Surgical Endoscopy (2019) 33:966–971
https://doi.org/10.1007/s00464-018-6529-x

DYNAMIC MANUSCRIPT

Use of the Xi robotic platform for total abdominal colectomy: a step forward in minimally invasive colorectal surgery

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Received: 8 May 2018 / Accepted: 11 October 2018 / Published online: 22 October 2018

Abstract

Background The use of the da Vinci robotic platform for total colectomy has been limited by the need to reposition the patient-side surgical cart from one side of the patient to the other, which increases operative time. In this study, we examined the feasibility of robotic total colectomy using the da Vinci Xi model, which offers a rotating boom-mounted system and laser-targeted trocar positioning.

Methods The study cohort consisted of 23 patients who underwent minimally invasive total colectomy for cancer or polyposis syndromes at a comprehensive cancer center between 2015 and 2017. Of the 23 colectomies, 15 were robotic and eight were laparoscopic. For the robotic colectomies, trocars were placed in the supraumbilical region and all four quadrants. The da Vinci Xi robot was placed between the patient's legs, and the boom was rotated from left to right and then to the middle in order to work sequentially on the right colon, the left colon, and the pelvis. Operating time and short-term outcomes were compared between the patients who underwent robotic surgery and the patients who underwent laparoscopic surgery.

Results The two groups of patients were comparable in age, gender, BMI, physical status, and disease types. In the robotic group, median length of stay (4 vs. 6 days, $p=0.047$) was significantly shorter and median operative time (243 vs. 263 min, $p=0.97$) and median estimated blood loss (50 vs. 100 ml; $p=0.08$) were similar between the groups.

Conclusions With the da Vinci Xi boom-mounted system, total abdominal colectomy can be performed without the need to move the patient-side surgical cart and is associated with shorter length of stay and similar operative time compared to the laparoscopic approach.

Keywords Robotic surgery · Total colectomy · Colorectal cancer

The use of robotic surgery for segmental colon resection has increased worldwide due to the enhanced three-dimensional visualization and improved dexterity of the robotic platform. While the literature suggests that the robotic approach may be associated with reduced conversion rates and lower morbidity compared to laparoscopic surgery, the robotic approach seems to be associated with longer operative time and higher hospital costs [1–3].

The numbers of segmental colectomies and proctectomies performed with the robotic platforms are increasing worldwide [4, 5], but the number of total colectomies performed robotically is limited due to the need to reposition the patient-side surgical cart in order to access both sides of the abdomen [4, 6–8]. The new da Vinci Xi system, in which all arms are anchored in a single boom, facilitates working in all four quadrants of the abdomen without the need to reposition the patient-side cart, which can be placed between the patient's legs, allowing rotation of the boom from left to right and permitting precise work on both sides of the abdomen. Placing the boom in the midline oriented toward the patient's feet facilitates access to all four quadrants of the abdomen and the pelvis.

In this study, we review our experience with robotic total abdominal colectomy using the da Vinci Xi platform and compare the results with those of patients treated

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00464-018-6529-x) contains supplementary material, which is available to authorized users.

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with laparoscopic total abdominal colectomy in terms of operative times, intraoperative variables, and short-term outcomes.

Materials and methods

Patients

We identified all patients with colorectal cancer or polyposis syndromes who underwent minimally invasive total abdominal colectomy between January 2015 and May 2017 at a comprehensive cancer center. We excluded patients who underwent emergency procedures. We collected demographics (age, gender, BMI, and physical status [American Society of Anesthesiologists classification]), intraoperative data (complications, conversion, operative time, estimated blood loss, and diverting stoma), and postoperative data (postoperative complications, reoperations, length of stay, readmission, and stoma closure). Results between patients treated with the robotic platform or combination laparoscopy were compared.

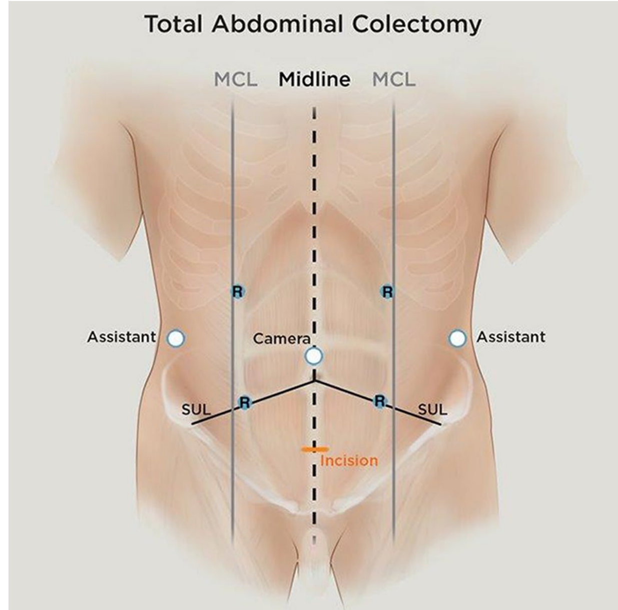

Fig. 1 Trocar positioning in the abdominal wall for robotic total colectomy. *MCL* midclavicular line

Statistical analysis

Qualitative variables were analyzed using absolute frequencies and percentages, and quantitative variables were analyzed using means and standard deviations or, for data with nonsymmetrical distribution, using medians and interquartile ranges. The statistical analysis was performed using Stata 15.0 software (StataCorp, Texas, USA) with contingency tables. The Chi-square test or the Fisher exact test was used to analyze categorical variables, and nonparametric tests were used for continuous variables.

Robotic technique

For the robotic procedure, the patient is placed in a modified lithotomy position with the legs in Allen stirrups. After pneumoperitoneum is created with a Veress needle in the left subcostal space, a total of seven ports are placed as shown in Fig. 1. A 12-mm port was placed in the right iliac fossa; 8-mm ports are placed in the umbilical region, in the left iliac fossa, and in the right and left upper quadrants; and 5-mm ports are placed in the right and left flanks. After the patient is placed in a 10° Trendelenburg position with a 15° right-side tilt, the patient-side surgical cart is positioned between the legs of the patient and docked (Fig. 2).

The procedure begins on the right side with entry into the retroperitoneum in the avascular portion of the mesentery between the superior mesenteric artery and the ileocolic vessels. After the retroperitoneal structures including the third portion of the duodenum and the pancreas are brushed posteriorly, ileocolic vessels are isolated and divided close to their origin. Dissection proceeds along the superior mesenteric vein axis to identify the right colic artery and vein (when present) and the middle colic artery and vein. All vascular pedicles are controlled with either the vessel sealer or Hem-o-lok clips based on surgeons' preferences. The mesentery of the right colon is mobilized from medial to lateral, leaving behind the pancreas, duodenum, and retroperitoneal structures. The omentum is then opened to enter the lesser sac and complete the mobilization of the right colon. For patients receiving an end ileostomy, the terminal ileum is divided with an EndoWrist stapler.

The arms of the robot are then detached from the trocars, the boom is rotated 180° without moving the patient-side cart (Fig. 2), and the patient is repositioned, with the Trendelenburg position maintained but with the left side tilted 15° up. The robotic arms are then connected to the trocars without moving the patient-side surgical cart. The inferior mesenteric artery and vein are divided, and a medial-to-lateral approach is used to detach the left mesocolon from the pancreas tail, the ureter, and gonadal vessels. The left paracolic gutter is opened to the splenic flexure, which is taken down. The omentum is completely disconnected from the left side of the transverse colon until the transverse colon is also completely released.

At this point, the robotic arms are detached, the patient is placed in a 25° Trendelenburg position without any lateral tilt, and the boom is turned to face the pelvis (Fig. 3) if proctectomy is needed. Total mesorectal excision is carried out to the pelvic floor, with sparing of sympathetic and

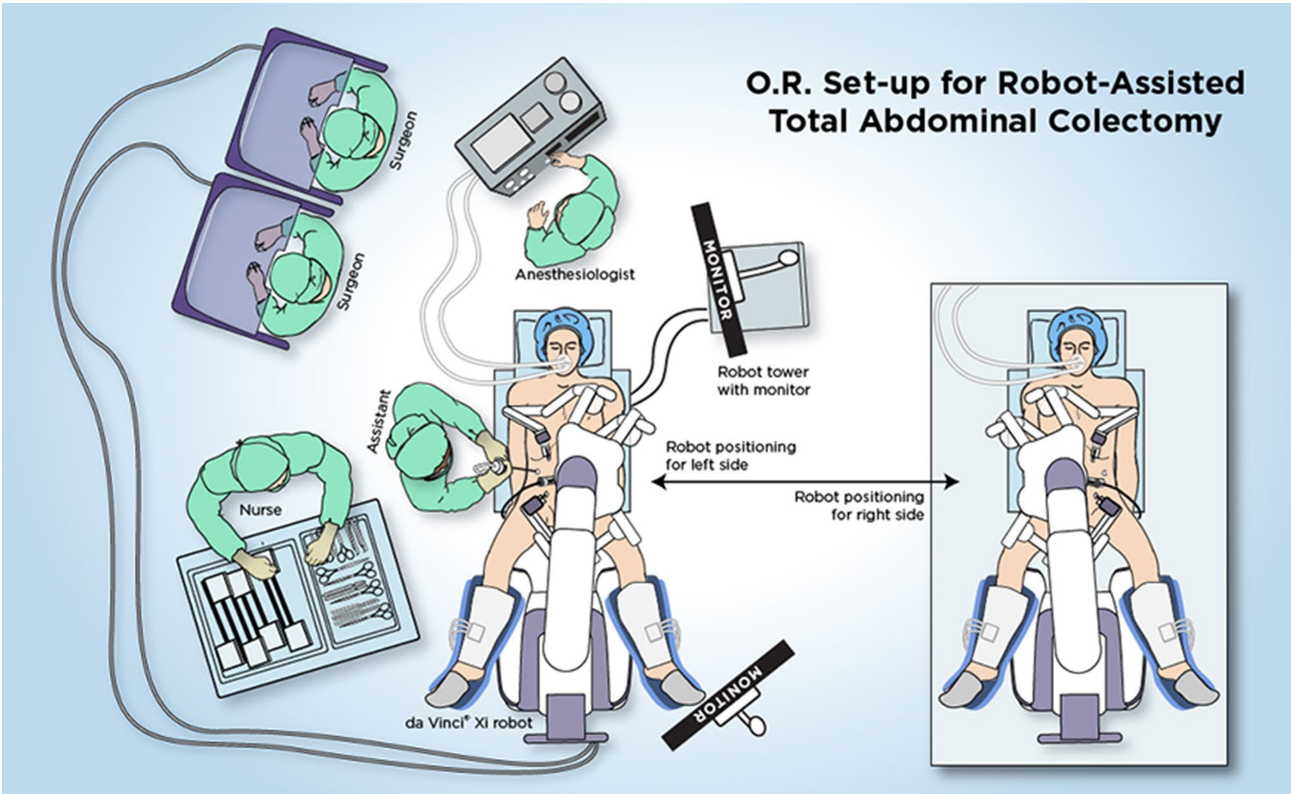

Fig. 2 Patient-side surgical cart remains between the patient's legs, and the boom is rotated to the right or left. *O.R.* operating room

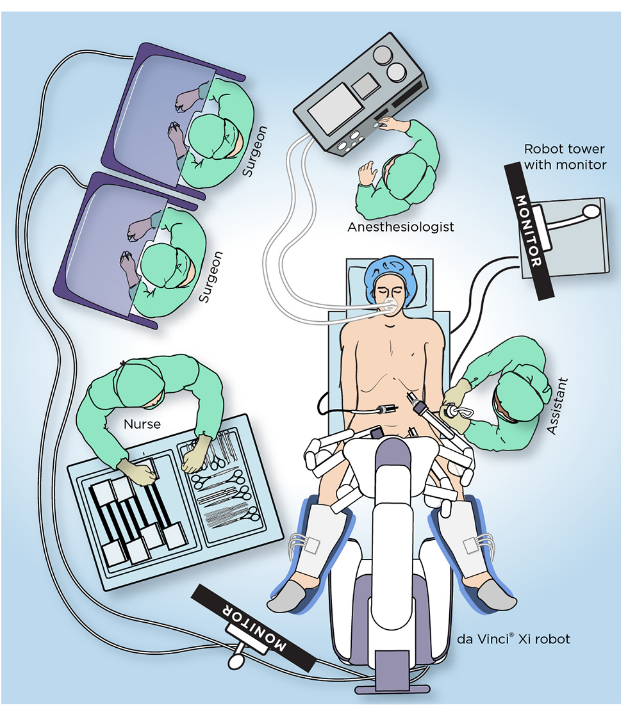

Fig. 3 Boom is rotated to face the pelvis for rectum dissection

parasympathetic nerves. In case a coloanal anastomosis is performed, intersphincteric dissection starting at the intersphincteric groove is made, and the specimen is extracted through the anus. If proctectomy is not needed, the robotic stapler is used to divide the superior rectum or distal sigmoid, and a transverse incision is made to extract the specimen and prepare the ileum for anastomosis.

Laparoscopic technique

For the laparoscopic procedure, the patient is placed in the supine position, pneumoperitoneum is established with a Veress needle, and ports are inserted in the same positions as for the robotic procedure except for the two 5-mm ports intended for the assistant. The dissection is carried out in the conventional manner, starting with division of the ileocolic vessels and then the middle colic vessels, followed by medial-to-lateral dissection of the right colon until the head of the pancreas and the duodenum are in view. The gastrocolic ligament is divided, and the hepatic flexure is taken down. The right colon is mobilized completely. The surgeon and the assistant then move from the left side of the patient to the right side; the inferior mesenteric artery and vein are divided; the retroperitoneal plane is dissected; the ureter, the gonadal vessels, and the tail of the pancreas are identified; and the splenic flexure is taken down. After the sigmoid is detached from the lateral attachments, mesorectal excision is performed and the rectum is divided below the tumor. The specimen is extracted through the anus if a coloanal anastomosis is performed or through a Pfannenstiel incision otherwise. For intracorporeal anastomoses, laparoscopic visualization is used.

Results

A total of 23 patients (13 women and ten men) were included in the study. Eight of the patients underwent laparoscopic total abdominal colectomy, and 15 patients underwent robotic total abdominal colectomy. The median age of the patients was 52 (20–69) years, and median BMI was 26 (21–40). Nine patients had familial adenomatous polyposis, seven had Lynch syndrome, four had synchronous cancers, two had ulcerative colitis-related cancer, and one had Noonan syndrome with superimposed cancer. The laparoscopic and robotic groups were comparable in age, gender, BMI, physical status, and disease types (Table 1). Anastomosis was performed in all patients in the laparoscopic group and in 12 patients in the robotic group.

The two approaches were associated with differences in length of stay but not in operative time (Table 1). Median length of stay was 4 days (range 2–10 days) in the robotic group and 6 days (range 4–12 days) in the laparoscopic group ($p=0.047$). Median operative time was 243 min (range 169–556 min) in the robotic group and 263 min (range 180–352 min) in the laparoscopic group ($p=0.97$). Median estimated blood loss was also similar: 50 ml (range 5–300 ml) in the robotic group and 100 ml (range 10–300 ml) in the laparoscopic group. No significant differences in types of procedures were found between the two groups ($p=0.910$).

No intraoperative complications occurred in either group. One patient in the robotic group underwent conversion to open surgery due to adhesions associated with previous surgery.

Two patients in the laparoscopic group experienced postoperative complications (a hypotensive episode and ileus); no postoperative complications occurred in the robotic group. All three patients who were readmitted within 30 days (diarrhea and chills, vomiting and abdominal pain) were in the robotic group. Total stay (including readmission) did not differ significantly between the two groups ($p=0.079$; Table 1).

Discussion

Our findings show that with the da Vinci Xi platform, total abdominal colectomy is feasible, and compared with laparoscopic total colectomy it was associated with a shorter length of stay and similar operative time, conversion rate, and complication rate.

Our results are consistent with those reported by Protyniak et al. [9], who demonstrated that the Xi platform can be used to perform multiquadrant surgery without the need to reposition the patient-side surgical cart, and with those reported by Morelli et al. [10, 11], who found that operative times for Xi were shorter on average than for the older Si platform. Our findings contrast with those of Moghadamyeghaneh et al. [4], whose retrospective analysis of an administrative national database found that operative times for the robotic approach were longer and short-term outcomes were not better than those for the conventional laparoscopic approaches. This difference in results may be due to the fact that those robotic cases used earlier-generation robotic platforms, which would have required multiple pauses for redocking.

Because our study is retrospective with limited power, conclusions must be drawn with caution. Patients may have been selected differently for the two approaches. Given that all patients underwent surgery at a high-volume cancer center by experienced robotic colorectal surgeons, the findings may not be generalizable to centers that perform fewer such operations or treat more patients with inflammatory bowel disease. Notwithstanding these limitations, this is the first study to show no differences in operative time and short-term outcomes for total abdominal colectomy between the robotic approach using the da Vinci Xi platform and the conventional laparoscopic approach. As suggested by other authors [11], the similar operative time and shorter length of stay with the Xi platform may lower the total costs associated with robotic surgery.

Conclusion

The da Vinci Xi robotic platform may overcome some of the disadvantages of older-generation platforms and is associated with similar operative time for this specific complex colorectal operation. Prospective studies, including cost analysis, would further elucidate our findings.

Table 1 Patient characteristics and outcomes

Characteristic or outcome	Value for the following group:		*p*
	Laparoscopic (*n* = 8)	Robotic (*n* = 15)	
Age (years)**	55 (24–65)	52 (20–69)	0.72
Female*	4 (50)	9 (60)	0.69
BMI (kg/m^2)**	25 (21–38)	26 (21–40)	0.65
ASA*			0.62
1	0	1 (6)	
2	4 (50)	5 (33)	
3	4 (50)	9 (60)	
Diagnosis*			0.46
FAP	4 (50)	5 (33)	
Lynch syndrome	2 (25)	5 (33)	
Synchronous cancers	1 (12)	3 (20)	
Ulcerative colitis	0	2 (13)	
Noonan syndrome with superimposed cancer	1 (12)	0	
Procedure			0.910
Total colectomy + ileorectal anastomosis	8 (100)	11 (73)	
Total colectomy + ileostomy	0	1 (7)	
Proctocolectomy + ileostomy	0	2 (13)	
Proctocolectomy + pouch	0	1 (7)	
Operative time (min)**	263 (180–352)	243 (169–556)	0.97
Anastomosis*	8 (100)	12 (80)	0.52
Stapled anastomosis*	7 (87)	11 (73)	0.99
Conversion*	0	1 (6)	0.99
Estimated blood loss (ml)**	100 (10–300)	50 (5–300)	0.08
Ileostomy*			
Terminal	0	3 (20)	0.26
Loop	0	1 (6)	
Loop ileostomy closure	–	1	–
Postoperative complications*	2 (25)	0	0.11
Length of stay (days)**	6 (4–12)	4 (2–10)	0.047
Length of stay including readmission (days)**	6 (4–12)	4 (2–10)	0.079
30-Day readmission rate*	0	3 (20)	0.18

ASA American Society of Anesthesiologists classification of physical status, *FAP* familial adenomatous polyposis

*The data are counts with percentages in parentheses

**The data are medians with ranges in parentheses

Funding NCI Grant P30 CA008748.

Compliance with ethical standards

Disclosure Garrett Nash: Conference expenses paid by NOVADAQ (2015), J J Smith has received travel support for fellow education from Intuitive Surgical Inc. and is an advisor for Endogenesis Inc. E Pappou has received support for a robotic training course by Intuitive (2015), J Garcia-Aguilar has received support from Medtronic, Johnson and Johnson and Intuitive Inc. R Jimenez-Rodriguez, F Quezada, M Tchack, I Wei, J Guillem, P Paty and M Weiser have no conflicts of interest or financial ties to disclose.

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