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Authors
Hollandsworth, Hannah M
Stringfield, Sarah
Klepper, Kristin
et al.

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Multiquadrant surgery in the robotic era: a technical description and outcomes for da Vinci Xi robotic subtotal colectomy and total proctocolectomy

Hannah M. Hollandsworth[1], **Sarah Stringfield**[1], **Kristin Klepper**[2], **Beiqun Zhao**[1], **Benjamin Abbadessa**[1], **Nicole E. Lopez**[1], **Lisa Parry**[1], **Sonia Ramamoorthy**[1], **Samuel Eisenstein**[1]

[1]Department of Surgery, Division of Colon and Rectal Surgery, John and Rebecca Moores Cancer Center, University of California San Diego, 3855 Health Sciences Dr. #0987, La Jolla, CA 92037, USA

[2]University of California School of Medicine, San Diego, CA, USA

Abstract

Background—Common colorectal procedures that require access to all quadrants of the abdomen are subtotal colectomy (STC) and total proctocolectomy (TPC). These are frequently performed with a surgical robot, but multiquadrant operations have unique challenges during robot-assisted surgery.

Methods—Patients who underwent robotic STC or TPC with the da Vinci Xi surgical robot at our institution from July 1, 2016 through June 30, 2019 were identified by diagnosis and procedure codes. A technical description is provided for the techniques utilized at our institution. Outcomes included operative times (OT), supply cost and length of stay. Associated morbidity and mortality was also analyzed.

Results—From a review of our institution's robotic surgery data, 37 cases were identified that utilized the described technique. Of these cases, 21 were robotic STC and 16 were TPC. Total mean OT was 276.86 min (SD ± 119.49). Mean OT was further analyzed by year, which demonstrated an overall decrease in OT from 350.91 min (SD ± 46.38) in 2016 to 221.43 min (SD ± 16.46) in 2018 ($p = 0.008$). A total of 21 cases were performed prior to 2018. Overall OT for STC was 222.81 min (SD ± 14.54) compared to overall TPC OT 347.81 min (SD ± 34.35). Median length of stay was 5 days [25th and 75th percentiles 4, 6, respectively]. There was no 30-day mortality and only one return to operating room for mesenteric bleeding. There was a low risk of mortality associated with this technique.

Conclusions—The current study provides the largest cohort of patients assessed who have undergone multiquadrant robotic STC or TPC. The study provides a detailed description of the technique utilized at our institution. There was no associated 30-day mortality and a low risk of

Samuel Eisenstein, seisenstein@ucsd.edu.

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morbidity. The data suggest that the learning curve for improved operative time is between 15 and 20 cases.

Keywords

Robotic surgery; Subtotal colectomy; Total proctocolectomy; Multiquadrant surgery; Surgical techniques

Background

With the emergence of new technologies, such as robotic platforms, colorectal surgeons have developed new surgical techniques for common operations. In prior studies, robotic colorectal procedures have been found to have an improved safety profile and similar efficacy to laparoscopic approaches; therefore, many colorectal procedures are now performed robotically [1, 2]. Robotic surgery has been shown to significantly improve outcomes in small operative fields such as the pelvis, including lower rate of positive margin and recurrence, decreased erectile dysfunction and conversion rate to open surgery, and shorter hospital stays [3]. It can also improve surgical ergonomics [3].

Multiquadrant operations present unique challenges during robotic surgery with the current generation of surgical robots. This is due to the need to shift the axis of visualization up to 360°, a feat which requires undocking the robot and rotating it on axis. The previous generation of robotic platforms, such as the da Vinci Si (Intuitive, Sunnyvale, CA), were generally used for single quadrant procedures. However, many colorectal procedures require access to the entire abdomen. Two colorectal procedures that require access to all quadrants of the abdomen are subtotal colectomy (STC) and total proctocolectomy (TPC). STC and TPC are common operations for various colonic diseases, including inflammatory bowel disease, colorectal cancer, chronic constipation and polyposis syndrome. The newer da Vinci Xi (Intuitive, Sunnyvale, CA) robot platform has the additional benefit of a rotating boom, which was not a feature on the earlier version [4, 5]. A prior study by Protyniak et al., compared the use of the da Vinci Xi to the Si model in low anterior resection and sigmoidectomy, which are common multiquadrant operations. They found that the da Vinci Xi may be a better platform for multiquadrant surgery and may decrease the need for combined robotic and laparoscopic techniques [4]. Additional studies have shown similar results, with an improvement in overall complication rates of totally robotic rectal surgery compared to laparoscopic and robotic-laparoscopic assisted rectal surgery [6].

Although prior studies have assessed multiquadrant robotic colorectal surgery, most of the literature included operations that did not require access to all four abdominal quadrants. One recent study provided technical description for robotic total abdominal colectomy, which requires access to all abdominal quadrants [7]. This study utilized the da Vinci Xi platform, which allowed the robot to remain on the same side of the patient during the entire operation due to the rotating boom capability [7]. Results from this study demonstrated similar operative time to the laparoscopic approach and a shorter length of stay compared to laparoscopic total abdominal colectomy [7].

At our institution, there are three colorectal surgeons that use this specific technique for multiquadrant robotic surgery, allowing us to assess a larger cohort of patients undergoing robotic STC and TPC and analyze the efficacy and outcomes of our surgical technique. In this study, we provide a technical description of our institution’s methods for robotic STC and TPC using the da Vinci Xi robot system.

Methods

Patient positioning

The patient is placed in a supine position on the operating table with arms tucked and legs in modified lithotomy position utilizing Yellowfin Stirrups (Allen Medical, Acton, MA). An orogastric tube is placed for gastric decompression. The entire abdomen is prepped with standard sterile surgical draping.

Access and port placement

The key to port placement is to stay low on the abdomen, usually below the umbilicus. Providing a high ligation of the inferior mesenteric artery (IMA) is not required, the rectal dissection will not be any more difficult and the transverse colon, which is generally the more complex dissection, will be much easier to access. Even if high ligation of the IMA is required, this is usually still straight-forward from this trocar position.

At our institution, if the patient is to have an ileostomy, we start by making the stoma site. This has been marked by the ostomy nurse preoperatively. Through this site, we place a wound protector with a laparoscopic cap (Applied Medical, Rancho Santa Margarita, CA). If an ileorectal anastomosis is to be made and no ileostomy will be created, we will instead obtain access with a Veress needle at Palmer’s point and then place the left midabdominal trocar using an Optiview (Ethicon, Somerville, NJ) technique infraumbilically. In this case we will extend our right lower quadrant (RLQ) 12 mm trocar site for our extraction site and ileal anvil placement.

The abdomen is insufflated using an AirSeal insufflator (ConMed, Utica, NY). Two left lower quadrant 8 mm robotic trocars and a RLQ 12 mm robotic trocar are placed. A 5 mm suprapubic laparoscopic trocar is placed for use as an assistant port (Fig. 1). This assist port is most useful for the upper abdominal dissection, but we have generally abandoned a right upper quadrant assist port for the pelvic dissection.

The patient is then placed in steep Trendelenburg. The da Vinci Xi robot is introduced on the left side of the patient and the robot is docked to the trocars with the boom toward the patient’s pelvis. Of note, this technique is performed without integrated table motion. A hook with cautery is initially used in the RLQ 12 mm port, a tip up double fenestrated grasper is introduced to the left medial 8 mm trocar and a small grasping retractor is introduced into the left lateral 8 mm trocar.

Caudal dissection

We begin with the pelvic portion of the operation. The rectosigmoid junction is identified and dissection takes place in the mesocolic plane posterior to the superior hemorrhoidal vessels. Care is taken to identify the left ureter. The sigmoid and superior hemorrhoidal vessels are ligated with the robotic vessel-sealing device. Lateral dissection is performed down to the rectosigmoid junction for STC or extended to the rectum for TPC. Left lateral dissection is continued superiorly to mobilize the descending colon from the left abdominal wall. The left colon is mobilized and the mesentery is taken as much as is possible from the pelvis-facing direction of the boom. Once this is no longer simple, we turn our attention to the right side.

In STC operations, the distal colon is transected at the sacral promontory after reducing any redundancy from the sigmoid in the pelvis using the robotic stapler. During TPC, if an ileal pouch anal anastomosis (IPAA) is to be performed, rectal dissection is carried through the meso-rectal plane and carried around circumferentially until the top of the anorectal ring is encountered, at which time the rectal wall is cleaned and transected with the robotic stapler. For a TPC without IPAA, a second team of surgeons assists with the perineal dissection of the rectum. For these procedures the rectosigmoid is usually transected and the rectum is passed through the perineal wound prior to the perineal team closing the perineal wound. The AirSeal allows for the abdominal team to continue working while the perineal team closes the wound. After completion of the left colon and/or rectum dissection, dissection is then begun in the RLQ. The right colon and appendix are mobilized off of the right lateral abdominal wall and dissection is continued superiorly to mobilize the ascending colon as much as is possible in this direction. We will often start the mesenteric dissection at this point in time, but it can also be reserved until the boom is rotated.

Cephalad dissection

After completion of the pelvic portion, the robot is undocked and the boom is flipped 180 degrees. The patient is placed into slight reverse Trendelenburg. For the abdominal portion of the case, the 8 mm port on the left medial side of the patient is utilized as the camera port. The hook is introduced into the left lateral 8 mm port, and the small grasping retractor is introduced into the right lateral 12 mm port. The 8 mm port located at the future ileostomy site is used for the tip up double fenestrated grasper (Fig. 2). The splenic flexure is first mobilized by carrying out the left lateral dissection superiorly. The dissection is then continued to the right side, taking the mesocolon and gastrocolic ligament en bloc whenever possible. The ligament of Treitz, gastroepiploic vasculature and small bowel are all identified and protected during the dissection. One key to this portion of the dissection is regular orientation. The small bowel should be below the robotic instruments and the stomach is often behind.

The hepatic flexure is then mobilized with careful dissection to avoid injury to the duodenum. This is usually identified through the hepatocolic ligament, and once found the colon is reflected caudally and medially to mobilize it off of the duodenum prior to mesenteric dissection. Dissection is continued down the right abdominal sidewall to complete the mobilization of the colon and the mesentery is taken close to the bowel to the ileocecal valve.

Extraction

Once the entire colon is devascularized, the distal staple line is grasped and the colon is eviscerated through the wound protector. The terminal ileum is transected either sharply or with a stapler and the specimen is removed from the field. The bowel is returned to the abdomen and the abdomen is once again insufflated. A portion of small bowel is brought up to the right-sided abdomen ostomy site and diverting loop ileostomy is created, or, if an IPAA is to be created, this can be done through the wound protector (Fig. 3).

Patient selection

Under University of California San Diego (UCSD) IRB 191476, patients who underwent robotic STC or TPC at our institution from July 1, 2016 through June 30, 2019 were identified through search of the Electronic Medical Record (EMR) operative reports. Any diagnosis that required one of these operations was included. Past medical history or health status did not exclude patients from the study. Given the rarity of these diagnoses in pediatric population at our institution, patients < 18 years of age were excluded. Patients who underwent surgery at a different institution or had less than 30-day follow up post-operatively were excluded from the study.

Outcomes

Outcomes collected were operative time (OT), 30-day mortality, length of stay (LOS) and supply cost. Morbidities associated with the procedure were analyzed including return to operating room, readmission, need for intensive care unit (ICU) admission, post-operative blood transfusion and post-operative infection. Demographic information was also collected, including age, gender and ethnicity.

Statistical analysis

Statistical analysis was performed on SPSS version 24 (IBM Corporation, Armonk, NY). For continuous variables, normal distribution of the data was confirmed by the Shapiro–Wilk test. Outcomes for variables with normal distribution were reported as mean with standard deviation. Length of stay, which had a non-normal distribution, was reported as median with 25th and 75th percentiles. For categorical variables, frequencies and proportions were reported. Mean total supply cost was stratified by procedure type. Mean OT was analyzed and stratified by year and for each procedure type. Comparison of yearly OT by procedure in 2017–2019 was compared to baseline OT in 2016 with independent Student's t test, using p value 0.05 for significance with two-tailed analysis.

Results

A review of our institutions robotic colorectal surgery data identified 37 cases that utilized the technique described above. Of these cases, 21 were robotic STC and 16 were TPC. This study includes operations performed by 3 surgeons. Surgeon 1 performed total 24 operations, 11 STC and 13 TPC; Surgeon 2 performed 10 total operations, 8 STC and 2 TPC; Surgeon 3 performed 3 total operations, 2 STC and 1 TPC. Each surgeon has performed approximately 250–300 robotic colorectal surgeries during the study time period (40–60 per year).

The most common diagnosis was ulcerative colitis (n = 22). Other diagnoses included Crohn's disease, colorectal cancer, colonic inertia, and polyposis syndrome. Demographic information for the entire cohort can be seen in Table 1. In this cohort, 9 patients underwent ileal pouch anal anastomosis and 3 patients underwent ileorectal anastomosis. Total mean supply cost was $4,202.67 (SD ± 871.79). By operation type, supply cost for STC was less than TPC ($3922.23 (SD ± $170.23) and $4570.62 (SD ± $217.68), respectively).

There was no 30-day mortality in any of the 37 cases and no patient required post-operative ICU admission. Only one patient required return to operating room for post-operative mesenteric bleeding. There were 7 readmissions, with the most common reason being dehydration due to high ileostomy output. There were 2 cases of post-operative infection due to intra-abdominal abscess (5.4%) requiring percutaneous drainage. One case of intra-abdominal abscess was associated with intra-operative contamination due to ruptured appendicitis. In addition, there were two instances of post-operative catheter-associated urinary tract infection (5.4%). Frequency of morbidities can be seen in Table 2. Median LOS was 5 days (25th and 75th percentiles = 4, 6), which included multiple cases of extended hospital stay (> 10 days) due to prolonged post-operative ileus (n = 4). 62.1% of patients had a hospital stay ranging from 3 to 5 days.

Total mean OT was 276.86 min (SD ± 119.49). Mean OT was further analyzed by year, which demonstrated a decrease in OT from 350.91 min (SD ± 46.38) in 2016 to 221.43 min (SD ± 16.46) in 2018 ($p = 0.008$). A total of 21 cases were performed prior to 2018. OT was further stratified by operation type and year. Overall OT for STC was 222.81 min (SD ± 14.54) compared to overall OT for TPC of 347.81 min (SD ± 34.35). There was a significant decrease in OT for TPC in 2018 compared to 2016 (227.20 min (SD ± 20.62) and 498.00 min (SD ± 83.43), respectively; $p = 0.01$). OT in 2019 was 144.00 (SD ± 10.00) compared to OT 266.86 (SD ± 20.19) in 2016 ($p = 0.018$), but 2019 is limited by small sample size (n = 2). Table 2 demonstrates the OT per year for each procedure.

Discussion

At our institution, 37 cases were identified that met inclusion criteria, making this the largest technical description of multiquadrant robotic colorectal operations. The results demonstrate that the technique described above is safe and feasible for robotic TPC and STC for any colorectal diagnosis. In the current study, there were no cases of 30-day mortality after robotic STC or TPC. The rate of morbidity was low, with the most common being readmission due to dehydration from high ostomy output. Only one patient required a return to the operating room, which was due to mesenteric bleeding.

One of the most important technical considerations when developing new surgical techniques is the learning curve required to improve efficacy of these procedures, which is often reflected in operative time. Prior studies have demonstrated a mean OT of approximately 250 min, which is consistent with our overall OT [7]. Studies have shown that transitioning to a completely robotic technique, such as the technique described in the current study, did not result in increased OT for robotic colectomies [8]. Mean OT for STC in 2018 was surprisingly higher than OT in 2017 and 2016, which is likely attributed to two cases with OT approximately 300 min which are outliers compared to other STC cases. The data demonstrating improvement in OT over time suggest that the learning curve for multiquadrant robotic colorectal surgery is approximately 15–20 cases. This may be different for individual surgeons, which was difficult to assess in the current study due to relatively low sample size. The learning curve to improve OT identified in this study is consistent with prior studies, which found a learning curve of 15 cases for complex robotic colorectal surgery [9]. Another previous study identified a learning curve of 9–12 cases to improve efficiency in robotic surgery [3]. While the sample size for 2019 is low, it is clear what can be achieved and the average case time for STC during this time was 144 min (SD ± 10.00) which is comparable to many laparoscopic STCs [10].

With the addition of the da Vinci Xi platform, novel techniques can allow for the surgeon to improve operative room time and outcomes. The Xi platform provides an advantage due to the ability of the boom to rotate to provide access to all four abdominal quadrants. This study provides a technical description of the use of the da Vinci Xi for multiquadrant colorectal surgery, which may improve efficacy and operative time during STC and TPC. Although the Xi platform is an improvement for multiquadrant surgery, there are still limitations and we would suggest that the next generation of robotic platform to have functions to improve multiquadrant surgery. Our institution’s technique demonstrates methods to overcome some of the limitations to performing multiquadrant surgery in colorectal operations. The low abdominal placement of the ports improves dissection of the transverse colon and helps to overcome difficulty with lateral dissection. This is all achieved without adding any difficulty to the pelvic dissection.

Limitations for this study include small sample size, which makes it difficult to assess individual learning curves for each surgeon. We also did not employ integrated table motion as our institution does not use this technology. This has the potential to make these procedures even simpler and could overcome some of the difficulties of positioning that we discuss in this article.

This study included three surgeons who performed these operations. The most operations performed by one surgeon over this time period was 24. Although this is the largest cohort used to describe this specific technique, the retrospective nature of this study is limited by the ability to assess the change in operative time for each procedure for individual surgeons. Future studies with a larger cohort could provide further insight into the learning curve for individual surgeons and outcomes associated with this technique. In addition, since there are many operative techniques for STC and TPC, including open, laparoscopic, robotic assisted, and hand assisted, it becomes difficult to compare new techniques for these operations. Although this is a relatively small cohort, this is the largest series of this technique to date and provides a valuable technical description with promising outcomes. Future studies with more cases over a longer period of time could be considered to compare the efficacy and outcomes of robotic versus other techniques for STC and TPC.

It has been cited that the da Vinci Xi has many improvements compared to the prior iteration, making it easier to perform multiquadrant colorectal surgery robotically [5]. In the present study, we provide a technical description of our institution’s approach to robotic

STC and TPC and prove the feasibility of the da Vinci Xi for these procedures. The present technical description provides means to overcome limits to robotic multiquadrant surgery with the current available robotic platforms. We also demonstrate that the described technique is a safe approach for multiquadrant robotic colorectal surgery given the low rate of associated morbidity and mortality, and has a reasonable learning curve for experienced colorectal surgeons.

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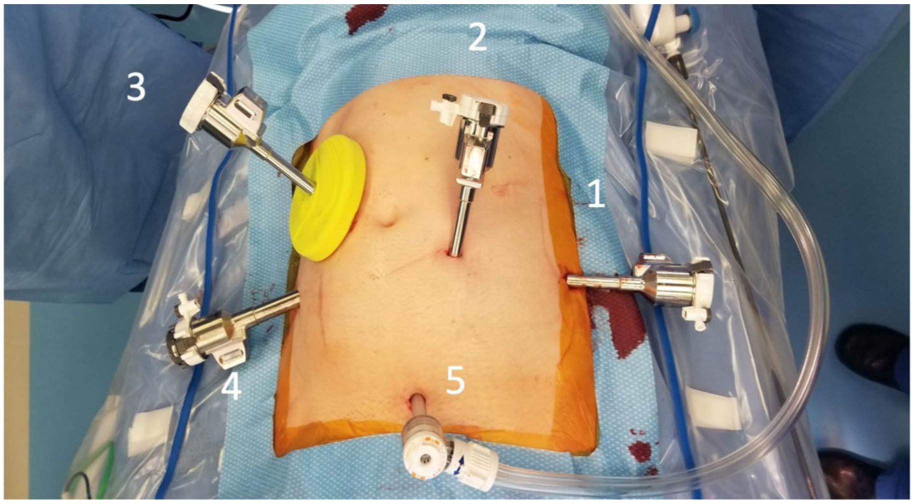

Fig. 1.

Trocar placement and instruments used during pelvic portion of the operation. (1) 8 mm port, small grasping retractor. (2) 8 mm port, tip up double fenestrated grasper. (3) 8 mm port, camera and future ileostomy site. (4) 12 mm port, hook with cautery, vessel sealer, stapler. (5) 5 mm laparoscopic assist port, mainly used during abdominal dissection

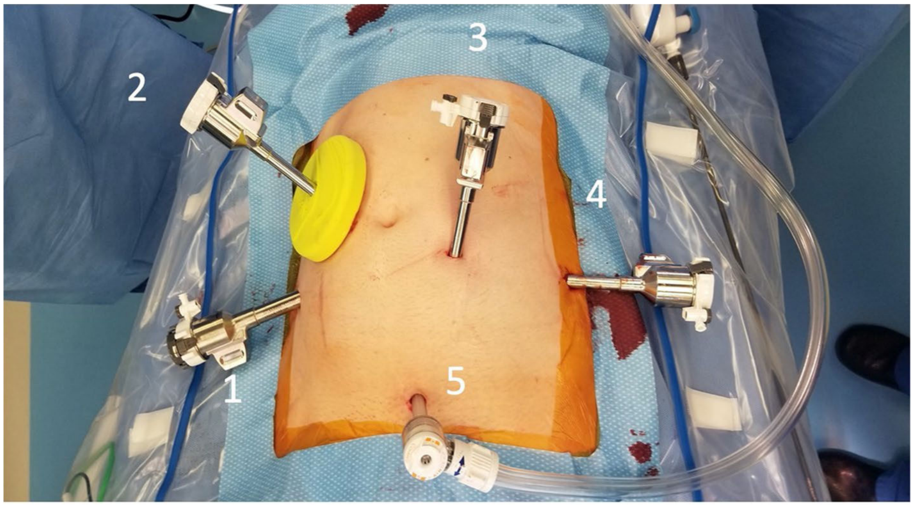

Fig. 2.

Instruments used during pelvic portion of the operation. (1) 12 mm port, small grasping retractor. (2) 8 mm port, tip up double fenestrated grasper. (3) 8 mm port, camera. (4) 8 mm port, hook with cautery, vessel sealer. (5) mm laparoscopic assist port

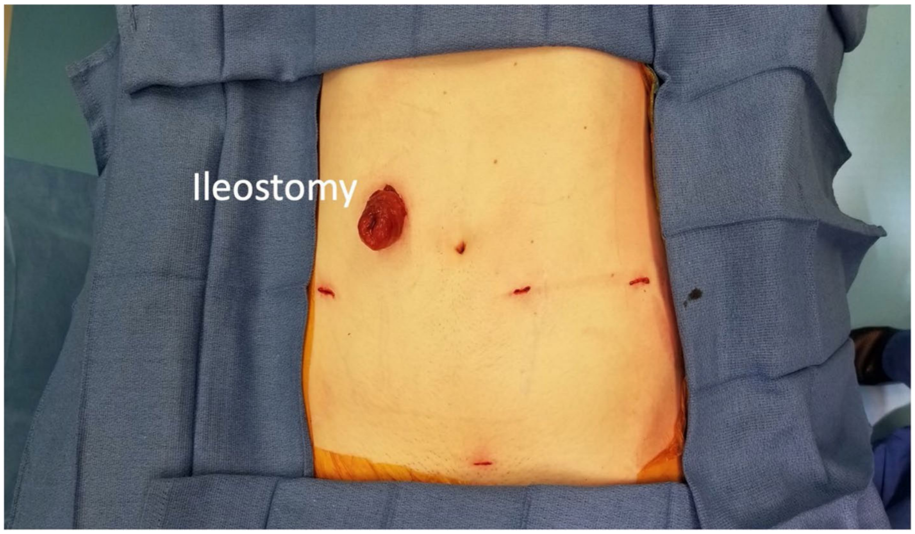

Fig. 3.
Conclusion of operation with ileostomy creation

Table 1

Demographic information and characteristics

Characteristic	**Occurrence (*n* = 37)**
Age, mean (data range)	40.11 (18–79)
Female sex, frequency (%)	20 (54.1)
BMI, mean (data range)	24.04 (13.67–39.33)
Race, frequency (%)	
White	27 (73)
Hispanic	9 (24.3)
Other	1 (2.7)
ASA, frequency (%)*	
1	1 (2.7)
2	18 (48.6)
3	17 (45.9)
Diagnosis, frequency (%)	
Ulcerative colitis	22 (59.5)
Crohns disease	5 (13.5)
Colorectal cancer	2 (5.4)
Colonic inertia	1 (2.7)
Polyposis syndrome	6 (16.2)
Procedure, frequency (%)	
Subtotal colectomy	21 (56.8)
Total proctocolectomy	16 (43.2)

*Missing data (*n* = 1)

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Table 2

Outcome frequencies and means

Outcome	Mean (SD)/median [25th and 75th percentiles]/frequency (%)	*p* value
Total operative time (*n* = 37)	276.86 (119.49)	-
Total operative time 2016 (*n* = 11)	350.91 (46.38)	-
Total operative time 2017 (*n* = 10)	299.60 (30.54)	0.377
Total operative time 2018 (*n* = 14)	221.43 (16.46)	0.008
Total operative time 2019 (*n* = 2)	144 (10.00)	0.094
Operative time STC (*n* = 21)[b]	222.81 (14.54)	-
Operative time STC 2016 (*n* = 7)	266.86 (20.19)	-
Operative time STC 2017 (*n* = 3)	186.33 (11.41)	0.039
Operative time STC 2018 (*n* = 9)	218.22 (23.73)	0.155
Operative time STC 2019 (*n* = 2)	144.00 (10.00)	0.018
Operative time TPC (*n* = 16)[c]	347.81 (34.35)	-
Operative time TPC 2016 (*n* = 4)	498.00 (83.43)	-
Operative time TPC 2017 (*n* = 7)	348.14 (25.92)	0.060
Operative time TPC 2018 (*n* = 5)	227.20 (20.62)	0.010
30-day mortality	0 (0)*	-
Length of stay (days)	5 [4, 6]#	-
Supply cost total	4202.67 (871.79)	-
Supply cost STC (*n* = 21)	3922.32 (170.23)	
Supply cost TPC (*n* = 16)	4570.62 (217.68)	
Post-operative ICU admission	0 (0)*	-
Post-operative blood transfusion	3 (8.1)*	-
Return to operating room	1 (2.7)*	-
Readmission	7 (18.9)*	-
Post-operative infection	4 (10.8)*	-

STC subtotal colectomy, *TPC* total proctocolectomy

p values compare operative time (year) to operative time in 2016

*Data are reported as frequencies of outcomes

#Data are reported as median with 25th and 75th percentiles