Comparison of recovery and outcome after left and right colectomy

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Abstract

Aim The present study aimed to compare functional recovery and surgical outcomes after left and right colectomies.

Method Consecutive elective left and right colon resections for benign and malignant indications, performed between 2011 and 2016 and recorded in a prospectively maintained enhanced recovery database, were analysed. Demographic and surgical items, as well as functional recovery and 30-day complications, were compared between left-sided and right-sided colectomies. Multi-variable analysis was performed to identify risk factors for postoperative ileus (POI).

Results In total, 1001 left and 1041 right colectomies were comparable regarding demographic factors; only body mass index (BMI) was higher in patients undergoing left-sided resections ($> 30 \text{ kg/m}^2$: 33% *vs* 27%, $P = 0.004$). Malignancy (29% *vs* 67%, $P < 0.001$) and Crohn's disease (1% *vs* 31%, $P < 0.001$) were preponderant in right colectomies, whereas diverticular disease (68% *vs* 1%, $P < 0.001$) was the most common indication for left colectomy. Compliance with the enhanced recovery pathway (ERP) was comparable. While the minimally invasive approach was the preferred approach

for both sides (61% *vs* 64%, $P = 0.158$), left colectomies took longer ($180 \pm 80 \text{ min}$ *vs* $150 \pm 70 \text{ min}$, $P < 0.001$), needed more perioperative fluids ($3.1 \pm 1.4 \text{ l}$ *vs* $2.7 \pm 1.5 \text{ l}$, $P < 0.001$) and resulted in greater postoperative weight gain ($3.9 \pm 6.5 \text{ kg}$ *vs* $2.6 \pm 6 \text{ kg}$, $P = 0.025$). Crohn's disease (OR = 2.64, 95% CI: 1.27–5.46) and fluid overload (OR = 2.02, 95% CI: 1.06–3.82) were independent risk factors for POI.

Conclusion Despite equal ERP compliance, postoperative ileus was higher after right-sided colectomies. This finding was associated with Crohn's disease and fluid overload.

Keywords Enhanced recovery, colectomy, outcome, ileus, Crohn's

What does this paper add to the literature?

This paper provides new potential explanations for side-specific differences in recovery and surgical outcome after left- and right-sided colectomy performed within an enhanced recovery pathway. In particular, patients with Crohn's disease were identified as at risk for postoperative ileus. The study emphasizes further the importance of meeting euvolaemia standards.

Introduction

While short-term outcomes after colorectal resections have been extensively studied, less is known about the impact of left- *vs* right-sided colon resections on functional and surgical recovery, particularly within a fully implemented enhanced recovery pathway (ERP) [1]. Most surgeons would probably intuitively label right-sided resections as less technically demanding than

left-sided colectomies, because of better exposure and intraperitoneal location of the anastomosis, especially when splenic flexure mobilization or rectal mobilization is warranted [2]. However, some recent studies described a tendency towards slower recovery after right-sided procedures, which was partly explained by increased postoperative ileus (POI) rates [3–5]. The reasons for delayed recovery after right-sided resections are as yet undetermined.

The aim of this study was to assess functional and surgical outcomes of left- *vs* right-sided colectomy, which were carried out using a highly standardized technique and perioperative care.

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Method

This was a retrospective analysis of consecutive elective left and right colon resections with primary anastomosis for benign and malignant indications, carried out between 2011 and 2016 at Mayo Clinic (Rochester, Minnesota, USA). Data were derived from a prospectively maintained institutional electronic enhanced recovery database. Items of the database have been described previously [6,7]. This study was approved by the Institutional Review Board as part of the institutional enhanced recovery quality improvement project.

Surgical and perioperative care

Left-sided colonic resections were sigmoidectomies and left colectomies with a primary colocolonic or high colorectal anastomosis. Rectal procedures with anastomoses to the mid or low rectum and Hartmann reversals were excluded. Right-sided colectomies included ileocaecal resections and right and extended right colectomies with a primary ileocaecal anastomosis. The main indications in this consecutive, unselected cohort were malignancy, Crohn's disease and diverticular disease. All procedures were standardized [8,9] and performed by board-certified colorectal surgeons.

All patients were treated within a comprehensive, fully implemented ERP. The institutional ERP was implemented during 2010 and accepted as a division standard of practice as of January 2011 in the Department of Colon and Rectal Surgery, focussing on:

- retrieval of the nasogastric tube (NGT) by the end of the procedure;
- multimodal opioid-sparing pain management with preferred use of intrathecal analgesia [10] and nonsteroidal anti-inflammatory drugs;
- postoperative nausea and vomiting prophylaxis (systematic preoperative gabapentin and celecoxib administration as per January 2014);
- restrictive intra-operative fluid management, in line with the recommendations of the American Society of Enhanced Recovery [11]; and
- early re-alimentation and ambulation.

Outcomes

Compliance to selected ERP items was compared between the two groups. Intravenous (IV) fluid administration on the day of surgery [postoperative day (POD) 0] was stratified with a cut-off of 3 l (Hübner, BJS Open, *accepted*) [12]. Further recovery items were adherence to the institutional re-alimentation policy (prescription of a normal low-fibre or diabetic diet) and

postoperative weight gain at POD 2, stratified with a cut-off of 2.5 kg (Hübner, BJS Open, *in press*), as well as discharge to home as opposed to a further rehabilitation facility.

Thirty-day outcomes were as follows: any complication according to the 5-point Dindo/Clavien grading scale [13]: POI (defined as need for NGT re-insertion); bleeding complication (need for transfusion); and overall rate of surgical site infection (SSI) excluding documented anastomotic leaks [14], which were assessed specifically when clinically or radiologically confirmed. Further assessed were reoperation and readmission rates and length of post-procedure stay.

In a second step, univariate risk factors ($P < 0.05$) for POI were identified and analysed using multivariable logistic regression. This *post-hoc* subgroup analysis was performed because POI was higher after right-sided colectomy.

A further *post-hoc* subgroup analysis regarding overall and specific outcomes was performed in patients with Crohn's disease and the results were compared with those patients in the remaining cohort.

Statistical analysis

Descriptive statistics are reported as median [interquartile range (IQR)] and range or mean $\pm$ SD, as appropriate for continuous variables, and as absolute or relative frequencies for categorical variables. Continuous variables were compared using the Student's *t*-test, and categorical variables were compared using Fisher's exact (χ^2) test. All tests were two-sided and a value of $P < 0.05$ was considered statistically significant.

Analysis of postoperative ileus was performed through multinomial logistic regression of univariate significant risk factors to provide adjusted estimations of the OR with 95% CI. Data analysis was performed with the Statistical Software for the Social Sciences SPSS ADVANCED STATISTICS 22 (IBM Software Group, Chicago, Illinois, USA).

Results

Of 2042 procedures included, 1001 (49%) were left and 1041 (51%) were right colectomies. Patient demographics were comparable except for body mass index (BMI), which was higher in patients undergoing left-sided resections ($> 30 \text{ kg/m}^2$: 33% *vs* 27%, $P = 0.004$) (Table 1). Malignancy (29% *vs* 67%, $P < 0.001$) and Crohn's disease (1% *vs* 31%, $P < 0.001$) were preponderant in right colectomies, whereas diverticular disease (68% *vs* 1%, $P < 0.001$) was the most common indication for left colectomy. A minimally invasive approach

was the preferred approach for both sides (61% *vs* 64%, $P = 0.158$). As surrogates of surgical difficulty, patients undergoing left-sided colectomy had longer surgery times and received a larger volume of perioperative fluids (3.1 ± 1.4 l *vs* 2.7 ± 1.5 l, $P < 0.001$).

Specific ERP- and postoperative recovery-related outcomes are displayed in Fig. 1. All ERP items, except perioperative fluid management, were comparable between the two groups. Weight gain at POD 2 was higher after left-sided resections (3.9 ± 6.5 kg *vs* 2.6 ± 6 kg, $P = 0.025$).

Figure 2 illustrates postoperative surgical outcomes. Significant differences were observed, with a larger number of overall complications (16% *vs* 20%,

$P = 0.029$), POI (6% *vs* 9%, $P = 0.035$) and bleeding complications (8% *vs* 11%, $P = 0.021$) in the right colectomy group. Median length of stay was 3 (2–10) days after left colectomy and 4 (1–12) days after right colectomy ($P = 0.072$).

Postoperative ileus

The POI rate was 7.4% overall, 6.2% in patients undergoing surgery for diverticular disease, 7.2% in cancer patients and 12.7% in patients with Crohn's disease. Univariate and multivariable risk factors for POI are displayed in Table 2. Crohn's disease (OR = 2.64; 95% CI: 1.27–5.46, $P = 0.009$) and fluid overload

Table 1 Demographics and surgical details

Variable	All ($n = 2042$)	Left ($n = 1001$)	Right ($n = 1041$)	<i>P</i>
Age (years)	60 ± 17	60 ± 14	60 ± 20	0.835
Gender (male)	938 (46)	457 (46)	481 (46)	0.113
BMI (≥ 30 kg/m ²)	604 (30)	326 (33)	278 (27)	0.004
ASA category (≥ 3)	620 (30)	298 (30)	322 (31)	0.594
Diabetes mellitus	263 (13)	126 (13)	137 (13)	0.741
Preoperative albumin (g/dl)	4 ± 0.6	4 ± 0.6	4 ± 0.5	0.924
Indication				
Malignancy	981 (48)	286 (29)	695 (67)	< 0.001
Crohn's disease	332 (16)	10 (1)	322 (31)	< 0.001
Diverticular disease	690 (34)	681 (68)	9 (1)	< 0.001
Other	39 (2)	24 (2)	15 (1)	0.114
Minimally invasive approach	1268 (62)	606 (61)	662 (64)	0.158
Operation duration (min)	160 ± 80	180 ± 80	150 ± 70	< 0.001
Operation duration > 180 min	649 (32)	415 (41)	234 (22)	< 0.001

The x-axis represents percentage of patients.

Baseline demographic and surgical parameters of patients undergoing left-sided ($n = 1001$) and right-sided ($n = 1041$) colectomy.

ASA, American Society of Anesthesiology; BMI, body mass index; SSI, surgical site infection.

Values shown in bold indicate significance at $P < 0.05$.

(OR = 2.02; 95% CI: 1.06–3.82, $P = 0.032$) were independent risk factors for POI.

Subgroup analysis of patients with Crohn's disease

Besides the aforementioned differences in POI rates, patients with Crohn's disease presented more overall complications (24% vs 17%, $P = 0.002$) and SSI (7% vs 4%, $P = 0.001$), while no significant differences were observed regarding bleeding complications (11% vs 9%, $P = 0.183$) and anastomotic leak rate (3% vs 2%, $P = 0.054$). Readmissions (13% vs 9%, $P = 0.029$) and

reoperations (7% vs 4%, $P = 0.033$) were more frequent in patients with Crohn's disease, who also had a longer median hospital stay [4 (1–12) days vs 3 (1–11) days, $P = 0.005$].

Discussion

This large single-centre experience revealed an increased POI rate after right-sided colectomy compared with left-sided colectomy, despite seemingly less challenging right-sided resections, as demonstrated by a shorter operating time and requirement for less perioperative fluid. Delayed intestinal recovery was significantly higher in patients with Crohn's disease who underwent almost exclusively right-sided resections. These results provide new potential explanations for side-specific differences of intestinal recovery after colectomy.

Recent reports comparing left- with right-sided resections described delayed gastrointestinal recovery after right-sided resections and provided several potential explanations for this finding. A UK multicentre snapshot observational study of 204 colectomies hypothesized that differences in vagal innervation or 'pacemaker' regions may be one explanation for this difference [15]. Campana *et al.* [3] described a POI rate of 11% (an increase of over four-fold) after right-sided laparoscopic cancer resections, despite shorter operative time, in a high-volume institution. In their study, all ileocolic anastomoses were hand-sewn, providing a potential explanation for this difference, according to the authors. A prospective analysis of 94 patients found an interesting positive association between length of resected bowel and time to recovery of bowel function after right- but not left-sided resections [4]. The authors speculated that fundamental physiological differences in recovery after left- vs right-sided resections were at play. Finally, a recent retrospective analysis of 223 consecutive patients found equally high ERP compliance in both groups, and adapted the institutional protocol by recommending half-size portions until bowel recovery after right colectomy [5].

The present study provides a potential explanation for side-specific delayed intestinal recovery: Crohn's disease. Similar observations were made by a recent Chinese report: 184 patients with inflammatory bowel disease (IBD) were matched and compared with 250 patients with colorectal cancer [16]. This latter cohort underwent heterogeneous elective and emergent colorectal procedures; a POI rate of 9.8% in patients with IBD compared with 4% in patients with cancer was described. The subgroup analysis of patients with IBD revealed preoperative steroids, malnutrition and systemic inflammatory response as risk factors for POI in patients

Figure 2 Outcome. Comparison of outcome in patients undergoing left-sided ($n = 1001$) and right-sided ($n = 1041$) colectomy. Reop, reoperation; SSI, surgical site infection. *Significance at $P < 0.05$.

Table 2 Risk factors for postoperative ileus

Factor	Univariate OR (95% CI)	Multivariable OR (95% CI)
Age > 70 years	1.01 (0.71–1.44)	–
Male gender	1.38 (1.00–1.94)	1.27 (0.72–2.26)
BMI > 30 kg/m ²	0.84 (0.58–1.22)	–
Diabetes mellitus	1.30 (0.82–2.05)	–
Hypoalbuminaemia	2.43 (1.35–4.39)	1.83 (0.98–3.43)
ASA category ≥ 3	1.73 (1.24–2.43)	1.66 (0.88–3.11)
Malignancy	0.94 (0.68–1.31)	–
Crohn's disease	2.14 (1.48–3.11)	2.64 (1.27–5.46)
Diverticular disease	0.81 (0.48–1.13)	–
Open surgery	2.09 (1.50–2.91)	1.37 (0.76–2.47)
Right colectomy	1.43 (1.03–2.01)	1.33 (0.63–2.80)
Duration > 180 min	1.62 (1.16–2.27)	1.73 (0.91–3.27)
POD 0 fluids > 3 l	2.39 (1.71–3.34)	2.02 (1.06–3.82)
POD 2 weight gain > 2.5 kg	1.70 (0.91–3.17)	–

ASA, American Society of Anesthesiology; BMI, body mass index; POD, postoperative day.

Values shown in bold indicate significance at $P < 0.05$.

with IBD. Our present study solely considered elective procedures in pre-optimized patients with Crohn's disease. Nevertheless, a persistent intrinsic inflammatory component in patients with Crohn's disease following exhausted medical treatment may account for delayed recovery, even in the elective setting [17].

Patients in this study followed exactly the same perioperative care protocol, with similar compliance recorded in both groups. Standardized surgical care accounted further for homogeneity of the patient cohort, and our findings are thus probably explained by factors outside perioperative care. Even though this study does not identify a causative factor, we hypothesize that manipulation of the small bowel during right-sided resections, together with the above-mentioned intrinsic inflammation in patients with Crohn's disease, triggered a complex interaction of inflammatory and neurohumoral mechanisms, which ultimately led to disrupted gastrointestinal motility [18–20]. Furthermore, and in line with former studies [21,22], the present study revealed increased postoperative overall morbidity and prolonged length of hospital stay in patients with Crohn's disease. Potential explanations for these findings include increased opioid use [23,24] and unfavourable baseline conditions with emergent or expedited procedures [25] in this particular subset of patients.

The present study further identified fluid overload (> 3 l) as an independent risk factor for POI. Rather large fluid volumes averaging nearly 3 l were administered in the setting of the established ERP of our institution. A recent multinational study of the enhanced recovery after surgery network found that 60% of patients undergoing colorectal resections exceeded the suggested restrictive fluid threshold of 3 l [26]. The independent protective effect of restrictive fluid management in this latter study and our present analysis emphasizes the importance of adhering to restrictive fluid administration patterns.

This study has limitations beyond its retrospective design that have to be considered when interpreting the results. Even though the groups were similar regarding demographic characteristics, they were not matched. However, BMI, potentially associated with POI [27], was higher in the left-sided group. Furthermore, surrogates for surgical difficulty, including surgical duration, fluids administered IV and (even though not statistically significant) an open approach, were all higher in left-sided resections. Therefore, the independent association of Crohn's disease with POI is all the more remarkable. Factors beyond the available list of items and early postoperative complications may confound the occurrence of POI. This needs to be considered when interpreting

the results. Data derive from a high-volume institution, impeding uncritical extrapolation of the results to other settings.

In conclusion, in our study the higher rate of POI after right-sided colectomy compared with left-sided resections could be attributed to Crohn's disease as a trigger for these side-specific differences. The study further emphasizes the importance of meeting euvoemia standards.

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Conflicts of interest

No conflicts of interest to declare.

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