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ORIGINAL ARTICLE

Robotic-assisted multivisceral resection for rectal cancer: short-term outcomes at a single center

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Abstract

Background The safety and feasibility of robotic-assisted multivisceral resection for locally advanced rectal cancer remain unclear. The aim of this study was to assess the short-term outcomes of this procedure at our institution.

Methods From December 2011 to December 2016, patients who underwent robotic-assisted multivisceral resection for rectal cancer were investigated. Patient demographics, treatment characteristics, perioperative outcomes, and pathological results were evaluated retrospectively.

Results There were 31 patients; 17 men (54.8%) and 14 women (45.2%), with a median age of 65 years (range 40–82 years). Twenty-one patients (67.7%) had a cT4 tumor, 9 patients (29.0%) had a pT4b tumor, and all patients except one (96.8%) underwent complete resection of the primary tumor with negative resection margins. Eleven patients (35.5%) received neoadjuvant chemoradiation. The most commonly resected organ was the vaginal wall (n = 12, 38.7%), followed by the prostate (n = 10, 32.3%). Lateral lymph node dissection was performed in 20 patients (64.5%). The median operative time was 394 min (range 189–549 min), and the median blood loss was 41 mL (range 0–502 mL). None of the patients received intraoperative blood transfusions or required conversion to open. Overall, postoperative complications occurred in 11 patients (35.5%). The most frequent complication was urinary retention (n = 5, 16.1%), and none of the patients developed serious complications classified as Clavien–Dindo grades III–V.

Conclusions Robotic-assisted multivisceral resection for rectal cancer is safe and technically feasible.

Keywords Robotic surgical procedures · Rectal cancer · Rectal neoplasms · Multivisceral resection · Laparoscopy · Lymph node excision

Introduction

Currently, laparoscopic surgery (LS) is widely used to treat colorectal cancer (CRC). It has been reported that LS for CRC has favorable short-term outcomes and similar oncological outcomes, as compared with open surgery (OS) [1–7]. However, cT4b rectal cancer was excluded from these studies, and the safety and feasibility of LS for locally advanced rectal cancer, which requires multivisceral resection due to the adhesion or invasion of the tumor to adjacent organs or structures, were not fully investigated. The most likely reason for this is the technical difficulty of LS in rectal cancer. In conventional laparoscopic surgery (CLS), the range of motion of straight rigid instruments is limited, and the unstable two-dimensional camera view makes it difficult to observe the space and depth in the deep and narrow pelvis. Furthermore, since dissection beyond the total mesorectal excision (TME) plane [8], i.e., extra-anatomic dissection is needed for multivisceral resection of rectal cancer, CLS for these cases is even more technically demanding. Possibly because of these technical difficulties, only few clinical studies have focused on surgical outcomes of laparoscopic multivisceral resection for rectal cancer [9], and these technical

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difficulties have to be resolved in order to perform this procedure more safely and easily.

Robotic surgery is one of the promising technologies that have the potential to overcome the intrinsic limitations of CLS. Robotic-assisted surgery (RAS) using the da Vinci® surgical system (Intuitive Surgical Inc., Sunnyvale, CA, USA) has some technical benefits over OS, such as free-moving multijoint forceps, digital suppression of hand tremor, motion scaling function, high-quality three-dimensional visualization with stable camera work by the operator, and greatly improved ergonomics. Compared with CLS, these advantages of RAS can make the laparoscopic procedure smoother and can increase the precision of the operation even in the deep and narrow pelvis. Previously, several retrospective studies have reported superior safety and technical feasibility of RAS, compared with OS or CLS, for rectal cancer [10–13]. However, only a few studies provided surgical outcomes of robotic-assisted multivisceral resection for rectal cancer [14, 15]. Therefore, we conducted a retrospective study on a larger number of patients, compared with previous reports, to evaluate the short-term outcomes of robotic-assisted multivisceral resection of rectal cancer invading or adhering to neighboring organs.

Materials and methods

Patient selection and study design

We retrospectively analyzed data from a prospectively collected institutional database at Shizuoka Cancer Center Hospital. In this study, the definition of multivisceral resection for rectal cancer is en bloc resection of primary rectal cancer with any adjacent organs or part of adjacent organs to obtain a clear resection margin. Even if the preoperative evaluation showed that the tumor depth was not T4b, multivisceral resection was performed when intraoperatively the tumor was found adhered to adjacent organs or to obtain a clear resection margin when the preoperative evaluation or intraoperative findings showed that the tumor would be close to the TME resection margin without multivisceral resection. RAS was introduced at our institution in December 2011. From December 2011 to December 2016, a total of 558 patients underwent RAS for rectal tumors. Thirty-one of these patients (5.6%) who underwent robotic-assisted multivisceral resection for primary rectal cancer were enrolled in this study. Exclusion criteria included tumors that required multivisceral resection with urinary diversion or reconstruction or total pelvic exenteration for complete tumor resection, as those cases were candidates for OS. In our institution, in rectal cancer surgery urinary diversion or reconstruction is performed by urologists, and in the study period, these procedures were performed by OS. In addition, RAS for rectal cancer is not covered by the Japanese health insurance. Since pelvic exenteration generally had higher postoperative complication rates and required a longer postoperative hospital stay compared with other rectal cancer surgery, robotic-assisted pelvic exenteration greatly increases the patient's and/or hospital's expense; therefore, we performed total pelvic exenteration only by OS in this period. In Japan, lateral lymph node dissection (LLD) is the standard treatment for locally advanced low rectal cancer [16], whereas in western countries, neoadjuvant chemoradiation (CRT) has become the standard treatment. The indications for LLD in the present series were low rectal cancer with cT3-T4, or cT1-T2 with metastasis to the lateral lymph nodes as previously described [11, 17]. Low rectal cancer was defined as the lower border of the tumor located distal to the peritoneal reflection. LLD was not performed in patients older than 75 years or at high risk of postoperative complications and without lateral lymph node metastasis on preoperative imaging or for patients who underwent neoadjuvant CRT and without lateral lymph node metastasis on preoperative imaging. Unilateral (involved side) LLD was indicated for patients who underwent neoadjuvant CRT and with lateral lymph node metastasis on preoperative imaging. At our institution, neoadjuvant CRT (50.4 Gy in 25 fractions for 5 weeks with systemic capecitabine chemotherapy) was used only in cases in which obtaining a clear resected margin (R0) without CRT was difficult or in which shrinkage of the tumor by CRT would make anal preservation possible or prevent urinary diversion. Preoperative evaluation included histological confirmation of adenocarcinoma, digital rectal examination, barium enema, colonoscopy, computed tomography, and magnetic resonance imaging. All patients were staged according to the tumor node metastasis classification [18]. Lateral lymph nodes were considered regional lymph nodes, as previously reported [19].

Cases appropriate for the robotic approach were selected through a multidisciplinary team (MDT) process in which colorectal surgeons, endoscopists, medical oncologists, pathologists, and radiologists participated. The patients were informed by the colorectal surgeon about the merits or demerits and costs of OS, CLS, and RAS. The preferred approach was selected by each patient.

Outcome variables

Data on patient characteristics, preoperative assessment, operative characteristics, postoperative complications, and pathological characteristics were collected. Postoperative complications within 30 days of surgery were stratified according to the Clavien–Dindo classification system [20]. Enteritis was diagnosed based on clinical manifestation, fecal culture, and/or *Clostridium difficile* antigen and toxin tests. As for radicality of the surgical procedure, R0, R1, and

R2 were defined as macroscopically complete resection with a microscopically free resection margin, macroscopically complete resection with microscopic presence of tumor at the resection margin, and macroscopically incomplete resection, respectively.

Surgical procedure

The da Vinci® S, Si, and Xi surgical systems (Intuitive Surgical Inc.) were used for all procedures. All procedures were performed only by colorectal surgeons. In the present series, 4 surgeons (T. Y., Y. K., A. S., and H. K.), each with long experience in OS and CLS, performed all procedures. The institutional standard procedure of RAS for rectal cancer has been described elsewhere [10, 21]. Briefly, a completely robotic approach, which included colonic and pelvic phases, was indicated. During the colonic phase, the ligations of the inferior mesenteric artery and vein via a medial-to-lateral approach and the mobilization of the descending and sigmoid colons were performed. If necessary, the splenic flexure was also mobilized. The pelvic phase involved rectal mobilization down to the pelvic floor. The surgeon kept the proper TME plane outside of the site where the tumor was suspected to invade based on intraoperative findings. At the suspected site of tumor invasion, dissection beyond the TME plane and en bloc resection of adjacent organs were performed. If necessary, pelvic autonomic nerves such as the inferior hypogastric nerves, pelvic splanchnic nerves, pelvic plexus, and/or neurovascular bundle were resected partially or completely. The surgical procedure of robotic-assisted LLD at our institution had been described elsewhere [17]. The setup for RAS was the same, regardless of the type of multivisceral resection.

Results

A total of 31 consecutive patients underwent robotic-assisted multivisceral resection for rectal cancer. The da Vinci S, Si, and Xi systems were used in 17, 12, and 2 cases, respectively. The patient and tumor characteristics of eligible patients are shown in Table 1. The majority (90.3%) of tumors was located at the lower rectum, and 11 (35.5%) patients underwent neoadjuvant CRT. Among these 11 patients, 2 underwent neoadjuvant CRT before they were referred to our hospital, according to the indications of the other hospitals. At our institution, neoadjuvant CRT was administered to obtain a clear resection margin in the prostate and/or seminal vesicles and to avoid urinary diversion in 8 cases, and preserve the anus in 1 case.

Table 2 lists the adjacent organs that underwent en bloc resection. The most commonly resected organ was the vaginal wall, followed by the prostate, seminal vesicles, and/or

Table 1 Clinical characteristics of the patients who underwent robotic-assisted multivisceral resection for rectal cancer

Characteristic	Total (*n* = 31)
Age (years) [median (range)]	65 (40–82)
Sex	
Male	17 (54.8)
Female	14 (45.2)
BMI (kg/m^2) [median (range)]	21.7 (16.6–30.9)
ASA classification	
I	7 (22.6)
II	22 (71.0)
III	2 (6.5)
Tumor location	
Above the peritoneal reflection	3 (9.7)
Below the peritoneal reflection (lower rectum)	28 (90.3)
Distance from anal verge (cm) [median (range)]	3.0 (0–10.0)
Previous abdominal surgery (yes)	9 (29.0)
Neoadjuvant chemoradiation (yes)	11 (35.5)
Emergency	0 (0)
cT	
T1	0 (0)
T2	2 (6.5)
T3	8 (25.8)
T4	21 (67.7)
cN	
cN0	3 (9.7)
cN1	11 (35.5)
cN2	17 (54.8)
cStage	
I	2 (6.5)
II	2 (6.5)
III	24 (77.4)
IV	3 (9.7)

Values represent numbers (percentages), unless indicated otherwise

BMI body mass index, *ASA* American Society of Anesthesiologists

Table 2 En bloc-resected organs (partial or complete)

	Total (*n* = 31)
Adjacent organs resected (partial or complete)	
Vaginal wall	12 (38.7)
Prostate	10 (32.3)
Seminal vesicle and/or vas deferens	6 (19.4)
Coccyx	2 (6.5)
Uterus	2 (6.5)
Ovary and/or fallopian tube	2 (6.5)
Bladder wall	2 (6.5)
More than one organ resected (yes)	4 (12.9)

Values represent numbers (percentages)

vas deferens. In 4 cases, more than one organ was resected en bloc. When necessary, defects after resection of the vaginal wall or bladder wall were closed by robotic suture, or hand-sewn suture using a perineal or transanal approach. No patients required vaginal reconstruction. In all cases that required excision of the prostate, we performed partial resection of the prostate without urethral anastomosis, urinary diversion, or urethral injuries.

Table 3 shows the perioperative outcomes. Seventeen patients (54.8%) underwent a sphincter-preserving procedure such as low anterior resection or intersphincteric resection. LLD was performed in 20 patients (64.5%). In patients in whom LLD was not performed (*n* = 11), the median operative time was 287 min (range: 189–390 min). None of the patients received intraoperative blood transfusions or required conversion to OS. The associations between operation, resected adjacent organs, and frequency of LLD are shown in Table 4.

Table 5 shows the postoperative complications. The most frequent complication was urinary retention, followed by

Table 3 Perioperative outcomes of robotic-assisted multivisceral resection for rectal cancer

	Total (*n* = 31)
Type of operation	
Low anterior resection	9 (29.0)
Intersphincteric resection	8 (25.8)
Abdominoperineal resection	14 (45.2)
Diverting stoma (yes)	13 (41.9)
Lateral lymph node dissection (yes)	20 (64.5)
Pelvic autonomic nerve resection (partial or complete) (yes)	10 (32.3)
Pelvic plexus	3 (9.7)
Pelvic splanchnic nerve	4 (12.9)
Neurovascular bundle	6 (19.4)
Operative time (minutes) [median (range)]	394 (189–549)
Blood loss (mL) [median (range)][a]	41 (0–502)
Intraoperative blood transfusion (yes)	0 (0)
Open conversion (yes)	0 (0)
Duration of liquid diet (days) [median (range)]	3 (3–4)
Postoperative hospital stay (days) [median (range)]	8 (6–15)
Readmission within 30 days (yes)	3 (9.7)

Values represent numbers (percentages), unless indicated otherwise

[a] "0 mL" means too low an amount of bleeding to measure

Table 4 Association between operation, resected adjacent organs, and frequency of lateral lymph node dissection

Type of operation	Adjacent organs resected	Lateral lymph node dissection (yes)
Low anterior resection (*n* = 9)	Vaginal wall (*n* = 3)	5 (55.6)
	Seminal vesicle and/or vas deferens (*n* = 3)	
	Uterus (*n* = 1)	
	Ovary and/or fallopian tube (*n* = 2)	
	Bladder wall (*n* = 2)	
Intersphincteric resection (*n* = 8)	Vaginal wall (*n* = 2)	6 (75.0)
	Prostate (*n* = 5)	
	Seminal vesicle and/or vas deferens (*n* = 1)	
	Uterus (*n* = 1)	
Abdominoperineal resection (*n* = 14)	Vaginal wall (*n* = 7)	9 (64.3)
	Prostate (*n* = 5)	
	Seminal vesicle and/or vas deferens (*n* = 2)	
	Coccyx (*n* = 2)	

Values represent numbers (percentages)

Table 5 Postoperative complications of robotic-assisted multivisceral resection for rectal cancer

	Total ($n = 31$)
Complication (yes)	11 (35.5)
Complication type	
Urinary retention	5 (16.1)
Deep pelvic abscess	2 (6.5)
Enteritis	2 (6.5)
Ileus	1 (3.2)
Wound infection	1 (3.2)
Pneumonia	1 (3.2)
Delirium	1 (3.2)
Chylous ascites	1 (3.2)
Hyperkalemia	1 (3.2)
Highest C–D grade	
I	2 (6.5)
II	9 (29.0)
II–V	0 (0)
More than one complication (yes)[a]	2 (6.5)

Values represent numbers (percentages)

C–D Clavien–Dindo

[a]One developed wound infection, deep pelvic abscess, and delirium, and the other developed ileus, pneumonia, and enteritis

Table 6 Pathological results of robotic-assisted multivisceral resection for rectal cancer

Pathological result	Total ($n = 31$)
pT or ypT	
T0	1 (3.2)
T1	0 (0)
T2	2 (6.5)
T3	17 (54.8)
T4a	2 (6.5)
T4b	9 (29.0)
pN or ypN	
N0	11 (35.5)
N1a	4 (12.9)
N1b	5 (16.1)
N1c	0 (0)
N2a	8 (25.8)
N2b	3 (9.7)
p or yp stage	
No residual tumor (complete response)	1 (3.2)
I	2 (6.5)
II	7 (22.6)
III	18 (58.1)
IV	3 (9.7)
Number of harvested lymph nodes [median (range)]	
Total lymph nodes	43 (16–112)
Lymph nodes except for lateral lymph nodes	27 (11–90)
Resection margin	
R0	28 (90.3)
R1	1 (3.2)
R2	2 (6.5)
Only local	0 (0)
Only distant	2 (6.5)
Both	0 (0)

Values represent numbers (percentages), unless indicated otherwise

deep pelvic abscess and enteritis. No patients developed anastomotic leakage. Both patients who developed pelvic abscess underwent abdominoperineal resection. In one case, the abscess was treated with antibiotics and drained through the perineal wound. In the other case, the abscess was treated with antibiotics and drained through a drainage tube placed during the operation. None of the patients developed serious complications classified as Clavien–Dindo grades III–V. There was no postoperative mortality in this series. Two patients developed more than one complication.

Table 6 shows the pathological results. Of 3 patients with distant metastasis, 2 underwent complete resection of only the primary tumor (R2, only distant) and 1 underwent complete resection of both the primary tumor and metastates (R0). Collectively, all patients except 1 (96.8%) underwent complete resection of the primary tumor with negative resection margins.

Discussion

Laparoscopic surgery is becoming the standard procedure for rectal cancer in many centers, and in approximately 10% of cases, extended surgery is required for complete resection due to the involvement of adjacent organs [22]. However, conventional laparoscopic multivisceral resection for rectal cancer is a challenging procedure and requires highly advanced surgical skills. In contrast, RAS is a promising advanced technology that can overcome the intrinsic limitations of CLS for rectal cancer. Compared with CLS, RAS enables a smoother and more precise dissection owing to the steady, flexible, motion scaling, and intuitive devices. We conducted the present study to evaluate the short-term outcomes of robotic-assisted multivisceral resection for rectal cancer. The present findings show that this procedure is safe and technically feasible for rectal cancer, which were appropriately selected through the MDT process, compared with OS or CLS.

Intraoperative blood loss is an indicator of the safety and feasibility of the surgery. In the present study, the median blood loss was 41 mL. In the main randomized controlled trials (RCTs) of CLS for rectal cancer, in which patients with cT4 were excluded and none of the patients underwent LLD, median blood loss was reported to be 100–200 mL in CLS and 150–400 mL in OS [3, 5, 23]. These studies showed that blood loss was significantly lower in CLS than in OS. Given that more than half of the patients in this study underwent not only multivisceral resection but also LLD, the median blood loss in the present study is acceptable. Moreover, none of the patients underwent intraoperative transfusion. These results are evidence of the safety of robotic-assisted multivisceral resection for rectal cancer.

The rate of unplanned conversion to OS is considered an indicator of technical difficulty and feasibility of LS. In previous reports, the main reason for conversion of CLS for rectal cancer was tumor fixation to adjacent organs or structures, which requires extra-anatomic dissection [3, 10, 24]. In CLS for T4 rectal cancer, the rate of conversion to OS was reported to be 16.7–21.2% [24, 25]. These findings suggest the technical difficulty of CLS in handling bulky rectal tumors. The guideline of the Society of American Gastrointestinal and Endoscopic Surgeons published in 2013 recommended OS if laparoscopic en bloc resection cannot be performed adequately for locally advanced CRC suspected of invading the adjacent structures [26]. In the present study, none of the patients underwent conversion to OS. Shin et al. [14] also reported that only 1 (4.5%) of 22 patients underwent conversion to OS during robotic-assisted multivisceral resection for rectal cancer, and the reason for the conversion was intolerance of the Trendelenburg position. These results showed that robotic-assisted multivisceral resection is technically feasible and can overcome the technical difficulties of CLS.

Generally, the postoperative complication rate is an important indicator of the safety of the surgery. In the main randomized controlled trials of CLS for rectal cancer or retrospective studies of CLS for T4 rectal cancer, the rate of postoperative complications was reported to be 21.2–41.7% in CLS [3, 5, 24, 25] and 23.5–48.1% in OS [3, 5, 24]. In the present study, overall, 11 patients (35.5%) developed postoperative complications, which was comparable with the rates in previous reports. The most frequent complication was urinary retention (16.1%), which resulted from damage to or resection of pelvic autonomic nerves. Except for urinary retention, only 6 patients (19.4%) developed postoperative complication. Moreover, it is notable that none of the patients developed postoperative complications classified as Clavien–Dindo grades III–V. These findings were considered positive results and indicated the safety and advantage of robotic-assisted multivisceral resection for rectal cancer.

The main concern regarding LS for locally advanced rectal cancer is the oncological outcome. The rate of incomplete resection of the primary tumor in open multivisceral resection for rectal cancer was 15.3–26.7% [27–29]. In conventional laparoscopic multivisceral resection, the rate of incomplete resection of the primary tumor was 5.0–13.1%, but both colon and rectal cancer surgeries were included [30, 31]. In the present study, all patients except 1 (96.8%) underwent complete resection of the primary tumor with negative resection margins. Compared with previous reports, this result is considered acceptable and suggests the oncological safety of robotic-assisted multivisceral resection for rectal cancer. Moreover, Shin et al. [14] reported excellent pathological results of robotic-assisted multivisceral resection for rectal cancer, in which all resections for primary rectal lesions had negative resection margins.

To our knowledge, only 1 study that reported on the surgical outcomes of robotic-assisted multivisceral resection for rectal cancer included more than 10 patients [14]. In that study, 81.8% of patients underwent neoadjuvant CRT and 18.2% underwent LLD, and these are the major differences from the present study. However, as noted above, the study showed good short-term outcomes and feasibility of robotic-assisted multivisceral resection. Furthermore, Shin et al. also reported the long-term outcomes of this procedure. Although their long-term outcomes were from procedures including not only en bloc multivisceral resection but also rectal resection with extramesorectal lymph node dissection, they reported that the 5-year overall survival and disease-free survival rates were 80 and 54.6%, respectively, and those results are acceptable.

Previously, we reported that the first 25 cases formed the learning phase in RAS for rectal cancer [32]. However, the learning curve for robotic-assisted multivisceral resection remains unclear, since this procedure is technically demanding and its frequency is relatively low. The surgical techniques of multivisceral resection vary depending on the adjacent organs resected. Therefore, it is difficult to conclude how many cases are required for the learning phase of robotic-assisted multivisceral resection. However, based on our previous findings, we consider that robotic-assisted multivisceral resection should be performed by surgeons with experience in at least 25 robotic-assisted rectal cancer surgeries.

For the resection of locally advanced rectal cancer, some patients require total pelvic exenteration. However, in our institution, robotic-assisted total pelvic exenteration has not been introduced because the use of RAS for rectal cancer is not covered by the Japanese health insurance. A current major consideration regarding RAS is its high cost [33], and robotic-assisted total pelvic exenteration considerably increases costs for the patient. However, except for the cost, RAS has better technical advantages than CLS. We believe that the effectiveness of RAS will be more demonstrable in more challenging situations, and total pelvic exenteration, which is a highly technically demanding procedure, would be a good indication for RAS. In particular, the advantages of RAS will be beneficial for the dissection and resection process of total pelvic exenteration in a narrow and deep pelvis. A smoother and more precise procedure will result in less blood loss and other clinical benefits. Outcomes of robotic-assisted total pelvic eventration for rectal cancer have only been reported in a very small number of patients to date [15, 34]. In the future, the clinical benefits of robotic-assisted total pelvic exenteration should be evaluated in a large number of patients with rectal cancer.

This study had several limitations. First, this was a retrospective study and not a case-matched or comparative study of OS and/or CLS. Second, the long-term oncological results of RAS were not assessed in this study owing to the short follow-up period. Third, the cost of RAS was not analyzed in this study. These problems should be examined in order to evaluate the true benefit of robotic-assisted multivisceral resection for rectal cancer, and randomized controlled trials are necessary to confirm these findings. However, it would be difficult to design such trials in the near future because of the technical difficulty of CLS, and a retrospective study is considered one of the realistic approaches to assess the clinical benefits of this procedure at this time. Moreover, to our knowledge, the present study has a higher number of patients than previous studies on robotic-assisted multivisceral resection for rectal cancer and it provides new insights into the clinical benefits of RAS for locally advanced rectal cancer.

Conclusions

RAS is safe and technically feasible for appropriately selected patients requiring multivisceral resection for rectal cancer. Although further study is needed, the present findings suggest that RAS can overcome the limitations of CLS and can increase the surgeon's ability to perform minimally invasive surgery for rectal cancer.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study protocol was approved by the institutional review board of our hospital (28-J140-28-1-3). Research was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments.

Informed consent Informed consent was waived due to the retrospective nature of the study.

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