



Feasibility and safety of robotic resection of complicated diverticular disease

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Abstract

This study aimed to assess intra- and postoperative outcomes of robotic resection of left-sided complicated diverticular disease. Retrospective analysis of a prospectively maintained institutional database on consecutive patients undergoing elective robotic resection for diverticular disease (2014–2018). All procedures were performed within an enhanced recovery pathway (ERP). Demographic, surgical and ERP-related items were compared between patients with simple and complicated diverticular disease according to *intra*-operative presentation. Postoperative complications and length of stay were compared between the two groups. Out of 150 patients, 78 (52%) presented with complicated and the remaining 72 (48%) with uncomplicated disease. Both groups were comparable regarding demographic baseline characteristics and overall ERP compliance. Surgery for complicated disease was longer (288 ± 96 vs. 258 ± 72 min, $p=0.04$) and more contaminated (\geq class 3: 57.7 vs. 23.6%, $p<0.001$) with a trend to higher conversion rates (10.3 vs. 2.8%, $p=0.1$). While postoperative overall complications tended to occur more often after resections for complicated disease (28.2 vs. 15.3%, $p=0.075$), major, surgical and medical complications did not differ between the two groups, and median length of stay was 3 days in both settings ($p=0.19$). Robotic resection of diverticular disease was feasible and safe regardless of disease presentation by the time of surgery.

Keywords Robotic · Diverticular disease · Complications · Enhanced recovery

Diverticular disease remains a major health issue in Western societies, and surgical management due to recurrent or complicated disease flares remains inevitable in many patients [1]. A recent randomized controlled trial comparing surgical to conservative management found superior quality of life in surgically managed patients with recurrent and persistent abdominal complaints [2]. However, a 6-year national observational study revealed that surgical outcomes after elective colectomy for diverticular disease was worse compared to patients with colon cancer, underlining the complexity of surgical management in these patients [3].

Due to its potential to overcome technical limitations of laparoscopy in deep and narrow anatomic spaces, robotic surgery emerged as a technical alternative in recent years [4]. However, a recently published landmark trial failed to demonstrate benefits in terms of conversion or complication rates in rectal cancer surgery [5].

While initial adoption of a robotic approach demands financial and technical efforts, more experienced centers have expanded their indications and emphasize the advantages of better exposure, increased dexterity and a steady visual field [6]. Our institution has progressively increased the use of the robotic platform after observing encouraging results in oncologic and pouch surgery [7–9]. As a consequence, indications have expanded to include complex diverticular disease, through with limited data regarding outcomes.

The present study aims to analyze short-term outcomes after elective robotic resection of complicated left-sided diverticular disease in patients treated within a comprehensive enhanced recovery pathway (ERP).

Materials and methods

All consecutive patients undergoing elective robotic left-sided or sigmoid colonic resection for diverticular disease at our institution were included in this retrospective analysis (January 2014–May 2018). Data were derived from a

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prospectively maintained institutional database. The study was approved by the institutional review board and written patient consent was obtained to analyze de-identified data. Included patients were assigned to two groups (uncomplicated vs. complicated diverticular disease) according to disease presentation at the time of surgery, previous disease course, and intraoperative and pathological findings.

Mandatory for assigning a patient to either group was disease presentation at the time of surgery according to imaging findings (computed tomography scans, evaluated by board-certified radiologists), which were correlated with intraoperative presentation and pathological reports. *Complicated* diverticular disease was defined as phlegmonous, pyogenic disease with presence of an abscess of > 1 cm, fistulizing disease (colo-vesical, -vaginal, -enteric) or contained perforation during surgery. Uncomplicated disease was defined as chronic or recurrent smoldering disease with none of the aforementioned findings and according to institutional definitions [10]. Since the present study focused on surgical feasibility, previous disease course was less important unless a clinically apparent fistula was present pre-operatively to indicate a priori complicated disease.

Demographic characteristics included age, gender, body mass index (BMI), American Society of Anesthesiology (ASA) score and immunosuppression within 2 weeks of surgery. Surgical details included case duration, conversion to open approach, wound class [11], additional organ resection during the same procedure, creation of either a stapled anastomosis or end ostomy and use of a temporary diversion (loop ileostomy). Postoperative hemoglobin levels (g/dL) were measured at postoperative day (POD) 1.

Procedure and perioperative care

All surgeries were performed by 4 experienced board-certified colorectal surgeons through a standardized approach using the Da Vinci® Xi platform. All participating surgeons had performed at least 20 robotic colorectal resections before operating on complicated diverticular cases. All surgeons were either performing the procedure by themselves, or assisting colorectal fellows in the setting of our teaching institution under direct supervision.

Briefly, to access the abdominal cavity, an Optiview® trocar (Ethicon Endo-Surgery, Inc.) was placed under direct visualization in the midline, either superior or inferior to the umbilicus, and approximately 15 cm away from the target anatomy. Once the trocar was in place and the abdomen insufflated, a 30 degree down angle camera was introduced with placement of 4 additional trocars under direct visualization. To decrease issues with internal and external collisions, trocars were placed at a distance of 6–8 cm across the abdomen in a horizontal line with the

camera. For specimen extraction, a small Pfannenstiel incision 2 cm above the pubis was created.

All patients were treated within a comprehensive ERP, which has been implemented for colorectal surgery in 2010 [12] and focused on

- perioperative fluid restriction with saline lock at 08:00 h on POD 1
- early removal of urinary catheter at 08:00 h on POD 1
- multimodal pain management including postoperative non-steroidal anti-inflammatory drug (NSAIDs) administration
- promotion of early mobilization and re-introduction of a normal diet within 48 h of surgery

Overall ERP compliance and compliance to specific postoperative recovery targets was compared between the two groups.

Outcome

The primary outcome was overall complication rate, classified according to the Dindo-Clavien grading scale as grade I–V [13]. Complications were further stratified in minor (I–IIIa), major (IIIb–V), surgical and medical. Specific surgical complications included postoperative ileus (defined as need for nasogastric tube reinsertion), small bowel obstruction (SBO), clinically or radiographically confirmed anastomotic leak, surgical site infection (SSI), bleeding complications (defined as need for peri- or postoperative transfusion) and urinary retention (defined as the need for urinary catheter re-insertion).

Reoperation, readmission, and length of stay were assessed. All complications were in-hospital and until 30 days postoperatively.

Statistical analysis

Descriptive statistics for categorical variables were reported as frequency (%), continuous variables as mean (standard deviation) or median (interquartile range (IQR)) according to distribution. χ^2 test was used to compare categorical variables. All statistical tests were two-sided and a level of ≤ 0.05 was used to indicate statistical significance. Since both study groups were comparable, statistical matching was not necessary. Data analysis was performed with the Statistical Software for the Social Sciences SPSS Advanced Statistics 22 (IBM Software Group, 200 W. Madison St., Chicago, IL; 60,606 USA).

Results

One hundred and fifty patients underwent robotic left-sided or sigmoid resection over the study period. Of these, 78 (52%) presented with complicated and 72 (48%) with uncomplicated disease. Disease presentation for complicated disease was as follows:

- phlegmonous, pyogenic disease in 54 cases (69.2%)
- fistulizing disease in 33 patients (42.3%)
- contained perforating disease in 11 patients (14.1%)

Both groups were comparable regarding demographic characteristics (Table 1).

Surgery for complicated disease was longer and more contaminated with a trend to higher conversion rates (10.3 vs. 2.8%, $p=0.1$), and temporary diversion was more often performed (29.5 vs. 13.9%, $p=0.029$, Table 1). Additional organ resections, performed in 17 patients (11.3%), were salpingo-oophorectomies (x5), small bowel resections (x4), appendectomies (x4), hysterectomies (x3) and partial bladder resection (x1). Overall, 28 patients (18.7%) had previous abdominal surgery, and adhesiolysis of at least 30 min was performed in 12 of these patients, with equal distribution among the 2 groups (6 patients (7.7%) vs. 6 patients (8.3%), $p=0.89$).

Overall compliance to the institutional ERP was comparable between both groups. Compliance to specific postoperative items is illustrated in Fig. 1.

Postoperative overall complications after resections for complicated disease (28.2 vs. 15.3%, $p=0.075$) were no

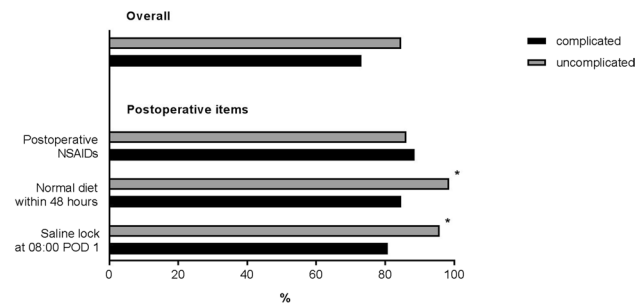


Fig. 1 ERP compliance. ERP overall compliance and compliance to selected postoperative items of patients with complicated diverticulitis ($n=78$) and patients with uncomplicated diverticulitis ($n=72$). NSAID non-steroidal anti-inflammatory drug, POD postoperative day Asterisk indicate statistical significance ($p < 0.05$)

different; moreover, major, surgical and medical complications did not differ between the two groups (Table 2). Overall, five patients (3.3%) were transfused with packed red blood cells (PRBC): two patients received two units and two further patients received one unit in the complicated group, while one patient received one unit in the non-complicated group.

Overall median length of stay was 3 (IQR 1–10) days and did not significantly differ between the groups ($p=0.19$), and no 30-day mortalities were observed.

Table 1 Demographics and surgical details

	All ($n=150$)	Complicated ($n=78$)	Uncomplicated ($n=72$)	p
Age (years) (mean \pm SD)	60.2 \pm 11.1	60.2 \pm 11.8	60.1 \pm 10.2	0.95
Gender (male, %)	68 (45.3)	36 (46.2)	32 (44.4)	0.87
BMI (kg/m^2) (mean \pm SD)	28.2 \pm 5.4	28.9 \pm 5.6	27.1 \pm 5.3	0.05
ASA ≥ 3 (%)	68 (45.3)	38 (48.7)	30 (41.7)	0.42
Immunosuppression (%)	4 (2.7)	1 (1.3)	3 (4.2)	0.35
Previous abdominal surgery (%)	28 (18.7)	12 (15.4)	16 (22.2)	0.28
Contamination class ≥ 3 (%)	62 (41.3)	45 (57.7)	17 (23.6)	0.00002
Operation duration (minutes) (mean \pm SD)	270 \pm 78	288 \pm 96	258 \pm 72	0.04
Additional organ resection (%)	17 (11.3)	10 (12.8)	7 (9.7)	0.61
Anastomosis (%)	144 (96)	73 (93.6)	71 (98.6)	0.21
Diversion (%)	33 (22)	23 (29.5)	10 (13.9)	0.03
Conversion (%)	10 (6.7)	8 (10.3)	2 (2.8)	0.10

Baseline demographic and surgical parameters of patients with complicated diverticulitis ($n=78$) and patients with uncomplicated diverticulitis ($n=72$)

BMI body mass index, ASA American Society of Anesthesiology Score

Bold characters indicate significant values ($p < 0.05$)

Table 2 Outcome

	All (<i>n</i> = 150)	Complicated (<i>n</i> = 78)	Uncomplicated (<i>n</i> = 72)	<i>p</i>
Any complication (I–V) (%)	33 (22)	22 (28.2)	11 (15.3)	0.08
Major complication (IIIb–V) (%)	7 (4.7)	5 (6.4)	2 (2.8)	0.45
Minor complication (I–IIIa) (%)	30 (20)	20 (25.6)	10 (13.9)	0.10
Surgical complication (%)	26 (17.3)	17 (21.8)	9 (12.5)	0.20
Ileus (%)	12 (8)	8 (10.3)	4 (5.6)	0.37
SBO (%)	2 (1.3)	0	2 (2.8)	0.23
Anastomotic leak (%)	5/144 (3.5)	3/73 (4.1)	2/71 (2.8)	0.67
SSI (%)	12 (8)	8 (10.3)	4 (5.6)	0.29
Bleeding complication (%)	5 (3.3)	4 (5.1)	1 (1.4)	0.37
Postoperative anemia (%)	6 (4)	6 (7.7)	0	0.03
Postoperative transfusion (%)	4 (2.7)	3 (3.8)	1 (1.4)	0.62
Hemoglobin POD 1 (g/L)	11.9 ± 1.5	11.6 ± 1.6	12.2 ± 1.4	0.02
Urinary retention (%)	10 (6.7)	5 (6.4)	5 (6.9)	1.00
Medical complication (%)	18 (12)	12 (15.4)	6 (8.3)	0.22
Reoperation (%)	4 (2.7)	2 (2.6)	2 (2.8)	1.00
Readmission (%)	11 (7.3)	6 (7.7)	5 (6.9)	0.86
Length of stay (days) (median, IQR)	3 (1–10)	3 (2–10)	3 (1–5)	0.19

Postoperative complication in patients with complicated diverticulitis (*n* = 78) and patients with uncomplicated diverticulitis (*n* = 72)

SBO small bowel obstruction, SSI surgical site infection, POD postoperative day

Bold characters indicate significant values (*p* < 0.05)

Discussion

This study revealed favorable short-term outcomes and a median hospital stay of 3 days after robotic left-sided colectomy for diverticular disease. Over half of patients presented with complicated disease. Robotic surgery was shown to be feasible and safe. High compliance to the institutional ERP, regardless of disease presentation, may have contributed to these encouraging short-term results.

Whether and when symptomatic, recurrent diverticular disease needs to be managed surgically is a matter of ongoing debate [2, 14]. Further, the ideal surgical approach has not yet been defined, even though laparoscopic surgery is presently considered the standard of care due to its potential to improve pain and recovery resulting in a decreased length of stay [15–17]. However, laparoscopic approaches may be challenging in complicated diverticular disease, as demonstrated by conversion rates of up to 14% [18, 19]. The first institutional series (1993–2004) reporting on both, complicated (37%) and uncomplicated (63%) diverticulitis, revealed a conversion rate of 26% and a 30-day overall complication rate of 25% [20]. A further institutional experience, which specifically assessed perioperative care within a fast track protocol, revealed an overall morbidity rate of 25.5% in conventional care and 15.2% in fast track care, which was also associated with improved gastrointestinal recovery [21].

The robotic platform represents a more recent treatment alternative for diverticular surgery and was associated with favorable outcomes in small retrospective case series. Maciel et al. described no conversions in 20 robotic procedures for fistulizing diverticular disease, compared to a rate of 14.5% in the laparoscopic comparative group [22]. A pioneer study reporting on 24 patients undergoing robotic resection 10 years ago showed encouraging results for recurrent diverticular disease [23]. Furthermore, recent reports demonstrated robotic resection of diverticular disease to be safe and technically feasible, however, within a case mix of oncological and non-oncological indications [24, 25].

The present study reports on 150 patients operated on in a center with advanced experience in robotic surgery. Conversion was slightly lower (6.7%) compared to reports in similar settings [26], and Hartmann procedures could be avoided in 96% of patients. The most recent institutional series of 361 patients with diverticular disease (38% complicated) operated by a minimally invasive approach found a conversion rate of 14% in complicated and 11.6% in uncomplicated disease, while overall morbidity was similar to the present study [19]. Even though the leak rate of 2% was slightly lower in this former series, length of stay averaged 5 days, with one-third of patients treated within a fast track protocol. Implementation of the institutional ERP in 2010 led to decreased length of stay with a median of 3 days [21], as seen in the present study.

The most important finding of our study is the similarity in complication rates and length of stay regardless of disease presentation by the time of surgery. Several factors may contribute to this result. First, advanced expertise in robotic surgery allowed for safe surgery despite unfavorable and challenging conditions with complicated disease. Second, standardized approach and teaching conditions lead to better outcomes, as repeatedly shown previously [27–29]. Finally and most importantly, high compliance to the institutional ERP, yielding over 70% even in patients with complicated disease, may have significantly contributed to these encouraging results. High ERP compliance regardless of the surgical approach has been repeatedly associated with favorable short-term outcomes [30, 31].

The present study has limitations that need to be addressed. The limited number of patients in both groups is prone to type II-error (small sample size). However, this study reports on the largest cohort of robotically performed colectomies for complicated diverticular disease. Since not all consecutive patients operated on for diverticular disease were performed robotically, selection bias may exist. However, over half of patients presented with complicated disease at the time of surgery, rendering a positive selection bias unlikely. Finally, the present results derive from an expert center and cannot be uncritically extrapolated to other settings.

In conclusion, elective robotic resection of complicated left-sided diverticular disease was feasible and safe in this series with encouraging short-term results regardless of disease presentation by the time of surgery. Surgical expertise, standardization and high ERP adherence may be key factors.

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Compliance with ethical standards

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