

# Enhanced Recovery Pathway for Right and Left Colectomy: Comparison of Functional Recovery

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## Abstract

**Background** Enhanced recovery (ERAS) guidelines do not differentiate between left- and right-sided colectomies, but differences in recovery have been reported for the two procedure types. We aimed to compare compliance with the ERAS protocol and outcomes after right versus left colectomy.

**Methods** Between June 2011 and September 2014, all patients undergoing elective colonic resection were treated according to a standardized ERAS protocol and entered a prospective database. This retrospective analysis compared right and left colectomy regarding application of the ERAS pathway, bowel recovery, complications, and hospital stay.

**Results** Eighty-five patients with right colectomy matched well with 138 left-sided resections for baseline demographics. Overall compliance with the ERAS protocol was 76 % for right versus 77 % for left colectomy patients ( $p = 0.492$ ). First flatus occurred at postoperative day 2 in both groups ( $p = 0.057$ ); first stool was observed after a median of 3 (right) and 2 days (left), respectively ( $p = 0.189$ ). Twenty patients (24 %) needed postoperative nasogastric tube after right colectomy compared to 11 patients (8 %) after left colectomy ( $p = 0.002$ ). Overall complication rates were 49 and 37 % for right and left colectomy, respectively ( $p = 0.071$ ). Median postoperative length of stay was 6 days (IQR 4–9) after right and 5 days (IQR 4–7.5) after left colectomy ( $p = 0.020$ ).

**Conclusion** Overall compliance with the protocol was equally high in both groups showing that ERAS protocol was applicable for right and left colectomy. Functional recovery however, tended to be slower after right colectomy, and postoperative ileus rate was significantly higher. More cautious early feeding after right colectomy should be considered.

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## Abbreviations

ERAS Enhanced recovery after surgery  
POD Postoperative day

## Introduction

Perioperative care has significantly evolved during the last decade for major abdominal surgery, especially colorectal surgery. Multimodal approaches with the use of enhanced recovery protocols allowed to reduce postoperative complications, length of stay, and costs [1–5]. The enhanced

recovery after surgery (ERAS) guidelines provides a summary of evidence-based measures in elective colonic surgery [6]. These measures aim for a decrease in surgical stress, maintenance of physiologic functions, and early mobilization, along with avoidance of prophylactic abdominal drain, routine nasogastric tube, and adoption of a stringent intravenous fluid administration policy [6]. The relationship between application of the enhanced recovery protocol (=compliance) and improvement in clinical outcome has been reproducibly demonstrated [3, 7]. The same protocol is advocated for left- and right-sided resections [6].

Outcomes after colonic resection were widely reviewed but few studies have focused on differences in outcome after right versus left colectomy. These studies evaluated complications, length of stay, and mortality [8–12]. They reported a higher rate of anastomotic leak [8, 10] and reoperations for sepsis [9], more superficial surgical site infections [9, 11], and more intraoperative complications [12, 13] after left colectomy. Conversely, one study showed more postoperative complications after right colectomy, such as urinary tract infection, pneumonia, and ileus [13]. Length of stay tended to be longer after right-sided resection in one study [9], but shorter in another [11]. Mortality was similar in both groups [8, 9, 11, 13, 14].

There is a common belief that recovery after right colectomy is more problematic and longer, although the surgical act is regarded less challenging and faster as compared to left-sided resections. However, data about functional recovery confirming or refuting this perception are lacking. It remains, therefore, unknown whether one single pathway fits equally for left- and right-sided colectomies.

The objective of this study was to compare right and left colectomy with regard to compliance with the ERAS protocol, functional outcomes, and clinical results.

## Methods

### Study design

This is a single-center, retrospective cohort study based on a prospective database. The institutional ethics committee approved the study (no. 46/15).

The study was conducted in accordance with the STROBE criteria (<http://strobe-statement.org/>) and registered under [www.researchregistry.com](http://www.researchregistry.com) (UIN 372).

### Patients

In May 2011, a standardized enhanced recovery protocol for elective colonic resection was implemented at the

University Hospital of Lausanne and applied systematically [4]. Since then, demographic and surgical information, application of protocol items, and functional and clinical outcomes until 30 days postoperatively were recorded routinely into a prospective database, the ERAS Interactive Audit System.

All patients undergoing elective colon resection were treated from June 2011 according to the ERAS protocol, and no patient was excluded from the pathway; consecutive patients until September 2014 were included in the present analysis. Patients undergoing right colectomy or ileocaecal resection were referred to the right colectomy group and patients undergoing left colectomy or sigmoidectomy were included in the left colectomy group.

### Surgical procedures

All surgeries were performed or supervised by a board-certified surgeon. Our institution has a strong mission for surgical education and hence a high turnover of junior staff surgeons. Overall, 13 different surgeons performed the colon resections of the study cohort, but always with a staff surgeon. In fact, surgical technique was standardized and the staff surgeon always present, so there were very few differences among junior surgeons. Laparoscopic resection was favored whenever thought to be feasible by the senior surgeon. End-to-end stapled anastomosis was performed after left colectomy [15, 16] and ileocolic side-to-side stapled anastomosis for right colectomy [17].

### Enhanced recovery after surgery protocol

The institutional enhanced recovery protocol was based on the published ERAS guidelines [6] and used in recent institutional publications [4, 18]. This protocol includes 21 items (online resource).

### Outcome measures

Adherence to the ERAS<sup>®</sup> protocol was assessed as dichotomous variable for every item of the institutional enhanced recovery protocol. Percentages for each individual item were calculated as compliant patients divided by total patients for both groups. Overall compliance was calculated as number of fulfilled items divided by 21, the total number of items. The adherence to the protocol was separately calculated for the pre-, intra-, and postoperative phase using the number of items in each phase, respectively, as denominator.

Functional outcomes included time to first passage of stool and flatus and time to tolerate solid food, measured in number of postoperative days (POD). Level of pain was assessed by use of a visual analogical scale (0–10 points)

and by the time to pain control with oral analgesics, measured in number of POD. Postoperative ileus was defined as the necessity of insertion of a nasogastric tube; indication for nasogastric tube placement was based on the following criteria: abdominal distension, no bowel movements, and nausea/vomiting occurring later than 24 h after surgery. These criteria are in line with a recent consensus definition of Vather et al. [19].

Clinical outcomes included complication rate and length of stay. Postoperative complications occurring within 30 postoperative days were graded according to the Clavien classification [20] on a 5-point severity scale. Grade III to IVb complications were defined as severe complications. For patients with more than one complication, the most severe complication was considered. Length of stay was measured from day of surgery until day of hospital discharge.

### Subgroup analysis

A significant higher rate of postoperative ileus was observed in the right colectomy group, with a trend for slower functional recovery. As open surgical approach represents a risk factor for delayed bowel recovery [21–24] and this approach was more often used for right colonic resection, it was decided to perform a post hoc analysis including only patients who underwent completed laparoscopic surgery.

### Statistical analysis

Descriptive statistics are reported as median (interquartile range) or mean ( $\pm$ standard deviation) as appropriate for continuous variables and absolute or relative frequencies for categorical variables. Continuous variables were compared using the Mann–Whitney *U* test or Student's *t* test. Categorical variables were compared with Chi-squared or Fisher's exact test. All tests were two-sided. A *p* value of less than 0.05 was considered significant.

Univariate risk factors for insertion of nasogastric tube and potential confounders were entered into a logistic multivariate regression model. Only variables with a *p* value of less than 0.1 on univariate testing were included.

Data were analyzed by use of IBM® SPSS® statistics 22.0 (IBM, Armonk, NY, USA).

## Results

### Demographics and surgical characteristics (Table 1)

Between June 2011 and September 2014, 223 consecutive and unselected patients underwent elective colonic resection and were included in our prospective ERAS database.

Eighty-five patients underwent right colectomy or ileo-caecal resection and 138 patients underwent left colectomy or sigmoidectomy, respectively. One hundred and fourteen men and 109 women, with a mean age of 64 ( $\pm$ 16) years were treated. Both groups were similar with regard to demographic data, besides a higher BMI in the left colectomy group. Malignant disease was more common for patients with right-sided colectomy (69 %) compared with patients with left-sided resections (52 %) (*p* = 0.012). There was a trend to choose laparoscopic approach more often for left (76 %) than for right (66 %) colonic resection (*p* = 0.124), with a conversion rate of 13 versus 9 % (*p* = 0.521). The added number of primarily open and converted procedures was 29/85 for right versus 33/138 for left colectomy (*p* = 0.124).

One patient received a loop ileostomy after right-sided resection and two patients after left colectomy. Three colostomies were performed in the left group.

### Compliance with the enhanced recovery protocol

Overall compliance with the enhanced recovery protocol was similar in both groups (76 % in right and 77 % in left-sided resections, *p* = 0.492). Compliance with the items of the preoperative phase was 97 and 98 % for right and left colon resection groups, respectively (*p* = 0.522), while intraoperative phase showed a compliance of 78 and 70 %, respectively (*p* = 0.005). Postoperative items were followed with 65 % compliance in right versus 68 % in left colectomy groups (*p* = 0.152). The application of individual items is detailed in Fig. 1.

### Functional outcomes

First flatus occurred in both groups after a median of two postoperative days (IQR 1–3 and 1–2 for right and left colectomy groups, respectively, *p* = 0.057). First passage of stool occurred on POD 3 (IQR 2–4) after right colectomy and on POD 2 (IQR 2–3) after left colectomy (*p* = 0.189). Time to tolerate solid food was 3 POD (IQR 1–3) in patients with right and 2 POD (IQR 2–3) in patients with left colectomy (*p* = 0.638). Postoperative ileus occurred in 20 patients (24 %) with right colectomy and in 11 patients (8 %) with left colectomy (*p* = 0.002).

Pain control with oral analgesics was achieved on POD 2 for both groups (IQR 1–3 for right versus 1–2 for left colectomy groups, respectively, *p* = 0.008). Level of pain was similar in both groups (Fig. 2).

### Complications and length of stay (Table 2)

Overall, 42 patients with a right colectomy (49 %) and 51 patients with a left colectomy (37 %) developed

**Table 1** Demographics and operation characteristics of patients undergoing right versus left colectomy

	Right colectomy ( <i>N</i> = 85)	Left colectomy ( <i>N</i> = 138)	<i>p</i> value
Age (years)	64.4 ± 19.2	63.4 ± 14.3	0.675 <sup>a</sup>
Gender ratio (male:female)	45:40	69:69	0.682 <sup>b</sup>
Body mass index (kg/m <sup>2</sup> )	25.0 ± 4.9	26.8 ± 5.1	0.012 <sup>a</sup>
ASA grade			0.526 <sup>b</sup>
I–II	62 (73)	106 (77)	
III–IV	23 (27)	32 (23)	
Pathology			0.012 <sup>b</sup>
Benign	26 (31)	66 (48)	
Malign	59 (69)	72 (52)	
Surgical approach			
Laparoscopic	56 (66)	105 (76)	0.124 <sup>b</sup>
Open	21 (25)	15 (11)	0.008 <sup>b</sup>
Converted	8 (9)	18 (13)	0.521 <sup>b</sup>
Stoma formation	1 (1)	5 (4)	0.411 <sup>b</sup>
Surgery duration (min)	182 ± 95	204 ± 69	0.066 <sup>a</sup>
Intraoperative blood loss ≥500 ml	10 (12)	10 (7)	0.237 <sup>b</sup>

Values are presented as mean ± SD or *N* (%) unless indicated otherwise

ASA American Society of Anesthesiologists, SD standard deviation

<sup>a</sup> *t* test

<sup>b</sup> Fisher's exact test

postoperative complications ( $p = 0.071$ ). Severe complications occurred in 10 (12 %) patients in the right and 10 (7 %) patients in the left colectomy group ( $p = 0.104$ ).

Three deaths occurred, all after left-sided resections. Causes were septic shock following anastomotic leakage, myocardial infarction with cardiac arrest, and hepatic failure due to Budd–Chiari syndrome.

Median postoperative length of stay was 6 days (IQR 4–9) in the right and 5 days (IQR 4–7.5) in the left colectomy group ( $p = 0.020$ ). Postoperative stay in patients without complications was 4 days (IQR 3–5) in both groups ( $p = 0.252$ ), while length of stay in patients with complications was 9.5 days (IQR 7–16) for right and 9 days (IQR 6–12.5) for left-sided resection ( $p = 0.343$ ).

### Subgroup analysis including completed laparoscopic resections

Fifty-six patients in the right colectomy group were compared to 105 patients in the left-sided resection group. Postoperative ileus rate was still significantly higher following laparoscopic right-sided resection, affecting 10 patients (18 %), compared to 4 patients (4 %) after laparoscopic left colectomy ( $p = 0.006$ ). However, first passage of flatus occurred on POD 2 (IQR 1–2) in both groups, as well as first passage of stool (IQR 2–3). Time to

tolerate solid food was 3 POD (IQR 1–3) in patients with right and 2 POD (IQR 2–3) in patients with left colectomy ( $p = 0.513$ ).

### Risk factors for postoperative ileus: multivariate analysis

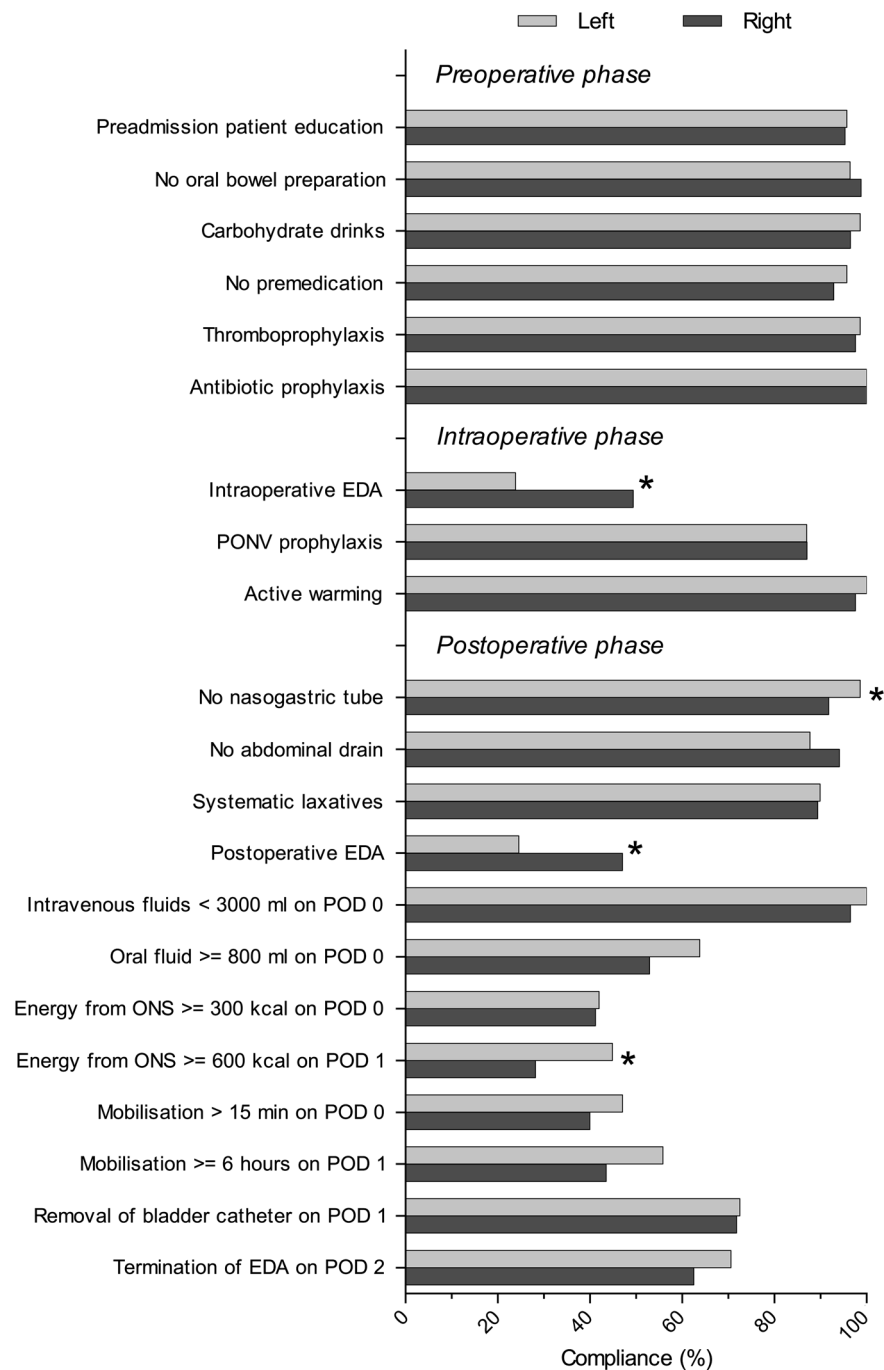
As shown in Table 3, four factors were significantly associated with the occurrence of postoperative ileus in our study cohort. After multivariate analysis, only right colectomy was retained as independent risk factor for insertion of nasogastric tube.

### Discussion

This study comparing functional recovery between right- and left-sided colectomies suggests a slower functional recovery and a significantly higher ileus rate after right colectomies. Overall compliance with the ERAS pathway was equally high among the two groups. Therefore, a more cautious early postoperative feeding protocol after right colectomy is suggested.

In this study, the observed postoperative ileus rate after right-sided resections was 24 %. As postoperative ileus is considered a grade II complication according to Clavien

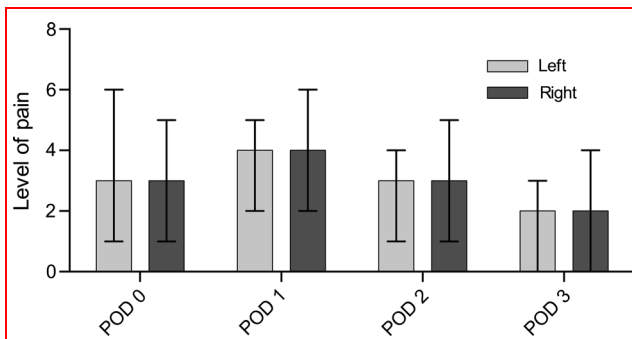
**Fig. 1** Compliance with ERAS protocol by item in patients undergoing left compared to right colectomy



\* indicates statistical significance ( $p < 0.05$ ).  
 EDA epidural analgesia, PONV postoperative nausea and vomiting, ONS oral nutrition supplement, POD postoperative day.

classification, it represents the majority of grade II complication in the present study cohort and hence accounts for the overall increased complication rates after right colectomy, even with laparoscopy. Overall, we observed an ileus rate after right- and left-sided resections of 13.9 %. This rate is similar to the findings of other publications [21, 25,

26]. One study showed a higher ileus rate after right colectomies (38 %) compared to left-sided resections (14 %) in univariate analysis [22]. However, the authors provide no explanation for this finding. Furthermore, patients were not treated within a standardized ERAS pathway containing an array of preventive measures.



**Fig. 2** Level of pain in patients undergoing left compared to right colectomy assessed with a visual analogic scale (0–10 points)

The definition of postoperative ileus is inconsistent in the literature rendering comparison between studies problematic. We used therefore the objective endpoint of insertion of nasogastric tube as definition for the purpose of this study. Vather et al. have recently proposed a consensus statement [19, 27]. The proposed definitions for postoperative ileus correspond to the clinical indications for nasogastric tube placement used in our study. Furthermore, this pragmatic approach has also been proposed in the recent systematic review of Wolthuis et al. [28] concluding «*that reinsertion of the NG tube should be adopted as the standardized definition in the future*».

In our cohort, demographics and surgical details were overall well matched. However, differences existed concerning several potential risk factors for delayed bowel recovery. These were in particular a higher BMI [26, 27, 29] and longer operative time [21, 25, 30], disfavoring left-sided resections. Several studies [21–24] have demonstrated lower ileus rates after a laparoscopic approach

compared to open procedures. In our cohort, the rate of laparoscopic procedures was slightly lower in the right-sided resection group. However, the added number of primarily open and converted procedures was not significantly different, and might therefore not explain the higher incidence of ileus after right colectomy. Furthermore, the subgroup analysis including only laparoscopic cases confirmed a higher rate of ileus following right-sided resection. Finally, our hypothesis was strengthened by multivariate analysis retaining right colectomy as the only independent risk factor for postoperative ileus.

Vather et al. [27] identified several other factors associated with postoperative ileus following colorectal surgery, namely copious administration of intravenous crystalloids in the perioperative period and delayed mobilization. In our cohort, exactly the same perioperative protocol was applied for both comparative groups as recommended [6] and we did not identify any difference with regard to these important factors in our patients.

A recent publication [21] identified ileocolic anastomosis as a risk factor for postoperative ileus, compared to colocolic or colorectal anastomosis. The authors suggest that anastomosis with small bowel could play a role in ileus occurrence. This could be a hypothesis regarding our findings, but paucity of the literature on this topic limits further explanation.

The impact of stoma formation on the incidence of postoperative ileus is controversial in the literature. Intuitively, patients with an ostomy might have earlier signs of bowel motion (e.g., first flatus, stool) as an ostomy removes (parts of) colonic recovery from the equation. On the other hand, Millan et al. [31] identified ileostomy as a risk factor for postoperative ileus, while Thoker et al. [32] found no

**Table 2** Clinical outcomes of patients undergoing right versus left colectomy

	Right colectomy (N = 85)	Left colectomy (N = 138)	p value
Patients with complication(s) within 30 days	42 (49)	51 (37)	0.071 <sup>a</sup>
Complications grade			
Grade I	10 (12)	19 (14)	0.839 <sup>a</sup>
Grade II	22 (26)	19 (14)	0.032 <sup>a</sup>
Grade III	5 (6)	8 (6)	1.000 <sup>a</sup>
Grade IV	5 (6)	2 (1)	0.109 <sup>a</sup>
Grade V	0	3 (2)	0.289 <sup>a</sup>
Postoperative stay (days)	6 (4–9)	5 (4–7.5)	0.020 <sup>b</sup>
Readmission within 30 days	4 (5)	3 (2)	0.432 <sup>a</sup>
Reoperation(s)	6 (7)	7 (5)	0.566 <sup>a</sup>

Values are presented as median (interquartile range) or N (%)

<sup>a</sup> Fisher's exact test

<sup>b</sup> Mann–Whitney U test



**Table 3** Risk factors for reinsertion of nasogastric tube

	Univariate OR (95 % CI)	Multivariate OR (95 % CI)
BMI >25	0.83 (0.39–1.77)	–
Open or converted approach	<b>3.97</b> (1.81–8.67)	2.21 (0.90–5.42)
Right colectomy	<b>3.55</b> (1.61–7.86)	<b>3.32</b> (1.39–7.95)
Operative duration >180 min	<b>2.33</b> (1.04–5.21)	2.22 (0.89–5.50)
Epidural analgesia	<b>3.94</b> (1.79–8.67)	2.12 (0.87–5.14)
IV fluid on day of surgery >3000 ml	1.00 (0.99–1.01)	–

Bold indicates statistical significance

OR odds ratio, CI confidence interval, BMI body mass index, IV intravenous

difference between patients with or without ostomy after rectal resection. In our study, removal of ostomy patients from the analysis did not change the results.

The overall compliance with the ERAS protocol in our analysis was similar to the rate observed in the literature [7, 18, 33, 34] and was equally high in both groups. Therefore, unequal application of the ERAS protocol does not explain the differences in functional outcomes. Detailed analysis of compliance with the intended ERAS protocol showed significant differences between the two groups for three items only; we found a higher rate of epidurals and prophylactic nasogastric tubes in the right colectomy group but a lower tolerance of oral supplements on POD 1. In line with the findings of Nelson et al. [35], our results confirm that prophylactic nasogastric drainage—nasogastric tube inserted in operating room and left in place in the post-operative phase—does not prevent ileus. The use of epidurals for colorectal surgery remains controversial, especially for laparoscopic resections. Concerning the open approach, bowel recovery tended to be faster with epidurals in some studies, while others did not find any difference [36]. Moreover, most of the included studies did not provide ERAS care to the included patients. For minimal-invasive resections within ERAS pathways, most recent studies could not find a benefit for epidurals that even appeared to slow down the recovery process in some studies [37, 38]. This is in accordance with the findings of the present study.

There is a panel of different strategies that could help to prevent ileus; a revision of some parts of the ERAS protocol by adding several of these new measures should be considered for right-sided resection. Some strategies could be implemented in the ERAS protocol in the light of recent therapies, as summarized in the review of Bragg et al. [39]. The systematic use of alvimopan, a peripheral opioid antagonist, allowed faster bowel function recovery and reduces length of stay [40–43]. Systematic lidocaine has shown to reduce time to bowel movement after abdominal surgery [44]. The stimulation of gut motility with chewing

gum [45] or coffee [46] should be encouraged. Laxatives such as bisacodyl act on colon peristalsis and may confer additional benefit [47].

The present study has several limitations. Certain differences between the comparative groups exist and might have influenced outcomes. More open surgeries and more epidurals might have disfavored the right colectomy group. On the other hand, higher BMI was more prevalent in the group of left-sided resections. In addition, operative time tended to be longer for left-sided resections. After all, the present study aimed to compare non-selected right- versus left-sided resections. As an inherent limitation of retrospective studies, additional potentially important variables were not available from the prospective database. This concerns, for example, the amount of opioids given after right and left colectomy, respectively. However, large differences appear to be unlikely with exactly the same perioperative care pathway for both comparative groups. Finally, the study sample is modest and these results have to be confirmed by future studies.

In conclusion, the present study provides some evidence for slower gastrointestinal recovery after right colon resections as compared to left colectomies. Given the similar overall compliance of perioperative care and well-matched groups, it can be hypothesized that this is mainly linked to the type of surgical procedure. The mechanism remains to be clarified. As a consequence, we have adapted our ERAS protocol by recommending half-size portion until bowel recovery and a careful monitoring of ileus symptoms after right colectomy.

#### Compliance with ethical standards

**Disclosure** No external funding was required for this study.

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