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ORIGINAL ARTICLE

Totally robotic modified complete mesocolic excision and central vascular ligation for right-sided colon cancer: technical feasibility and mid-term oncologic outcomes

Sung Uk Bae [1,2] · Seung Yoon Yang [2] · Byung Soh Min [2]

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Abstract

Background Recently, an operative strategy involving complete mesocolic excision (CME) and central vascular ligation (CVL) for colonic cancer has been introduced. We aimed to describe our initial experience and assess the long-term outcomes of robotic modified CME (mCME) and CVL (mCME+CVL) for right-sided colon cancer.

Methods Of the 677 patients with histologically confirmed, right-sided colon adenocarcinoma who underwent curative mCME+CVL between February 2008 and October 2016, 43 who were treated entirely using the robotic approach were included in this retrospective study. Survival rates were determined using the Kaplan-Meier method, and P values of < 0.05 indicated statistically significant differences.

Results The total operation and docking times were 293 (180–644) min and 5 (3–19) min, respectively, with an estimated blood loss of 50 (10–400) mL. The time to soft diet was 4 (1–16) days and the length of hospitalization was 8 (4–48) days. Based on the Clavien-Dindo classification, grade I, II, IIIa, IIIb, and IV complications were noted in 3 (7.0%), 5 (11.7%), 2 (4.7%), 1 (2.3%), and 0 (0%) patients, respectively. The proximal and distal resection margins were 14 (4–54) and 19 (4–48) cm, respectively, and 29 (6–157) lymph nodes were harvested per patient. The patients were followed-up for a median of 55 (2–109) months, during which the overall survival rate, median disease-free period, disease-free survival rate, and tumor recurrence rate were 93.6%, 38 (2–109) months, 81.1%, and 16.3% (7 patients), respectively.

Conclusions Robotic mCME and CVL for right-sided colon cancer was feasible and safe. It can be added to the surgeon's toolbox as an optional strategy for the management of colon cancer patients.

Keywords Complete mesocolic excision · Robotic modified CME · Colon cancer

Introduction

Total mesorectal excision (TME) is recommended for rectal cancer, as this procedure is typically associated with lower recurrence rates and improved 5-year survival rate [1]. A strategy involving complete mesocolic excision (CME) and central vascular ligation (CVL) has recently been introduced for the management of colon cancer. It involves en-bloc resection of the tumor and its surrounding soft tissue by sharp dissection of the visceral plane from the parietal fascia layer, along with the entire regional mesocolon as a single and intact corps, which is similar to the concept of TME. This surgical model offered reduced local recurrence and improved survival rates compared to conventional colectomy [2, 3] For years, we have been practicing an equivalent lymphadenectomy principle depending on tumor location and extent and have defined the procedure "modified CME (mCME) with CVL (mCME+CVL)" [4].

Several studies comparing conventional laparoscopic versus open CME for right-sided colon cancer have shown feasibility and safety of the laparoscopic approach with acceptable oncologic outcomes [5, 6]. However, CME and CVL for

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✉ Byung Soh Min
bsmin@yuhs.ac

1 Division of Colorectal Surgery, Department of Surgery, School of Medicine, Keimyung University and Dongsan Medical Center, Daegu, South Korea

2 Department of Surgery, College of Medicine, Yonsei University, 50 Yonsei-ro, Seodaemun-Gu, Seoul 120-752, South Korea

right-sided colon cancer using a minimally invasive approach is a challenging procedure because laparoscopic dissection of the lymph nodes (LN) around the superior mesenteric vessels is troublesome due to the complex variable vascular anatomy of the right colon and technical limitations of laparoscopic instruments.

A surgical robotic system was developed to overcome the inherent limitations of laparoscopic surgery and was introduced to the colorectal field to overcome the challenges of laparoscopic rectal cancer surgery in the narrow pelvis. Nonetheless, it is unclear whether robotic surgery has significant clinical benefits over laparoscopic surgery for treating colonic malignancy [7–9]. Despite reports showing comparative results of laparoscopic CME+CVL, in general, the penetration of laparoscopic procedures is still considered slow. The robotic approach may have a role in overcoming this hurdle. The aim of the current study, therefore, was to critically review our initial experience and the oncologic outcomes of robotic mCME+CVL for right-sided colon cancer.

Materials and methods

Patients

This study is a retrospective study based on a prospectively maintained database. Between 2008 and 2016, 677 patients with histologically confirmed adenocarcinoma arising from the right-sided colon underwent radical resection. Exclusion criteria were unresectable stage IV tumor, cancer related to familial adenomatous polyposis or hereditary nonpolyposis colorectal cancer, synchronous or previous malignancies, acute obstruction or perforation, and lymphoma or mucocele. In this period, patients were selected after the surgeon explained the advantages of the robotic system for the disease and its disadvantages, including its higher cost, which is not covered by the government, than that of laparoscopic surgery. We identified 78 patients that received totally robotic right colon resection and of these, 43 patients had received mCME+CVL and were enrolled in the study after excluding 35 patients that had undergone robotic single port surgery. All procedures were performed using the da Vinci Si or Xi surgical systems (Intuitive Surgical, Sunnyvale, CA). Postoperative complications were graded according to the Clavien-Dindo classification [10].

Evaluation parameters

We defined right-sided colon cancer as cancer of the cecum and the ascending colon up to the proximal transverse colon. Conversion to open surgery was defined as interruption of the robotic approach, followed by the need for a laparotomy at any time to complete the entire surgical procedure. The Clavien-Dindo classification system was used for analyzing surgical complications [11]. Grade I included minor complications not requiring pharmacological treatment with the exception of electrolytes, physiotherapy, antipyretics, analgesics, diuretics, and antiemetics. Grade II was defined as potentially life-threatening complications that required pharmacological treatment other than the drugs used for grade I. Blood transfusion and total parenteral nutrition were also included in grade II. Grade III was defined as complications that required surgical, endoscopic, or radiological intervention that causes disability or longer hospital stay. Grade III was divided into 2 subgroups, namely grade IIIa, which required intervention not under general anesthesia, and grade IIIb, which required intervention under general anesthesia. Grade IV complications were defined as life-threatening complications that required intensive care unit management. The seventh edition of the American Joint Committee on Cancer classification system was used to determine the pathological tumor depth, number of metastasized lymph nodes, and cancer stage. Recurrence was defined as the presence of radiologically confirmed or histologically proven tumor. The location of recurrence was defined as the first site of recurrence after complete resection. Local recurrence was defined as any tumor recurrence in the surgical field. Overall survival (OS) was defined as the time from the date of surgery to the date of the latest follow-up visit or the date of death due to any cause, and disease-free survival (DFS) was defined as the time from surgery to any type of recurrence.

Surgical procedure

Overall, mCME+CVL was performed in all 43 patients according to preoperative clinical stage that is indicated for radical resection, and all the cases were performed by a single surgeon (M.S. Min) who developed the surgical technique of the totally robotic approach for right-sided colon cancer. The procedure and its modification from the original concept have been described in detail elsewhere [4]. To summarize it briefly, first, complete kocherization was not performed routinely unless the tumor invaded the duodenum or perinephric fat tissue. Second, we preferred to preserve the root of the middle colic vessel and ligated only the right branch unless the tumor was located in the distal hepatic flexure or more distally. Third, the length of the distal ileum was determined by the extent of the mesenteric dissection. Specifically, if the tumor was located in the proximal ascending colon or cecum, we included a few distal ileum branches of the superior mesenteric artery into the specimen.

Operative setup and docking of the robotic system

Because intracorporeal anastomosis was routine, all patients had bowel preparation. Colonic lavage was performed the day before surgery using 4 L of polyethylene glycol (PEG) solution. All patients were given 2 to 3 doses of prophylactic antibiotics. The patient was placed supine in the Trendelenberg position at 30° with about 10–15° of right-side tilt. Port placement and robot position differed depending on the generation of the robotic system. For the Si system, five ports were used including one 12-mm camera port, three 8-mm robotic working ports, and one 12-mm laparoscopic port for the assistant, which was used for laparoscopic staplers for bowel division and anastomosis (Fig. 1A). Subsequently, with the availability of a robotic stapler, this assistant port was changed to 5-mm port. The robot was placed above the right shoulder of the patient obliquely at an angle of 30–40°. For the Xi robotic system, four robotic ports were placed in a transverse line at 3–4 cm above the pubic symphysis (Fig. 1B). Both 8-mm lateral ports (R1 and R3 in Fig. 1B) were placed at a minimum distance of 3 cm medial to the ASIS on each side. The 8-mm port for the robotic laparoscope was inserted on right medial side and the 12-mm port for the robotic stapler (R2) insertion was placed on the left medial side. The robotic cart was then placed on the right side of the patient for the convenience of the patient-side assistant. Regardless of the generation of the system, the instrumentation used was the same: a monopolar scissor was used as the main dissector through the R1 port. A bipolar grasper was inserted through R2, and a tip-up grasper or a double fenestrated grasper through R3. A robotic stapler and a needle driver were used through R1 in exchange of the monopolar scissor when necessary.

Inferior to superior mobilization of the ascending colon

For the initial exposure, the greater omentum was flipped over the transverse colon toward the liver, and the small bowel loops were retracted into the left side of the abdominal cavity. Inferior-to-superior dissection was initiated by retracting the cecum anteriorly, medially, and superiorly using the double-fenestrated or tip-up grasper in the third robotic arm (R3). The peritoneum at the retrocecal recess was incised, and the retroperitoneal avascular plane was developed up to the third portion of the duodenum and the pancreas head (Fig. 2A). An avascular surgical plane composed of Told's line and the prerenal fascia was exposed to uncover the head of the pancreas, the second portion of the duodenum, the right gonadal vessels, and the ureter (Fig. 2B and C). The integrity of the mesocolon was strictly preserved as for the procedure followed during total mesorectal excision (TME) for rectal cancer.

Central vascular dissection

After completion of the inferior approach, we proceeded to handle the medial and anterior side of the mesocolon, and central vascular dissection with lymphadenectomy at the origin of the ileocolic, right colic, and middle colic vessels was performed along the left border of the superior mesenteric vein. The third robotic arm (R3) was used to lift the ileocolic pedicle, and dissection was commenced along a vertical line to expose the superior mesenteric vein, with stable and durable retraction. The ileocolic artery and vein were transected at the root and the dissection continued upwards to the right colic vessels (if present) and the gastrocolic trunk (Fig. 2D). We transected the colonic branch of the gastrocolic trunk, preserving its pancreatic and gastric branches, and exposed the middle colic artery at its origin (Fig. 2E). After LN dissection in this region, the right branch of the middle colic artery was ligated (Fig. 2F). When the primary tumor was located at the hepatic flexure and proximal transverse colon, the root of the middle colic artery and vein were identified and cut. The transverse mesocolon was suspended by the third robotic arm (R3) and the lesser sac was entered just above the head of the pancreas.

Dissection around the gastrocolic and gastroepiploic area

The greater omentum of the transverse colon was then transected to allow entry into the lesser sac, joining with the previous surgical plane of the medial dissection. At this point, the fixed third-arm traction on the greater omentum and

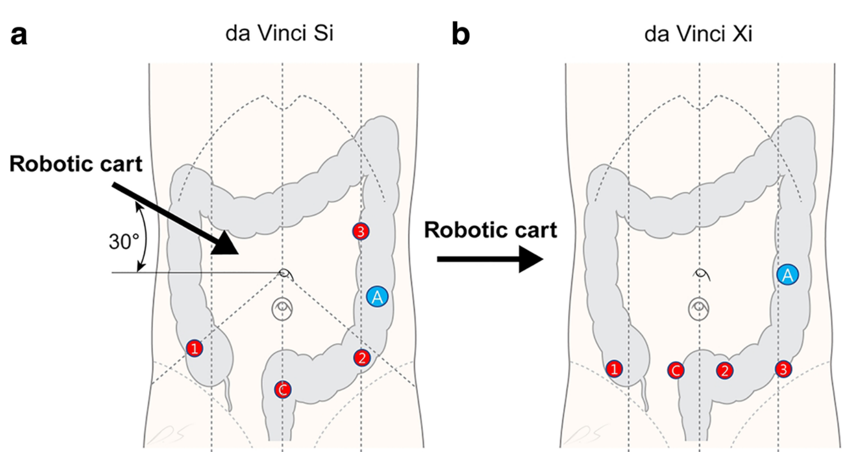

Fig. 1 Ports and robotic cart placement for totally robotic right hemicolectomy. The S and Si da Vinci robotic system B Xi da Vinci robotic system are shown. *R*, robotic port; *A*, assistant port

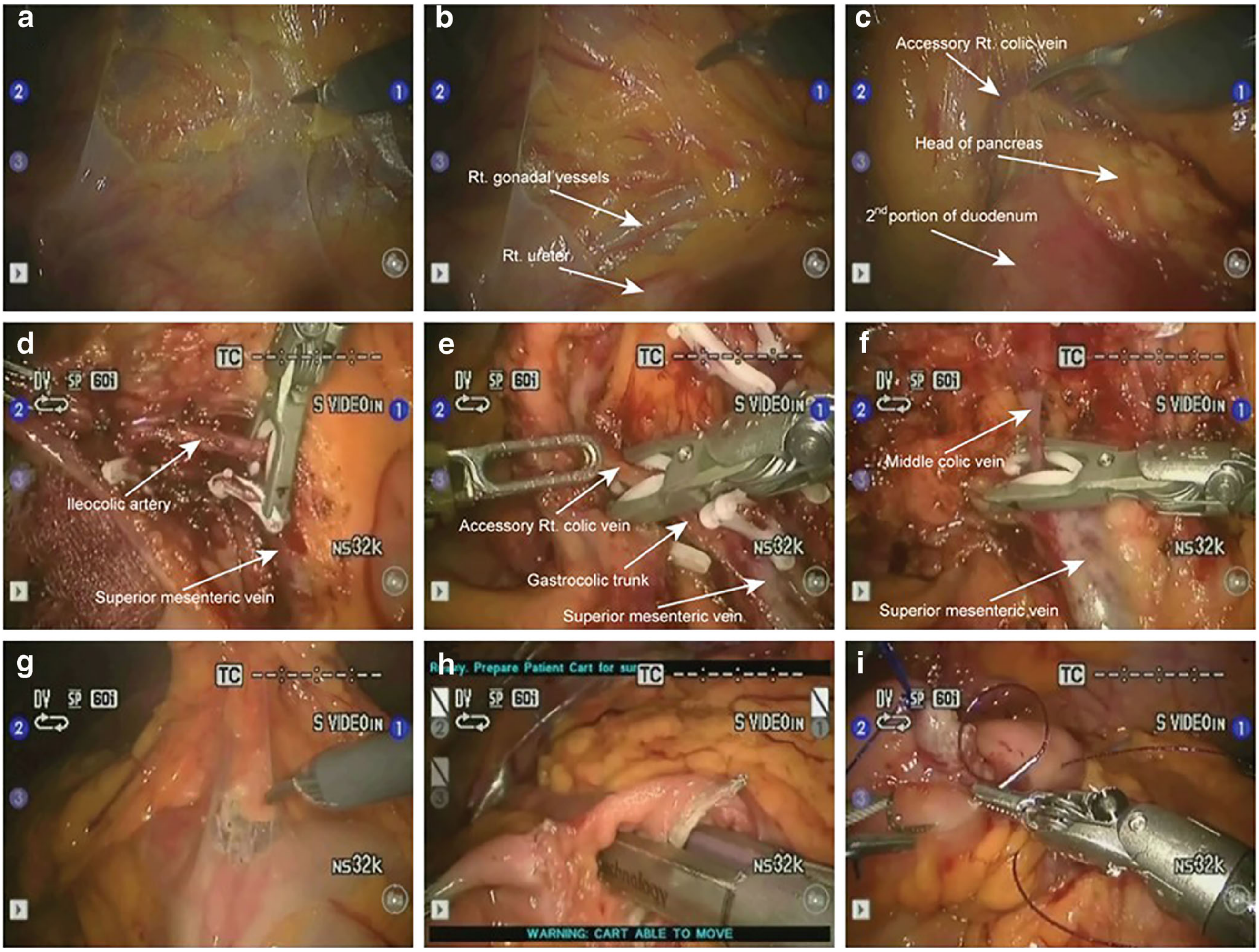

Fig. 2 Totally robotic modified complete mesocolic excision and central vascular ligation for right-sided colon cancer. A. Incision of the peritoneum at the retrocecal recess. B. Identification of the right gonadal vessels and ureter. C. Exposure of the third portion of the duodenum and the head of the pancreas. D. Control of the ileocolic vessels. E. Ligation of the colonic branch draining to the gastrocolic trunk. F. Ligation of the middle colic vein. G. Separation of the greater omentum from the transverse colon. H. Side-to-side intracorporeal isoperistaltic anastomosis. I. Closure of the stapler insertion site with robotic-assisted continuous stitches

posterior wall of the stomach helped facilitate dissection of the omentum (Fig. 2G). We routinely removed the omentum with preservation of gastroepiploic vessels and performed the dissection of the gastroepiploic lymph node and ligation of gastroepiploic vessels for advanced disease, especially those located on the hepatic flexure or transverse colon. After the lateral peritoneum of the ascending colon and the attachment of the hepatic flexure were detached, the gastrocolic ligament and the right side of the greater omentum were dissected.

Intracorporeal anastomosis and specimen extraction

The transverse mesocolon and small bowel mesentery were divided. The transverse colon and terminal ileum were then transected using laparoscopic linear staplers by the assistant at the patient table in the earlier period when the robotic stapler was not available, but subsequently it was performed using the robotic stapler. Enterotomies were made in both cut-ends of the ileum and the transverse colon. A linear stapler was introduced to create a side-to-side anastomosis isoperistaltically (Fig. 2H). Next, the monopolar curved scissors were replaced with the Suture Cut Needle Driver (Intuitive Surgical, CA, USA), and the common enterotomy hole was closed with continuous stitches using a barbed polypropylene suture or V-Loc suture (Medtronic, Minneapolis, USA) (Fig. 2I). Finally, a drainage tube was placed at the right paracolic sulci through the R2 port. The specimen was wrapped in a sterile bag and extracted through either an extended camera or via the R1 port incision (Fig. 3).

Statistical analysis

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS) software, version 20.0

(SPSS Inc., Chicago, IL) and data were typically expressed as frequency (percentage) or median (range). Survival rates were determined by the Kaplan-Meier method and *P* values of less than 0.05 indicated statistically significant differences.

Results

Patient characteristics

The baseline demographics of patients are summarized in Table 1, whereas the perioperative characteristics are listed in Table 2. The age and body mass index were 66 (32–85) years and 22.9 (17.1–32.0) kg/m^2, respectively. Of the 43 procedures evaluated in the study, 38 (88.4%) were performed using the Si robotic system, whereas 5 (11.6%) were performed using the Xi system. Tumor location involved the cecum, ascending colon, and transverse colon in 12 (27.9%), 29 (67.4%), and 2 (4.7%) patients, respectively. The preoperative levels of carcinoembryonic antigen were 3.0 (1.0–474.0) ng/mL. Four patients (9.3%) had previously undergone abdominal surgery, whereas 25 patients (58.1%) received adjuvant chemotherapy after operation.

Short-term outcomes

All 43 procedures achieved technical success without the need for conversion to laparoscopic or open surgery. The total operation and docking times were 293 (180–644) and 5 (3–19) min, respectively, with an estimated blood loss of 50 (10–400) mL. D3 lymphadenectomy was performed in all patients. The time to first flatus and soft diet was 3 (1–16) and 4 (1–16) days, respectively. The duration of hospitalization was 8 (4–48) days. Paralytic ileus occurred in two patients (4.7%), both responding to conservative management with intravenous fluids, bowel rest, and nasogastric aspiration. Chyle leakage

Fig. 3 The postoperative patient view

Table 1 Patient characteristics

Sex, *n* (%)	
Male	20 (46.5)
Female	23 (53.5)
Age (years), median (range)	66 (32–85)
ASA score, *n* (%)	
1	35 (81.4)
2	5 (11.6)
3	3 (7.0)
Body-mass index (kg/m^2), median (range)	22.9 (17.1–32.0)
Robotic system, *n* (%)	
S or Si system	38 (88.4)
Xi system	5 (11.6)
Tumor location, *n* (%)	
Cecum	12 (27.9)
Ascending colon	29 (67.4)
Transverse colon	2 (4.7)
Preoperative CEA (ng/mL), median (range)	3.0 (1.0–474.0)
History of abdominal surgery, *n* (%)	4 (9.3)
Adjuvant chemotherapy, *n* (%)	25 (58.1)

SD, standard deviation; ASA, American Society of Anesthesiologists; CEA, carcinoembryonic antigen

Table 2 Perioperative outcomes

Total operation time (min), median (range)	293 (180–644)
Docking time (min), median (range)	5 (3–19)
Blood loss (mL), median (range)	50 (10–400)
Conversion (%), *n* (%)	0 (0)
D3 lymphadenectomy, *n* (%)	31 (100)
Morbidity within 30 days after surgery, *n* (%)	9 (21.0)
Pulmonary complications	2 (4.7)
Cirrhotic ascites	1 (2.3)
Chyle leakage	2 (4.7)
Ileus	2 (4.7)
Intra-abdominal abscess	1 (2.3)
Anastomotic leakage	1 (2.3)
Clavien-Dindo classification	
Grade I	3 (7.0)
Grade II	5 (11.7)
Grade IIIa	2 (4.7)
Grade IIIb	1 (2.3)
Grade IV	0 (0)
Days to 1st flatus (day), median (range)	3 (1–16)
Days to 1st soft diet (day), median (range)	4 (1–16)
Hospital stay, median (range)	8 (4–48)
Mortality, within 30 days after surgery, *n* (%)	0 (0)

SD, standard deviation

requiring total parenteral nutrition occurred in two patients (4.7%) but recovered with conservative management. One patient (2.3%) had pneumonia and recovered with antibiotic treatment. There was one case (2.3%) of pleural effusion, which was successfully treated with percutaneous drainage. Two cases of intra-abdominal abscess occurred; one was recovered with percutaneous drainage only, and the other with anastomosis leakage was treated by surgical drainage and re-anastomosis. There was no mortality associated with the procedure. According to the Clavien-Dindo classification, complications of grades I, II, IIIa, IIIb, and IV were noted in 3 (7.0%), 5 (11.7%), 2 (4.7%), 1 (2.3%), and 0 (0%) patients, respectively.

Postoperative pathologic outcomes

Pathologic characteristics are summarized in Table 3. One patient with pathologically T0N0M0 was diagnosed after radical resection that was indicated with non-lifting sign on preoperative colonoscopy. The moderately differentiated histological type (76.7%) was most commonly noted and eight tumors (18.6%) showed lymphovascular invasion. A total of 29 (6–157) LNs were harvested per patient, with 2 (1–11) positive nodes. The proximal and distal resection margins were 14 (4–54) and 19 (4–48) cm, respectively.

Oncologic outcomes

OS and DFS rates are presented in Fig. 4. The patients were followed-up for a median of 55 months, during which the mean OS rate was 93.6%, the median DFS was 38 months, and the DFS was 81.1%. Seven patients (16.3%) had recurrence after surgery (Table 4). Five systemic recurrences (11.6%) developed in the liver, left ovary, paraaortic lymph node, and peritoneum, respectively, and two local recurrences (4.7%) developed in upper boarder and anterior surface of pancreas, respectively.

Table 3 Postoperative pathological outcomes

TNM Stage, *n* (%)	
Stage 0	1 (2.3)
Stage I	9 (20.9)
Stage II	15 (34.9)
Stage III	15 (34.9)
Stage IV	3 (7.0)
Histology, *n* (%)	
Well differentiated	7 (16.3)
Moderately differentiated	33 (76.7)
Poorly differentiated	2 (4.7)
Mucinous	1 (2.3)
Lymphovascular invasion, *n* (%)	8 (18.6)
Tumor size (cm), median (range)	4.0 (1.0–13.0)
Retrieved LNs, median (range)	29 (6–157)
Positive LNs, median (range)	2 (1–11)
PRM (cm), median (range)	14 (4–54)
DRM (cm), median (range)	19 (4–48)

TNM, tumor node metastasis; SD, standard deviation; LNs, lymph nodes; PRM, proximal resection margin; DRM, distal resection margin

Discussion

Data from our study demonstrate the feasibility and safety of the robotic CME and CVL, with mid-term oncologic outcomes comparable with those reported in previous studies. The overall rate of complications within 30 days postoperatively was 21.0%, most of which were Clavien-Dindo grades I to II. None of the robotic procedures had to be converted to open surgery. These findings are consistent with previous observations that describe a morbidity rate of approximately 20% and very low conversion rate for robotic colorectal operations [12–14]. Moreover, 29 LNs were harvested per patient and only 1 patient (1.3%) had fewer than 12 LNs resected. The mean overall and disease-free 5-year survival rates were 93.6% and 81.1%, respectively, which are consistent with those reported in previous studies of CME and CVL [3, 6, 15]. The mid-term oncologic outcomes suggest that the robotic approach can implement D3 lymphadenectomy with delicate sharp dissection for CME.

We have been practicing an equivalent LN dissection principle in function of tumor location and extent for many years. We have named the procedure "modified CME with CVL" and recently reported its comparable outcomes [4]. Such systematic lymphadenectomies require skeletonizing feeding vessels of the cancer-risen site up to their origin and considering vitality of the feeding vessels of right side colon. The procedure is technically demanding. Since we first began to use a robotic system to perform colorectal cancer surgery in June 2006, we have developed a robotic technique for right-sided colon cancer that involves CME and CVL with intracorporeal anastomosis.

From our experience, we appreciate the advantages of tremor-free articulated movement of robotic instruments, especially during vascular dissection where a single error may lead to a catastrophic disaster. The high degree of freedom of the monopolar scissor and steady traction by another robotic grasper could compensate the limited availability of advanced energy instruments. In addition to wristed instrumentation, the intra-operative near-infrared fluorescence imaging system incorporated into the robotic system allows the surgeon to identify the colic branches of the superior mesenteric vessels near the central vascular trunk and choose the extent of LN dissection. In addition, the surgeon may identify the demarcated ischemic zone in the transverse colon and distal ileum during

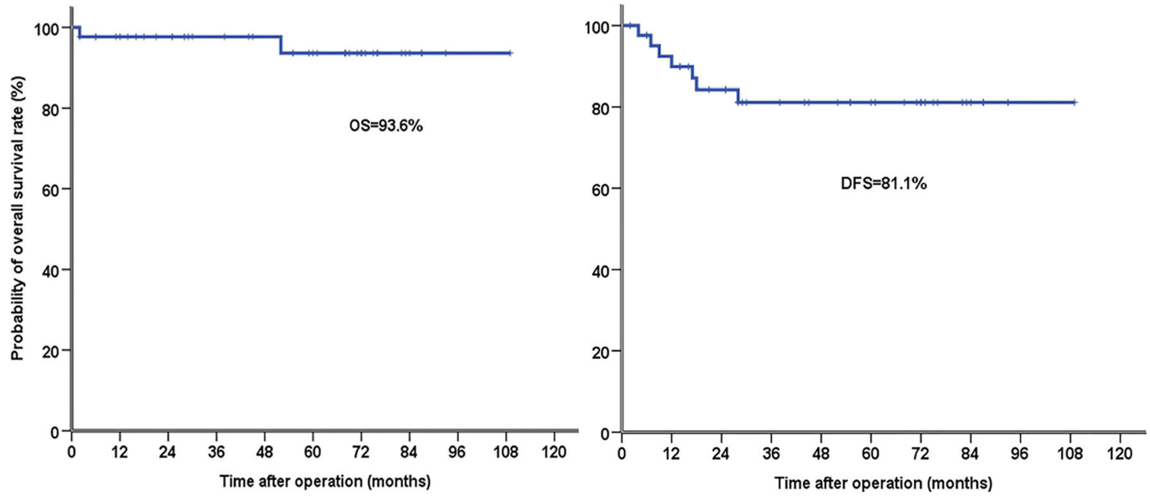

Fig. 4 Overall and disease-free survival rates. *OS*, overall survival; *DFS*, disease-free survival

intracorporeal anastomosis, which could help define the resection margins. Further study is needed to demonstrate the clinical benefits of using this technique in robotic CME and CVL for right-sided colon cancer.

Regarding short-term outcomes, the data from our study demonstrate the technical feasibility and short-term safety of robotic CME. Bertelsen et al. [16] reported that the 90-day mortality rate was 6.2% in the CME group and 4.9% in the non-CME group (p = 0.219), and that CME was associated with more intraoperative complications, including central vascular injury, and severe non-surgical complications than non-CME resection for colon cancer [16]. Wang et al. [17] demonstrated that CME was associated with greater intraoperative blood loss and more postoperative morbidity than non-CME. In our study, no mortality was associated with the procedure, and the overall complication rate was 21.0%, most of which were Clavien-Dindo grade I to II. We think that some advantages of the surgical robotic system could be used to overcome the drawbacks of CME resection in spite of its oncologic benefit.

Table 4 Recurrence patterns of robotic mCME for right-sided cancer

Systemic recurrence	5 (11.6%)
Liver	1 (2.3)
Left ovary	1 (2.3)
Paraaortic node	1 (2.3)
Carcinomatosis	1 (2.3)
Seeding nodule on sigmoid colon	1 (2.3)
Local recurrence	2 (4.7)
Upper border of pancreas	1 (2.3)
Anterior surface of pancreas	1 (2.3)
Total number of recurrences	7 (16.3%)

mCME, modified mesocolic excision

Recently, Spinoglio et al. [18] reported the oncologic outcomes of a comparative study between 101 robotic CMEs and 101 laparoscopic CMEs. The 5-year OS and DFS rates were 77% and 73%, and 85% and 83%, respectively, without significant differences. In the present study, the OS and DFS rates during the 55-month follow-up period were 93.6% and 81.1%, respectively. In our previous comparative study that compared 128 patients who underwent laparoscopic CME and 137 patients who underwent an open CME with propensity score matching, the 5-year OS rates of the open and laparoscopic CME groups were 77.8% and 90.3% (p = 0.028), respectively, and the 5-year DFS rates were 71.8% and 83.3% (p = 0.578), respectively [19]. These results suggest that CME incorporated with the robotic approach is oncologically safe, although the present study is not a comparative study between the laparoscopic and open approaches.

Intracorporeal anastomosis is another technical issue for which many surgeons have expressed interested. Limited high quality evidence is available, but recently Oostendorp et al. [20] reviewed 12 non-randomized studies of 1492 patients (763 and 729 with intra- or extracorporeal anastomosis). They observed that intracorporeal anastomosis was associated with reduced short-term morbidity and decreased length of hospital stay and concluded that the technique might lead to faster recovery compared with extracorporeal anastomosis. In the current series, we used stapled side-to-side anastomosis technique. Then benefit of the robotic approach was appreciated when closing the common enterotomy hole (where the linear stapler was inserted) with a continuous running suture, and would be particularly valued when a sawn anastomosis is preferred.

The differences between the generations of robotic system were noticeable. Using the previous generation Si, an arc-shaped port placement was required to maintain an adequate range of motion of the robotic instruments and to avoid collisions between devices. With the new system, given the mechanical improvements, a lower abdominal transverse port placement was possible [21]. This difference was not translated into clinical parameters (data not shown). One may expect some cosmetic benefits and less postoperative pain from the new port placement because incisions are made in the lower abdomen. Nonetheless, the differences, if any, might be trivial. The actual advantage of lower abdominal transverse port placement is that it can be used for left-sided colon resection unlike an arc-shaped placement. However, a drawback is the different orientation of the operative view. Because the camera is placed in the low abdomen, the orientation of the view is from-inferior-to-superior. This view may be awkward if the direction of the dissection is from-superior-to-inferior especially when dealing with mid-colic vessels and the gastroepiploic vessels area. However, from our experience, we have observed that surgeons with anatomical notions became familiar to the view after a few cases.

The current study was designed to provide an overview of the clinical feasibility and the oncologic safety of the robotic mCME+CVL for right-sided colon cancer, and therefore, one should be cautious to draw any conclusion regarding advantages and disadvantages of this technique in comparison with others, including the laparoscopic or the open approach. Despite some limitations of this study such as the single surgeon's experience, lack of quality assessment for CME/tissue morphometry, potential selection bias by the surgeon or patient due to cost and insurance issue, the small number of patients, and the unproven replicability of this technique, the results suggest that the total robotic approach for mCME+CVL may provide the following advantages for right-sided colon cancer treatment. First, it may allow precise and safe LN dissection along the superior mesenteric trunk. Second, the procedure facilitates performing appropriate mesocolic resection with enhanced visualization and stable traction. Third, the procedure allows safe and feasible intracorporeal anastomosis. The results of this study are not conclusive, but urge further study to obtain high-level evidence in favor of the use of robotic mCME+CVL procedures for right-sided colon cancer.

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Compliance with ethical standards

Conflicts of interest Drs. Bae, Yang, and Min have no conflicts of interest or financial ties to disclose.

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