0-400)	26.4	5.7	100	2.5 (0.5-10)	0
Cho *et al.*[32]	Korea (2012)	278 (yp Stage 0-III)	24.8	32.7	0.4	179.0 ± 236.5	25.9	10.4	100	2.0 ± 1.4	5.0
Park *et al.*[33]	Korea (2015)	133 (yp Stage I-III)	24.8	11.3	0	77.6 ± 153.2 (0-700)	19.7	4.5	100	2.75 ± 2.14 (1-14)	6.8
Ghezzi *et al.*[34]	Brazil/Italy (2014)	65 (yp Stage 0-III)	100#	72.3	1.5	0 (0-175)	41.5	7.1	86.2	2.7 (1.6-4.4)	0
Hara *et al.*[35]	Korea (2014)	200 (yp Stage 0-IV)	56.5	27.5	0	190 (0-1500)	38.5	9.5	93.5	1.8 (0-22.0)	1.5
Baik *et al.*[36]	Korea (2013)	370 (yp Stage 0-IV)	26.8	21.1	0.8	245.7 ± 222.1 (10.0-1300.0)	24.6	7.7	99.2	2.6 ± 1.4	6.9
Ahmed *et al.*[37]	UK (2016)	83	NA	21.7	0	10 (0-200)	49	2	88.0	2.7 (0.4-8.0)	3.6
Hellan *et al.*[38]	USA (2007)	39 (yp Stage I-IV)	53.9#	84.6	2.6	200 (25-6000)		12.1	84.6	2.65 (0.4-7.5)	0
Luca *et al.*[39]	Italy (2009)	28 (yp Stage I-IV)	NA	0	0	68 ± 138 (0-600)	NA	NA	75.0	2.5 ± 1.3 (0.6-5.5)	0
Yamaguchi *et al.*[40]	Japan (2016)	203 (yp Stage 0-IV)	60.1#	0.5	0	15.4 ± 26.4	9	1.5	95.1	2.8 ± 1.9	NA
Ramji *et al.*[41]	Canada (2016)	26	NA	58	12	296 ± 155	42	8	85	2.96 ± 2.05	0
Abdel-Gawad *et al.*[42]	Egypt (2014)	55	100	45.4	0	NA	25.5	7.2	100	NA	5.5

*< 7 cm; #extraperitoneal. CCRT: concurrent chemoradiotherapy; CRM: circumferential resection margin; DRM: distal resection margin; NA: not applicable

Table 5. Comparison of short-term oncological outcomes of robotic-assisted total mesorectal excision

Study	Country (year)	Local recurrence (%)	Distant metastasis (%)	Disease-free survival	Overall survival
Present study (low-lying rectum)	Taiwan (2018)	3.5	8.8	88.3% (2-year)	96.7% (2-year)
Pai *et al*.[29] (all rectum)	USA (2015)	4	17	79.2% (3-year)	90.1% (3-year)
Kim *et al*.[30] (all rectum)	Korea (2016)	1.9	26.4	72.8% (4-year)	87.7% (4-year)
Feroci *et al*.[31] (mid and low-lying rectum)	Italy (2016)	1.9	17	79.2% (3-year)	90.2% (3-year)
Cho *et al*.[32] (all rectum)	Korea (2012)	1.8	12.2	81.8% (5-year)	92.2% (5-year)
Park *et al*.[33] (all rectum)	Korea (2015)	2.3	12.0	81.9% (5-year)	92.8% (5-year)
Ghezzi *et al*.[34] (low-lying rectum)	Brazil/Italy (2014)	3.2	18.5	73.2% (5-year)	85.2% (5-year)
Hara *et al*.[35] (all rectum)	Korea (2014)	4.5	10	81.7% (5-year)	92.0% (5-year)
Baik *et al*.[36] (all rectum)	Korea (2013)	3.6	17.6	79.2% (3-year)	93.1% (3-year)
Abdel-Gawad *et al*.[42] (low-lying rectum)	Egypt (2014)	14.8	14.4	82.6% (3-year)	88.7% (3-year)

Table 6. Comparison of short-term oncological outcomes of low-lying rectal cancer

Study	Country (year)	Local recurrence (%)	Distant metastasis (%)	Disease-free survival	Overall survival	Surgery method: open (%)	Surgery method: laparoscopic (%)	Surgery method: robotic (%)
Present study	Taiwan (2018)	3.5	8.8	88.3% (2-year)	96.7% (2-year)	0%	0%	100%
Ghezzi *et al*.[34]	Brazil/Italy (2014)	3.2	18.5	73.2% (5-year)	85.2% (5-year)	37.3%	0%	62.7%
Abdel-Gawad *et al*.[42]	Egypt (2014)	14.8	14.4	82.6% (3-year)	88.7% (3-year)	NA	NA	0%

NA: not applicable

was performed first, followed by robotic ISR 203 days later. Pathology reports showed that both CRM and DRM were positive. During follow up period, she was still alive 2 years after operation.

In our study, none of the surgical procedures were converted to open or laparoscopic surgery. Studies have shown that advanced local cancer stage, bulky tumors, and high body mass index may be responsible for conversions[14,23,31,38]. Although our study consisted of some difficult cases, including large tumors (4 patients with a tumor size > 5 cm), low-lying rectal cancer (distance of 3.5 cm from the anal verge), a greater proportion of men (36 patients), and more challenging operation requirements (37 patients with intersphincteric dissection), our morbidity results appeared promising. The anastomosis leakage rate in our study is 3.3%, which is slightly lower than that in other studies [Table 4].

This study had some limitations. First, this was a single-institution retrospective study consisting of only 60 patients. Second, the follow-up interval was short, with a median follow-up duration of 28 months; thus, only short-term (2-year) survival and oncological outcomes are reported. Nevertheless, the 2-year overall survival (96.7%) and disease-free survival (88.3%) in our study were consistent with those reported in previous studies [Table 5]. We also compared the short-term ontological outcomes of low-lying rectal cancer [Table 6]. Third, we did not evaluate the postoperative outcomes with regard to urinary and sexual functions.

In conclusion, through comparison of short-term clinical outcomes, we have demonstrated that the robotic TME technique is safe and feasible for patients with low-lying rectal cancer. Moreover, combining this approach with appropriate preoperative CCRT can deliver favorable short-term oncological outcomes. However, further investigation of long-term oncological outcomes is required using studies with longer follow-up durations.

DECLARATIONS

Authors' contributions

Conception and design of the study, Data analysis and interpretation: Chen PJ, Huang CW, Tsai HL, Yeh YS, Wang JY

Data acquisition, provided administrative, technical, and material support: Su WC, Chang TK, Huang MY, Huang CM, Wang JY

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

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Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

This study was approved by hospital ethics committee of Kaohsiung Medical University Hospital. Consent to participate was obtained.

Consent for publication

Not applicable.

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