SCIENTIFIC PAPER JSLS

Operative Time and Outcome of Enhanced Recovery After Surgery After Laparoscopic Colorectal Surgery

Oliver J. Harrison, MRCS, Neil J. Smart, FRCSEd (Gen Surg), Paul White, PhD, Adela Brigic, MRCS, Elinor R. Carlisle, MBChB, Andrew S. Allison, FRCSEd (Gen Surg), Jonathan B. Ockrim, FRCS (Gen Surg), Nader K. Francis, FRCS (Gen Surg)

ABSTRACT

Background and Objectives: Combining laparoscopy and enhanced recovery provides benefit to short-term outcomes after colorectal surgery. Advances in training and techniques have allowed surgeons to operate on cases that are technically challenging and associated with prolonged operative time. Laparoscopic techniques improve the outcome of enhanced recovery after colorectal surgery; however, there are no specifications on the effect of prolonged operations on the outcome. The objective was to elucidate the impact of prolonged surgery and blood loss on the outcome of enhanced recovery after surgery after laparoscopic colorectal surgery.

Methods: Four-hundred patients who underwent elective colorectal resection on enhanced recovery after surgery in Yeovil District Hospital between 2002 and 2009 were retrospectively reviewed. Delayed discharge was defined as a prolonged length of stay beyond the mean in this series (≥8 days).

Results: Three-hundred eighty-five patients were included. Median operative time was 180 minutes with a median blood loss of 100 mL. Conversion was not associated with a prolonged length of stay. Operative time and blood loss correlated with length of stay in a stepwise fashion. There were 2 cutoff points of operative time at 160 minutes and 300 minutes (5 hours), where risk of prolonged stay increased significantly (odds ratio [OR] = 2.02; 95% confidence interval [CI], 1.05–3.90; $P = .027$), and blood loss of >500 mL (OR = 3.114; 95% CI, 1.501–6.462, $P = .002$).

Conclusions: Total operative timing impacts negatively on the outcome of enhanced recovery after laparoscopic colorectal resections with increased risk of delayed discharge seen after ~2.5 hours and 5-hour duration.

Key Words: Blood loss, Colorectal surgery, Enhanced recovery, Laparoscopy, Operative time.

INTRODUCTION

Enhanced recovery after surgery (ERAS) is a multimodal care pathway that aims to reduce the stress response to surgery and optimize postoperative recovery by guiding perioperative management.[1] The association of ERAS with improved short-term outcomes, including reduced length of stay, reduction in morbidity, faster return of bowel function, earlier mobilization, and lower pain scores, is well documented.[2–7] The introduction of laparoscopic surgery to ERAS, compared with open procedures and standard postoperative care, has produced further reductions in morbidity and hospital stay.[8] In most well-established ERAS units, it is now anticipated that most patients would be discharged within 1 week.

Advances in training and techniques in laparoscopic surgery have allowed surgeons to operate on complex cases that are technically challenging and associated with prolonged operative time.[9–12] Although it has been shown that laparoscopic techniques improve the outcome of enhanced recovery after colorectal surgery,[13,14] there are no specifications on different operative elements such as total operative time and operative blood loss on the outcome.

Anecdotally, it is well perceived that prolonged operative time and major operative blood loss are associated with poorer outcomes that could lead to delayed recovery even in the presence of an established enhanced recovery program. Two recent publications from our unit examined broadly the factors associated with deviation from ERAS and prolonged hospital stay.[15,16] Our previous publications examined all perioperative factors that influence length of stay and predict delayed discharge. An additional findings included association of stoma formation with delayed discharge. Conversion to an open procedure and excision of the rectum (versus colon) were not examined. Postoperative complications were predictive of

Department of General Surgery, Yeovil District Hospital, Yeovil, Somerset, United Kingdom (Drs. Harrison, Smart, Brigic, Carlisle, Allison, Ockrim, and Francis).

University of the West of England, Bristol, United Kingdom (Dr. White).

Address correspondence to: Oliver J. Harrison, MRCS, Yeovil District Hospital, Higher Kingston, Yeovil, Somerset BA21 4AT, UK. Telephone: (44) 01935 384244, Fax: (44) 01935 384653, E-mail: ojharrison@doctors.org.uk

DOI: 10.4293/108680813X13753907291918

enhanced recovery program deviation and delayed discharge. The aim of this study was to examine specifically the operative factors including total operative time and blood loss and to identify the cutoff point of these markers on the outcome of ERAS.

MATERIALS AND METHODS

A retrospective review of patients who underwent elective colorectal resection in Yeovil District Hospital (YDH) between 2002 and 2009 was performed. Surgical procedures included in this study were right, left, or subtotal colectomies; segmental resections; sigmoid colectomy; and rectal resections performed for benign and malignant lesions. Patients were identified from a prospectively maintained database, and all patients were cared for within an enhanced recovery program. The colorectal unit at YDH has been a well-established center for enhanced recovery and laparoscopic colorectal surgery since 2002. It is a recognized training center for the national training program for laparoscopic colorectal surgery. Full details of the methodology and multivariate analysis used can be found in the earlier publications from this series.[15,16]

Data included patient demographics and compliance with the enhanced recovery pathway. Operative factors such as total operative time, total blood loss, and conversion from laparoscopic to open surgery were recorded. Conversion from laparoscopic to open surgery was defined as the inability to complete the dissection laparoscopically, including the vascular ligation, and usually, but not always, requiring an incision larger than that required to remove the specimen.

Length of stay was based on the time spent in hospital postoperatively. This was defined as the day of operation (day 0) to the day of discharge. Patients were discharged from the hospital when they met the following criteria: the patients could tolerate normal diet and take only oral analgesia (if required); the patients were mobile; and the patients and their families agreed to the discharge. Postoperative complications and readmissions were recorded from the patients' notes up to 30 days postoperatively. Long-term follow-up was not included in this study.

Definitions

Total operative time was defined as the time taken from skin incision to completion of skin closure. *Total blood loss* was defined as the volume of blood collected in the suction bag and estimated from swabs at the end of the operation. *Delayed discharge* was defined as a prolonged length of stay of beyond 8 days in the absence of major surgical or medical complications, as in a well-established ERAS unit it is anticipated that patients with uneventful recovery should be discharged within 1 week.[6,17] The mean length of stay in this study was 8 days, which was used as a cutoff. For this reason, the operationally dependent variable in the following analyses is length of stay dichotomized into stays of up to 1 week ($\leq$7 days) or $>$1 week ($\geq$8 days). This form of the dependent variable removes possible weekend or day of week effects that might influence precise length of stay and ensures that the statistical impact of any unusually long stays is minimized to help establish robust conclusions.

Statistical Analysis

The data were recorded in an Excel spreadsheet and analyzed using SPSS statistical software (version 19; SPSS Inc, Chicago, Illinois). Univariate and multivariate analyses were performed.[15,16] In addition, χ^2 testing was used to identify relationships between variables and outcomes, and assumptions made to valid applications of the test were examined and justified. The magnitude of effect was quantified with odds ratios (OR), and confidence intervals for these were derived. Two-sided tests of statistical hypotheses with $P < .05$ to indicate statistical significance were used throughout.

RESULTS

Four hundred patients underwent elective laparoscopic colorectal resections within the enhanced recovery program at YDH between 2002 and 2009. Fifteen patients were excluded because notes were unobtainable for data extraction. A total of 385 patient records were included in the analysis. Of those 385, 276 (72%) had surgery for malignancy and 189 (49%) were men. The mean age was 68 years (range, 15–94), with 82 patients (21%) $>$80 years. **Table 1** illustrates patient demographics and operations. Overall, median postoperative stay was 6 days (range, 2–49) with a mean of 8 days. The 30-day readmission rate was 8% (n = 31).

Of the 385 patients analyzed, the compliance rate was $>$85% in all pre- and intraoperative elements of ERAS **(Table 2)**. Median operative time was 180 minutes with a median blood loss of 100 mL. Rectal resection or pelvic dissection was required in 36% of cases. The first surgeon was listed as a consultant in 331 (86%) cases. Conversion to open procedures occurred in 17.9% of cases, while 8.3% were unsuitable for laparoscopic resections and therefore surgical open procedures were performed. Con-

Table 1.
Patient Demographic and Operational Data (n = 385)[a]

Age, y, median (range)	68 (15–94)
Sex, n	196 female, 189 male
BMI, median (range)	26 (17–44)
ASA	
1	71 (18.4)
2	236 (61.3)
3	75 (19.5)
Not recorded	3 (0.8)
Operative approach	
Laparoscopic	283 (73.5)
Laparoscopic converted to open	69 (17.9)
Open	32 (8.3)
Not recorded	1 (0.3)
Operation	
Ileocolic/right/extended right/transverse	128 (33.2)
Left	20 (5.2)
Sigmoid	75 (19.5)
Hartmann/Hartmann reversal	15 (3.9)
Subtotal colectomy	10 (2.6)
Total colectomy and proctectomy	14 (3.6)
Anterior resection	106 (27.6)
Abdominoperineal excision	17 (4.4)

ASA, acetylsalicylic acid; BMI, body mass index.
[a]Unless otherwise indicated, data are n (%).

Table 2.
Compliance and Deviation With Elements of ERAS[a]

	Compliance	Deviation
Preoperative		
Patient counseling	100	0
No premedication	100	0
Avoidance of bowel prep	92	8
Carbohydrate loading	98	2
No starvation	99	1
Intraoperative		
Short-acting anesthesia	94	6
Minimum incision length	86	14
No routine nasogastric tube or drains	91	9
High inspired oxygen fraction	94	6
Postoperative		
Discontinuation of IV fluids	29.7	70.3
Epidural	76.1	23.9
Mobilization	83.1	16.9
Nasogastric tube	89.1	10.9
Catheterization	90.1	9.9

ERAS, enhanced recovery after surgery; IV, intravenous.
[a]Data are percentages.

version to open surgery was not associated with a prolonged length of stay.

Postoperative complications are displayed in **Table 3** and included anastomotic leak (1.6%), return to theater (7.5%), wound infection (10.1%), intra-abdominal collection (2.1%), medical complications (5.9%), and death (1%).

Data on operative time was available for 365 (94.8%) patients. Operative time was seen to adopt a stepped relationship to the risk of prolonged hospital stay with critical times at 160 minutes and 300 minutes (5 hours), where risk of prolonged stay increased significantly **(Figure 1)**. Resections of the rectum or pelvic dissection had a mean operative time of 230 minutes versus 178 minutes for all other operations. Operative time of ≥5 hours was associated with length of stay >1 week (OR = 2.02; 95% confidence interval [CI], 1.05–3.90; $P = .027$) **(Table 4)**. Similarly, data on blood loss were available for 335 (87.0%) patients, and that data indicated that with an operative blood loss of 500 mL, patients had an increase in risk of prolonged length of stay **(Figure 2)**. The association between patients with a blood loss of >500 mL and a length of stay >1 week was significant (OR = 3.114; 95% CI, 1.501–6.462; $P = .002$) **(Table 5)**.

DISCUSSION

The impact of increased operative time and blood loss on outcomes in laparoscopic colorectal surgery is multifactorial and difficult to quantify and has not been evaluated in detail previously. The aim of this study was to determine the impact of prolonged surgery and major blood loss on recovery within a well-established ERAS program after elective laparoscopic colorectal surgery. Average length of stay in uncomplicated cases in our institution has previously been reported at between 4 and 5 days.[15,16] In the present study for patients with an operative time of <120 minutes, the average length of stay was 6.4 days. We specifically investigated those patients with prolonged

Table 3.
Complications of Surgery

Complication	n (%)
Anastomotic leak (all managed operatively)	6 (1.6)
Return to theater	29 (7.5)
Refashioning of stoma	5 (1.5)
Defunctioning stoma	3 (0.8)
Examination under anesthesia	2 (0.5)
Laparotomy for small-bowel obstruction	6 (1.6)
Laparotomy and redo anastomosis	4 (1.0)
Laparotomy and washout for sepsis or hematoma	6 (1.6)
Wound dehiscence	3 (0.8)
Wound infection	39 (10.1)
Intra-abdominal collections	8 (2.1)
Atrial fibrillation	7 (1.8)
Deep vein thrombosis or pulmonary embolism	1 (0.3)
Pneumonia	7 (1.8)
Acute renal failure	4 (1.0)
Urinary tract infection	2 (0.5)
Clostridium difficile infection	2 (0.5)
Death	4 (1.0)

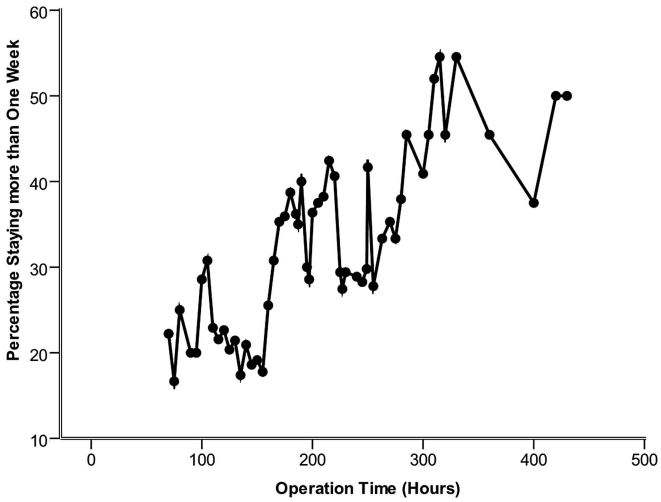

Figure 1. Five-point smoothed average line plots showing the relationship between operative time and percentage of patients staying >1 week.

operative time and increased blood loss to elucidate the impact of this factor on the outcome of ERAS, as measured by length of stay. This study identified a critical operative time of >5 hours and blood loss of >500 mL, even in uneventful recovery, as being associated with prolonged lengths of stay.

Table 4.
Operative Time and Length of Stay

			Length of Stay		Total
			≤7 Days	≥8 Days	
Operation time	<5 h	Count	227	97	324
		Percentage	70.1	29.9	100.0
	≥5 h	Count	22	19	41
		Percentage	53.7	46.3	100.0
Total		Count	249	116	365
		Percentage	68.2	31.8	100.0

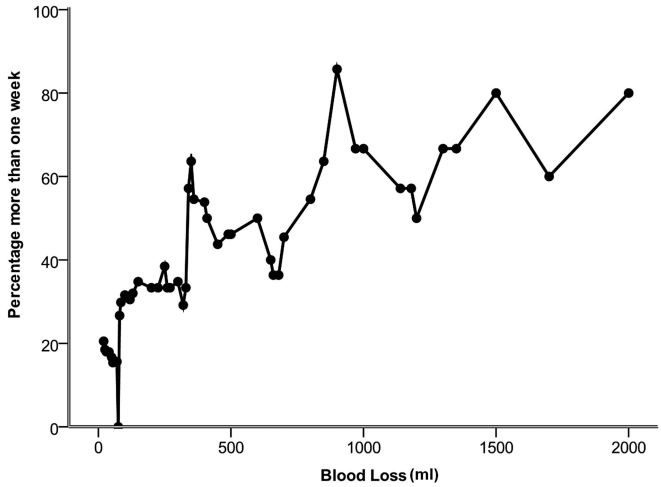

Figure 2. Five-point smoothed average line plots showing the relationship between blood loss and percentage of patients staying >1 week.

Operative Time

Operation time of >5 hours was associated with delayed discharge and is likely to be a surrogate marker of surgical difficulty. This retrospective cohort of consecutive patients who have undergone elective colorectal resections performed at YDH included patients who had surgery for advanced rectal cancer after long-course radiotherapy and pouch reconstruction. Similar results have been noted in other series undergoing laparoscopic colorectal[18] and advanced laparoscopic urological surgery,[19] indicating that operative times of >4.5 and 5 hours, respectively, are associated with prolonged lengths of stay. However, while our study supports the finding that operative time of

Table 5.
Blood Loss and Length of Stay

			Length of Stay		Total
			≤7 Days	≥8 Days	
Blood loss	≤500	Count	218	84	302
		Percentage	72.2	27.8	100.0
	>500	Count	15	18	33
		Percentage	45.5	54.5	100.0
Total		Count	233	102	335
		Percentage	69.6	30.4	100.0

>5 hours was associated with prolonged lengths of stay, this was not necessarily associated with postoperative complications.

Our institution has offered laparoscopic colorectal resections routinely to most patients since 2002. Open cases are usually selected preoperatively or occasionally converted intraoperatively where completion laparoscopically would be difficult. Mean operative time for our open cases was 207 minutes. Conversion of difficult laparoscopic cases would likely skew this figure and is thus unrepresentative of our selected open case operative time. However, 3 large randomized controlled trials of open versus laparoscopic colorectal resections quote average operative times for open procedures of between 95 and 135 minutes.[20–22]

Uneventful prolonged surgery >5 hours, with no major postoperative complications such as anastomotic leak or return to theater, still resulted in prolonged lengths of stay in this series despite a well-established enhanced recovery program in our institution. Although the conversion rate in this series was 17.9%, it was not associated with delayed discharge. We hypothesize that for those patients with prolonged surgery, an earlier conversion might have avoided their delayed discharge.

The underlying mechanism of delayed discharge after prolonged surgery can be explained in part by the complexity of the pathology requiring surgical intervention and in part by the prolonged exposure to anesthetic agents.[23] The combination of these factors is manifested clinically in the postoperative deviation from ERAS and results in delayed discharge.[24] Theoretically, prolonged operative time may indicate excessive intravenous fluid administration, but in our practice, we have adopted a goal-directed fluid therapy to control administration of fluid. In addition, prolonged operations are likely to be rectal procedures during which a steep, head-down position is required to allow exposure of the operative field.

The negative cardiorespiratory effects of prolonged pneumoperitoneum and Trendelenburg position are well documented.[25–27] Increased central venous and pulmonary artery pressures with reciprocal decreases in cardiac output and lung compliance potentially increase the risk of adverse outcomes in patients with pre-existing diseases. The risk of periorbital edema increases in prolonged laparoscopic surgery with the Trendelenburg position.[23] In addition, cases of lower limb compartment syndrome have been reported after prolonged laparoscopic procedures with steep positional changes. Therefore, avoidance of prolonged Trendelenburg positioning in colorectal surgery has been recommended.[28] The metabolic effects of pneumoperitoneum are well documented. Hypercarbia produces a respiratory acidosis in a time-dependent manner that persists with increased minute ventilation.[29–31] Acidosis suppresses myocardial function, causes pulmonary vasoconstriction, and might worsen right ventricular heart failure.[32] Sympathetic stimulation and increased afterload may represent a challenge to patients with borderline cardiac reserve.[33] $PaCO_2$ values appear to normalize ~1 hour after the release of pneumoperitoneum.[34]

Our data demonstrate that the risk of delayed discharge begins to increase with operative times of >160 and 300 minutes. Consequently, in our institution, a policy of pausing the operation at a surgically convenient point at between 2 and 2.5 hours has been adopted. The pneumoperitoneum is released and the patient's position is corrected for up to 20 minutes before the surgery continues. The theoretical aims are to correct the adverse metabolic and cardiorespiratory effects of laparoscopy in the Trendelenburg position and to reduce the risk of lower limb compartment syndrome. We hypothesize that releasing the pneumoperitoneum at this time allows partial correction of the acidosis and reduces the likelihood of delayed discharge. Further studies are required to validate this, since the relationship between pneumoperitoneum-associated acidosis and impact on delayed discharge has not been established.

Blood Loss

Increased intraoperative blood loss correlates with increased length of stay in association with confounding factors such as conversion rate in laparoscopic colorectal surgery.[17,35] Laparoscopic surgery is known to be techni-

cally challenging and may be prolonged by operative complexity, the need for conversion, and unexpected intraoperative findings that delay progression.[24,36,37]

With the advances in technology of laparoscopic equipment, such as tissue energizers, minimal blood loss is anticipated during elective colorectal resections. Blood loss of >500 mL is most likely an indication of increased operative complexity and prolonged surgery; hence, its association with delayed discharge. Delayed discharge following excessive intraoperative blood loss and subsequent blood transfusion in open colorectal surgery has been documented previously.[38] Administration of a blood transfusion, however, is an independent predictor of increased morbidity and length of stay for surgical patients, including colorectal patients, although literature specific to laparoscopy is sparse.[39,40]

Risk Stratification

Lengths of postoperative stay for elective laparoscopic colorectal resections as short as 24 hours have been achieved,[41,42] but the factors that determine successful candidates for this approach have not been clearly defined. Although a median operative time of 73 minutes was reported for 10 successful patients, no reference to blood loss was made by the investigators.[41] Conversely for those patients with prolonged operative times of >5 hours and/or blood loss of >500 mL, a modified operative and postoperative care pathway with a different expectation (of day of discharge) could be beneficial. The modified postoperative pathway should be tailored to enhance the restoration of gut function after relative hypoperfusion and prolonged anesthetic, both of which increase the risk of developing postoperative ileus. Mechanisms to combat this could include aggressive physiotherapy to mobilize the patient, optimizing and continuing analgesic regimens (such as epidurals) for >48 hours postoperatively, and the use of chewing gum, which is a form of "sham feeding" that enhances gastrointestinal motility through cephalic-vagal stimulation.[43] Further studies are required to validate this modified postoperative care pathway for those patients.

CONCLUSIONS

Operative timing impacts negatively on the outcome of enhanced recovery after laparoscopic colorectal surgery. A prolonged operative time of >5 hours is significantly associated with delayed discharge of >1 week. Total blood loss of >500 mL is also associated with delayed discharge. For those patients, a modified postoperative care pathway may be considered.

The authors thank Jenifer Wares, MBChB, Rebecca Probert, MBChB, Mildred Yeo, MBChB, and Tobias Pringle, MBChB, the foundation doctors at Yeovil District Hospital who helped collect data for this study. They also thank the Audit Department for its support during this project.

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