



Totally robotic complete mesocolic excision for right-sided colon cancer

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Abstract

Complexity and operative risks of complete mesocolic excision (CME) seem to be important drawbacks to generalize this procedure in the surgical treatment of right colon cancer. Robotic systems have been developed to improve quality and outcomes of minimal invasive surgery. The aim of this study was to evaluate the feasibility of robotic right-sided CME and present our initial experience. A retrospective review of 37 patients undergoing totally robotic right-sided CME between February 2015 and November 2017 was performed. All the operations were carried out using the key principles of both CME with intracorporeal anastomosis and no-touch technique. Data on perioperative clinical findings and short-term outcomes were analyzed. There were 20 men and 17 women with a mean age of 64.4 ± 13.5 years and a body mass index of 26.8 ± 5.7 kg/m². The mean operative time and estimated blood loss were 289.8 ± 85.3 min and 77.4 ± 70.5 ml, respectively. Conversion to laparoscopy occurred in one patient (2.7%). All the surgical margins were clear and the mesocolic plane surgery was achieved in 27 (72.9%) of the cases. The mean number of harvested lymph nodes was 41.8 ± 11.9 (median, 40; range 22–65). The mean length of hospital stay was 6.6 ± 3.7 days. The intraoperative and postoperative complication rates were 5.4 and 21.6%, respectively. We believe that use of robot for right-sided CME is feasible and appears to provide remarkably a high number of harvested lymph nodes with good specimen quality.

Keywords Right-sided colon cancer · Complete mesocolic excision · Robotic surgery · Feasibility

Introduction

During the last two decades, surgical treatment for colon cancer has seen very important revolutions following the introduction of complete mesocolic excision (CME) [1] and robotic technology. The main concepts behind CME are radical oncologic resection with central vascular ligation in the embryologic tissue planes and preservation of the intact envelope of visceral peritoneum to maximize lymph node harvest and minimize tumor spread [1, 2]. Data suggest that

this technique produces a higher degree of lymphadenectomy and better oncologic outcomes compared to standard, non-mesocolic excision [3, 4].

In its original description, CME was performed via laparotomy, and eventually, the technical feasibility and oncological safety of laparoscopic approach have been reported [5–7]. Nevertheless, laparoscopic right-sided CME, especially when combined with an intracorporeal anastomosis, is still considered as one of the most challenging and technically demanding procedures to perform [8, 9]. This may be due to the complex vascular anatomy of the right colon [10, 11] and inherent technical limitations of the laparoscopic approach, such as rigid instrumentation, decreased range of motion and poor ergonomics.

The technical advantages of robotic systems over laparoscopy, including stable instrumentations with a higher range of motion, precise dissection and better ergonomics has further revolutionized minimal invasive approach in colorectal surgery [12, 13]. However, there seems to be a relatively slow adoption of robotic surgery for the right-sided CME

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procedure. In this study, we report the feasibility of totally robotic CME with intracorporeal anastomosis for right-sided colon cancer and present short-term outcomes.

Materials and methods

This study was approved by the Institutional Review Board. Between February 2015 and November 2017, 37 patients underwent robotic CME with high vascular ligation for right-sided colon cancer. Informed consent was obtained from all patients for being included in the study. All data regarding patient demographics, operative and histopathologic results and postoperative outcomes were collected prospectively. Research Electronic Data Capture (REDCap) hosted at the University of Minnesota [14] was used for data collection. Docking time was defined as the time from moving the robot in the surgical field to setting the robotic arms into the port sites. Overall, operative time was defined as the time from the first skin incision to final closure of the abdominal wall. Conversion was defined as the completion of any part of the procedure with an open or standard laparoscopic technique, excluding the delivery of the specimen.

Preoperative work-up and preparation

After the diagnosis of right colon cancer was made by colonoscopic and histologic examinations, a computed tomography scan of the abdomen and thorax was performed to determine the clinical tumor stage. Bowel preparation protocol included a fiber-free diet for 2 days and 90 ml Na-phosphate soda and enema 1 day before surgery. Preoperatively, all the patients received venous thrombosis prophylaxis with compressive elastic stockings 12 h, antibiotic prophylaxis 1 h before the operation. After induction of general anesthesia, a nasogastric tube and a urinary catheter were placed.

Operative procedure

All the operations were carried out with the da Vinci Xi[®] Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA). The outlines of our surgical technique were previously reported in a multimedia article [15]. Describing in detail, the operation was performed using the medial-to-lateral, no-touch approach through four robotic and one assistant ports. Two types of operative strategies were followed; for cecal or proximal ascending colon cancers, dissection was performed in a usual inferior-to-superior manner along the superior mesenteric vein (SMV). For distal ascending colon, hepatic flexure or proximal transverse colon cancers requiring an extended CME with central ligation of the middle colic vessels, a top-to-down dissection technique which

is a modified version of the cranial-to-caudal approach [16, 17], was used as described below.

Patient was placed in a modified lithotomy position with both arms placed alongside the body. Pneumoperitoneum was established with a Veress needle introduced through an 8-mm incision in the left upper quadrant and maintained at 12 mmHg. An 8-mm robotic port was placed through this incision and a 30-degree camera was introduced via this port. The remaining three 8-mm robotic ports and one 5-mm assistant port were placed under direct vision. The assistant port was primarily used for suction and bowel retraction. The robotic ports were placed at least 6 cm apart from each other and arranged in a line, as shown in Fig. 1. Following visual inspection of the abdominal cavity to assess any obvious evidence of distant metastatic disease, the patient was placed in a 30-degree Trendelenburg position with the operating table tilted to the left side. The small bowel loops were retracted medially and the omentum above the transverse colon, exposing the ventral side of the ascending and transverse mesocolon. The robotic cart was docked from the right side of the patient and the robotic arms were mounted to the ports. In the starting configuration, camera was positioned at arm 3, and then, double fenestrated tip-up grasper was at arm 1, double fenestrated bipolar forceps at arm 2, and monopolar curved scissors at arm 4. Later in the operation, arm 4 served for stapling and placing sutures.

Dissection was initiated by retracting the ascending mesocolon near the ileocecal junction anteriorly and laterally with the tip-up grasper. The peritoneum overlying the ileocolic vascular pedicle was gently lifted up with bipolar forceps and incised with monopolar scissors. First, the ileocolic vein, and then, the ileocolic artery were isolated individually, clipped with 5-mm robotic clips near its origin from the SMV and SMA and divided (Fig. 2). Dissection was continued superiorly along the ventral side of the SMV, dissecting out the entire mesocolic tissues until the second portion of the duodenum and head of the pancreas were



Fig. 1 Port set-up for robotic complete mesocolic excision

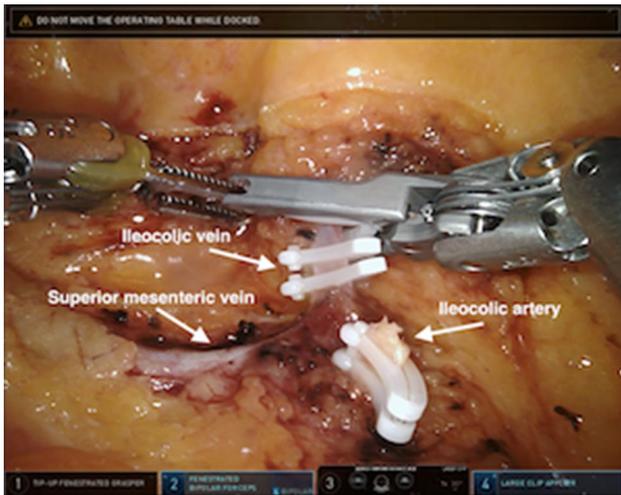


Fig. 2 Division of the ileocolic vein

reached. During this dissection process, the right colic vessels, if present, were clipped and divided near their origins in the same fashion. Careful dissection onto the duodenum and the inferior border of the neck of the pancreas was made to expose the right branch of the middle colic vessels, which were clipped and divided (Fig. 3). The medial-to-lateral mesenteric dissection was completed staying between the embryological planes just over the Toldt's fascia, preserving the duodenum, right ureter and gonadal vessels. With caudal traction of the transverse colon, the bursa omentalis was entered and the gastrocolic ligament was divided from left to the right along the greater curvature of the stomach. Robotic clips or vessel-sealing system introduced through the fourth port were used for vascular control during this dissection. Then, the terminal ileum and transverse colon

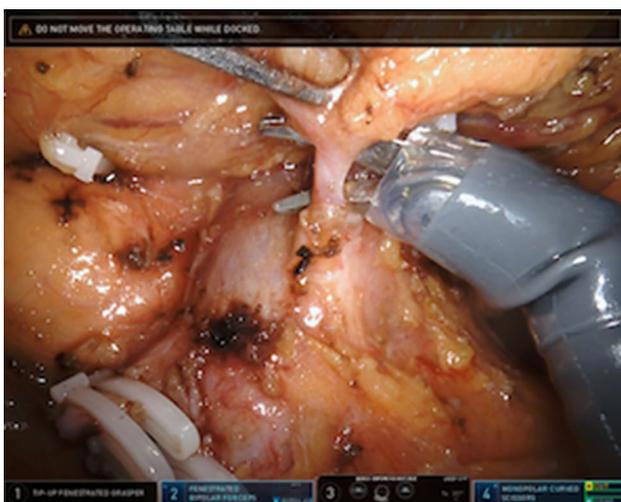


Fig. 3 Division of the right branch of the middle colic artery

were dissected free of its mesentery for bowel transection. To introduce the stapler, the fourth robotic arm port was temporarily demounted and the port-site was enlarged to insert a 12-mm port. The terminal ileum and the transverse colon were transected sequentially using robotic EndoWrist® staplers with blue cartridge (Intuitive Surgical Inc., Sunnyvale, CA, USA). After bowel transection, the hepatic flexure and lateral attachments of the ascending colon were mobilized using scissors. Following completion of CME, an endobag was introduced through a 15-mm laparoscopic trocar placed at the suprapubic 8-mm robotic port site and the specimen was placed in the endobag.

The next step of operation was to perform a side-to-side isoperistaltic ileotransversostomy anastomosis. The anastomosis was created intracorporeally. For this, an obturator was inserted into the existing 12-mm trocar so as to accommodate robotic needle holder. The terminal ileal and transverse colonic ends were placed adjacent to each other; a stay suture was placed through the bowel and anterior abdominal wall to aid approximation of the two bowel segments and use as traction during stapler insertion. Then, an enterotomy and colotomy were made using scissors and a stapled anastomosis was created (Fig. 4). The stapler insertion site was closed with a continuous 3/0 V-Loc™ and a second layer of interrupted sero-serosal 3/0 silk sutures. After hemostasis was ensured, the robot was undocked. No abdominal drain was routinely placed. The specimen was extracted with the endobag through a suprapubic incision at the suprapubic port site to a length comparable to the size of the specimen (Fig. 5). The extraction site was closed using a 2/0 polydioxanone suture. The fascia at the camera port and skin incisions were closed with 2/0 Vicryl and subcuticular absorbable stitches, respectively.

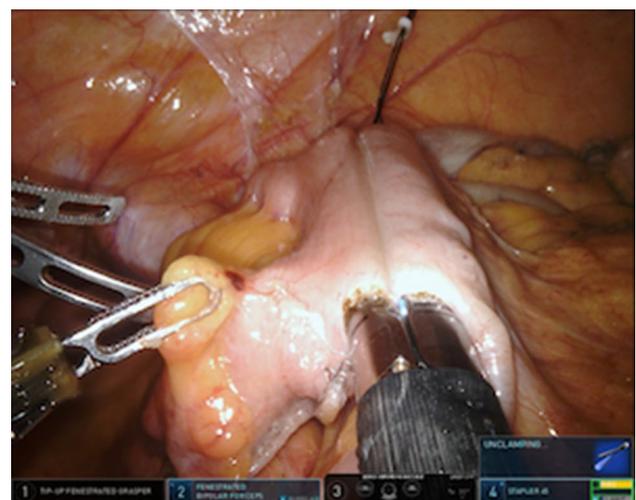


Fig. 4 Creation of an intracorporeal ileocolic anastomosis using a robotic stapler

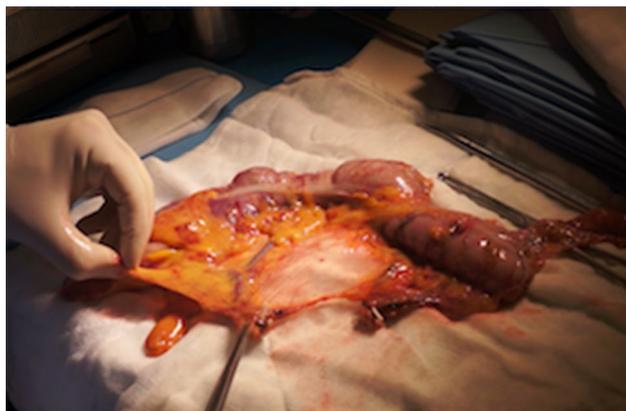


Fig. 5 View of the surgical specimen

In the top-to-down technique for an extended CME, all the operative steps were the same as those described above except dissection was initiated superiorly in the gastrocolic ligament. First, the omental bursa was opened and the right gastroepiploic vessels were identified. Using this vein as a landmark (Fig. 6), dissection was continued caudally to expose the gastrocolic trunk of Henle. The right gastroepiploic vessels, branches of the gastrocolic trunk and the main pedicle of the middle colic vessels were isolated, clipped and divided individually. After this step, the transverse colon was raised ventrally and dissection was continued in an inferior-to-superior fashion along the SMV, dividing the ileocolic and right colic vessels (if present). Finally, the ascending and transverse mesocolon were separated from the retroperitoneal tissues, completing CME.



Fig. 6 Top-to-down technique. Using the right gastroepiploic vein as a landmark, dissection is conducted caudally until the superior mesenteric vein and gastrocolic trunk of Henle are exposed

Postoperative course

Postoperative intravenous narcotics were given as needed for postoperative pain control. Removal of nasogastric tube and start of oral intake were determined on the basis of return of bowel movement and decision of the surgical team. Patients were discharged from the hospital when sufficient oral intake, full ambulation, and adequate pain control with oral analgesics were achieved.

Results

Patient demographics and preoperative clinical data are presented in Table 1. There were 20 men and 17 women with a mean age of 64.4 ± 13.5 years and a body mass index of 26.8 ± 5.7 kg/m². Nine patients had a history of previous abdominal surgery. At admission, two patients with cancer localized to the ascending colon had a clinical presentation of partial bowel obstruction.

Operative findings and perioperative outcomes are provided in Table 2. CME and extended CME were performed in 21 and 16 patients, respectively. Accordingly, the top-to-down approach with robot double-docking was used in 16 patients. All the procedures were completed without changing the port set-up. One case was converted to laparoscopy

Table 1 Demographics and clinical characteristics

| | |
|--|-----------------|
| Age, years, mean \pm SD | 64.4 \pm 13.5 |
| Gender, <i>n</i> (%) | |
| Male | 20 (54.1) |
| Female | 17 (45.9) |
| BMI, kg/m ² , mean \pm SD | 26.8 \pm 5.7 |
| ASA score, <i>n</i> (%) | |
| I | 8 (21.6) |
| II | 24 (64.9) |
| III | 5 (13.5) |
| Previous abdominal surgery, <i>n</i> (%) | 9 (24.3) |
| Hysterectomy | 2 |
| Appendectomy | 2 |
| Prostatectomy | 2 |
| Left hemicolectomy | 1 |
| Cystectomy | 1 |
| Cholecystectomy | 1 |
| Tumor location, <i>n</i> (%) | |
| Cecum | 15 (40.6) |
| Proximal ascending colon | 6 (16.2) |
| Distal ascending colon | 5 (13.5) |
| Hepatic flexure | 6 (16.2) |
| Proximal transverse colon | 5 (13.5) |

BMI body mass index, *ASA* American Society of Anesthesiologists, *SD* standard deviation

Table 2 Operative findings and perioperative outcomes

| | |
|--|--------------------------|
| Type of operative procedure, <i>n</i> (%) | |
| CME | 21 (56.7) |
| Extended CME | 16 (43.3) |
| Operative technique, <i>n</i> (%) | |
| Caudal-to-cranial | 21 (56.7) |
| Modified cranial-to-caudal (top-to-down) | 16 (43.3) |
| Robot docking time, min, mean \pm SD | 5.3 \pm 2.6 |
| Operative time, min | |
| Mean \pm SD | 289.8 \pm 85.3 |
| Median (range) | 265 (180–445) |
| Estimated blood loss, ml, mean \pm SD (range) | 77.4 \pm 70.5 (10–300) |
| Length of suprapubic incision, cm, mean \pm SD (range) | 6.9 \pm 1.6 (4–10) |
| Conversion, <i>n</i> (%) | 1 (2.7) |
| Intraoperative complication, <i>n</i> (%) | 2 (5.4) |
| Time to first flatus, days, mean \pm SD | 2.9 \pm 1.9 |
| Time to first bowel movement, days, mean \pm SD | 3.6 \pm 2.2 |
| Time to resume soft diet, days, mean \pm SD | 3.4 \pm 2.3 |
| Length of hospital stay, days, mean \pm SD | 6.6 \pm 3.7 |
| 30-day morbidity, <i>n</i> (%) | 8 (21.6) |
| Wound infection | 2 |
| Intraabdominal abscess | 1 |
| Intraabdominal hemorrhage | 1 |
| Ileus | 1 |
| Pulmonary embolism | 1 |
| Nosocomial pneumonia | 1 |
| Atelectasis | 1 |
| Reoperation, <i>n</i> (%) | 1 (2.7) |
| 30-day readmission, <i>n</i> | 0 |
| 30-day mortality, <i>n</i> | 0 |

CME complete mesocolic excision, SD standard deviation

(2.7%) due to the presence of diffuse abdominal adhesions secondary to the previous surgery. The mean operative time and estimated blood loss were 289.8 ± 85.3 and 77.4 ± 70.5 min, respectively. There were no intraoperative complications except in two patients with minor vascular injury. Both of these injuries occurred at the origin of a jejunal branch of the SMV and repaired uneventfully with prolene sutures.

The mean time to first bowel movement and receiving a soft oral diet were 3.6 ± 2.2 and 3.4 ± 2.3 days, respectively. The mean length of hospital stay was 6.6 ± 3.7 days. During the postoperative 30-day period, seven patients developed eight complications (21.6%); wound infection ($n=2$), intraabdominal abscess followed by hemorrhage ($n=1$), paralytic ileus ($n=1$), pulmonary embolism ($n=1$), nosocomial pneumonia ($n=1$) and atelectasis ($n=1$). The intraabdominal hemorrhage occurred 10 days after an extended CME in a male patient who had primarily developed an abscess in the lesser omental sac that required a percutaneous drainage postoperatively. Due

to hemodynamic instability, emergency laparotomy was performed in this patient and the bleeding vessel from the mesocolic site of the abscess cavity was controlled with sutures. For wound infections, local drainage of the incision site was required. The patient with ileus was effectively managed with nasogastric tube decompression. Pulmonary embolism was treated with heparin therapy. The patient with pneumonia and the other with atelectasis were successfully managed with medical therapy.

Histopathologic findings are presented in Table 3. The mean number of harvested lymph nodes was 41.8 ± 11.9 (median, 40; range 22–65). Fifteen patients had metastasis in the lymph nodes. All the surgical margins were clear. The mean length between vascular tie and tumor was 12.7 ± 3.4 cm. The mesocolic plane, intramesocolic plane and muscularis propria plane were observed in 27 (72.9%), 9 and 1 specimens, respectively. At a mean follow-up time of 14.8 ± 9.2 months, there was no recurrence or disease-related mortality.

Table 3 Pathology results

| | |
|--|------------------------|
| pT category, <i>n</i> (%) | |
| <i>T</i> ₀ | 1 (2.7) |
| <i>T</i> ₁ | 1 (2.7) |
| <i>T</i> ₂ | 7 (18.9) |
| <i>T</i> ₃ | 12 (32.4) |
| <i>T</i> ₄ | 16 (43.3) |
| pN category, <i>n</i> (%) | |
| <i>N</i> ₀ | 22 (59.5) |
| <i>N</i> ₁ | 10 (27.0) |
| <i>N</i> ₂ | 5 (13.5) |
| pTNM stage, <i>n</i> (%) | |
| 0 | 1 (2.7) |
| I | 6 (16.2) |
| II | 16 (43.2) |
| III | 11 (29.7) |
| IV | 3 (8.1) |
| Tumor size, cm, mean ± SD (range) | 5.2 ± 2.5 (0.6–10.0) |
| Number of harvested lymph nodes | |
| Mean ± SD | 41.8 ± 11.9 |
| Median (range) | 40 (22–65) |
| Number of metastatic lymph nodes, mean ± SD (range) | 1.4 ± 2.8 (1–12) |
| Specimen length, cm, mean ± SD (range) | 34.1 ± 9.7 (21.0–59.5) |
| Proximal resection margin, cm, mean ± SD (range) | 12.7 ± 8.1 (8.0–39.3) |
| Distal resection margin, cm, mean ± SD (range) | 16.5 ± 7.5 (6.5–38.5) |
| Radial resection margin, cm, mean ± SD (range) | 4.8 ± 2.1 (0.8–9.5) |
| Length between vascular tie and tumor, cm, mean ± SD (range) | 12.7 ± 3.4 (5.0–20.0) |
| Completeness of CME, <i>n</i> (%) | |
| Mesocolic plane | 27 (72.9) |
| Intramesocolic plane | 9 (24.4) |
| Muscularis propria plane | 1 (2.7) |

CME complete mesocolic excision, SD standard deviation

Discussion

Our outcomes suggest that robotic CME is a safe and feasible surgical procedure with acceptable morbidity and provides excellent specimen quality. The technical superiority of the robotic system seems to overcome the complexity of CME in minimally invasive surgery. Better visualization of tissues provided by depth perception and stable retraction in particular eases sharp dissection, an important factor in oncologic resections.

Robotic surgery has gained a wide acceptance due to its advantages overcoming the limitations of laparoscopy. In the field of colorectal surgery, however, the predominant indication for robotic approach has been pelvic procedures such as proctectomy, and therefore, the role of the robot in colon resections has remained unclear [18]. Abdominal and pelvic operations are different surgeries with distinctive challenges. For a right-sided colon cancer, CME is considered the gold standard procedure [2] and this procedure involves

an extensive scope and a number of important organs, where a clear understanding of the vascular anatomy is needed to complete oncologic dissection.

To the best of our knowledge, applicability of robotic approach in CME has been explored in only five studies [9, 15, 19–21], of which two studies reported data on case series [9, 19] and the other three involve operative techniques only [15, 20, 21]. Trastulli et al. [19] reported on a series of 20 robotic CME procedures the technical feasibility of the robotic system. In this series, the mean operative time was 327.5 min and there was no conversion. The mean number of harvested lymph nodes was 17.6 (range 14–21) and the only postoperative complication was wound infection. In our series, the mean operative time was 289.8 min and this parameter in recent studies of robotic surgery for standard right hemicolectomy ranges from 159 to 287 min [12, 13, 22]. Formisano et al. [9] presented their preliminary findings of unpublished data in 53 robotic versus 69 laparoscopic CME. In their series,

although the authors presented limited information on clinical outcomes and no data on histopathologic results, they report a reduction in conversion and anastomotic leak rates in favor of the robotic approach. The number of harvested lymph nodes is crucial for the prognosis and regarded as a measure of quality in colon cancer care [23]. In our series, the mean number of harvested lymph nodes (41.8) is higher than that of the majority of studies reported on open, laparoscopic [1, 3, 5–7] as well as robotic right-sided CME [19]. Of note, it should be taken into account that 16 (43%) patients had an extended right hemicolectomy procedure and this might have contributed to an increased number of lymph nodes.

The key concepts of CME with a medial-to-lateral approach were successfully applied in all the robotic procedures. As opposed to the lateral approach, the medial approach has the advantages of no-touch isolation technique. The no-touch technique is used in an attempt to perform an optimal R0 resection as operative manipulation of the tumor-bearing colonic segment may result in cancer cell metastasis through venous or lymphatic structures [5, 6, 24]. Yet, the benefits of no-touch procedure have not been clearly defined and contradictory results exist in the literature [25, 26]. This may be due to the fact that the original procedure does not expose the SMV or remove the root of the vessels. A Japanese trial (JCOG1006) is currently underway to demonstrate if the no-touch technique is superior to conventional technique [27]. By combining the principles of both CME and no-touch techniques in our robotic procedures, we aimed to obtain better oncologic resections with maximal lymph node harvest and minimize tumor spread. These features make this technique worth considering.

Anatomic variations of the gastrocolic trunk of Henle could lead to troublesome bleeding and controlling can be difficult. To avoid this potential complication, we modified the cranial-to-caudal technique [16, 17] for our robotic operations in 16 patients undergoing extended CME. Using the right gastroepiploic vessels as a landmark, this technique allowed easy exposure and control of the gastrocolic trunk and middle colic vessels in the early phase of the operation.

Creation of intracorporeal anastomosis can be achieved comfortably in robotic CME. Intracorporeal creation of ileotransversostomy provides several advantages including minor visceral trauma secondary to less tissue stretching, less dissection of the distal transverse colon for a tension-free anastomosis [20, 28], decreased risk of intestinal twist, smaller abdominal incision for specimen extraction and possibility of making this incision in a more optimal location [9, 12, 19, 20, 22, 28]. All the anastomoses were performed intracorporeally in this series. We routinely perform suprapubic incision as it is reported to offer less postoperative pain, better cosmesis and lower incisional hernia rates after laparoscopic colorectal surgery [9, 22, 29].

Limitations of the study are its non-comparative nature and lack of long-term data. The learning curve effect in robotic CME might potentially influence the results of this study. Nevertheless, the number of operations necessary to complete the learning curve for robotic colorectal surgery is reported to be between 15 and 35 cases in general series [9, 18] and our caseload is higher than these numbers [30, 31].

Our experience suggests that totally robotic CME for right-sided colon cancer is feasible, safe and provides remarkably good quality of resected specimens with acceptable short-term outcomes. Future prospective studies are needed to confirm our results and better evaluate other potential benefits of the robotic systems in these patients.

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Compliance with ethical standards

Conflict of interest Authors Volkan Ozben, Erman Aytac, Deniz Atasoy, Ilknur Erenler Bayraktar, Onur Bayraktar, Ipek Sapci, Bilgi Baca, Tayfun Karahasanoglu and Ismail Hamzaoglu declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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