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ORIGINAL ARTICLE

# Enhanced recovery after surgery for emergency colorectal surgery: Are there any differences between intra-abdominal infection and other indications?



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## KEYWORDS

Enhanced recovery after surgery;  
ERAS;  
Emergency;  
Colon;  
Rectum;  
Intra-abdominal infection

## Summary

**Aim of the study:** Enhanced recovery after surgery (ERAS) has become the standard of care for elective colorectal operations. However, there are few data regarding ERAS in emergency setting. This study aimed to evaluate the results of ERAS protocol for emergency colorectal resection and to compare its difference between patients with intra-abdominal infection (IAI) and those without.

**Patients and methods:** Patients undergoing emergency colectomy and/or proctectomy with ERAS protocol from 2011 to 2017 a university hospital was reviewed. Clinical outcomes and ERAS compliance were analyzed and compared depending on whether there was IAI.

**Results:** This study included 60 patients; 14 (23%) had IAI. Median ERAS compliance was 75% (IQR: 63–83). Rates of overall complication and severe complication were 35% and 15%, respectively. The 60-day mortality was 6.7%. Median length of postoperative stay was 5 days (IQR: 4–8). Thirty-three patients (55%) achieved targeted discharge within postoperative day 5. High adherence to ERAS protocol was associated with lower morbidity ( $P < 0.001$ ) and shorter hospitalization ( $P = 0.006$ ). Patients with IAI had less ERAS compliance (50% vs. 78%;  $P < 0.001$ ), higher complication rates (64% vs. 26%;  $P = 0.009$ ), and higher mortality (21% vs. 2%;  $P = 0.036$ ), and longer time to first defecation (4 days vs. 3 days;  $P = 0.049$ ). Of note, patients with IAI had significant lower compliance with preoperative optimization, scheduled removal of urinary catheter and early mobilization than the other group.

**Conclusions:** ERAS program is applicable for patients undergoing emergency colorectal surgery. In patients with intra-abdominal sepsis, the ERAS compliance was lower and the complications rate was higher.

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## Introduction

Since the concept of enhanced recovery after surgery (ERAS) pathway for colorectal surgery was introduced in the 1990s [1], this multidisciplinary perioperative program has been consistently shown to reduce postoperative complication and length of hospitalization in both open and laparoscopic colorectal surgery [2,3]. Despite mounting evidence of ERAS program for improving outcomes in elective colorectal operations, there are a limited number of studies evaluating the safety and effectiveness of ERAS program in emergency colorectal surgery [4–7].

In a case-matched study from Thailand, Lohsiriwat has demonstrated that an ERAS protocol is safe and feasible for emergency colectomy and/or proctectomy for obstructed colorectal cancer [4]. Patients within an ERAS program had approximately 2-day shorter hospital stay and 50% lower rate of complication than the control group. Another study from Japan reported that ERAS protocol reduced length of hospitalization without affecting morbidities and readmission after emergency resection for obstructed colorectal cancer [5]. However, both studies excluded patients with concomitant intra-abdominal sepsis. A smaller study focusing on urgent colectomy also suggested the feasibility of ERAS application in emergency setting [6]. Lately, a retrospective study with a combination of emergency colorectal operations and other laparotomies has shown a significant reduction in postoperative complication in patients with ERAS application [7].

Since emergency presentations of colorectal diseases – especially acute colonic obstruction and purulent/fecal peritonitis are likely to be excluded from ERAS program and may represent a barrier to the implementation of ERAS protocol, this study primarily aimed to determine the outcomes of ERAS program for acute presentations of various colorectal diseases requiring emergency surgery. The secondary objective of this study was to compare compliance and clinical outcomes of ERAS protocol between patients undergoing emergency colorectal operations for intra-abdominal infection and those for other indications.

## Patients and methods

### Patients

Patient's data were extracted from a single-surgeon's (the author) prospectively collected database of consecutive patients undergoing colorectal resection (colectomy and/or proctectomy) within an ERAS program in the Department of Surgery, Faculty of Medicine Siriraj Hospital, Bangkok, Thailand. Patients with emergency colorectal surgery from January 2011 to September 2017 were reviewed. In this context, emergency surgery was defined as an operation performed within 24 hours after the patients were presented or consulted at the institute's acute surgical care unit. Indications for emergency colorectal surgery included acute colonic obstruction, massive lower gastrointestinal bleeding, and peritonitis with colon or rectum in origin. Patients with traumatic colon/rectal injury and those having non-resection operation (e.g. proximal colostomy and bypass surgery) were excluded. The study was approved by the institutional ethics committee (Si482/2560) and written informed consent was obtained from each patient.

### Author's 'modified' ERAS protocol for emergency colorectal operations

All patients were operated on and treated by a board-certified colorectal surgeon and his team with an established ERAS protocol which were adopted from the ERAS society recommendations for perioperative care in elective colorectal surgery [8,9]. It is worth noting that, although an ERAS protocol for elective colorectal surgery has been implemented at our institute, only the author has modified and applied it into emergency cases. Some parts of the 'modified' ERAS protocol for emergency colorectal operation were published in 2014 [4]. Table 1 compares our ERAS protocol for colorectal surgery between elective and emergency setting – with a list of elements based on the ERAS recommendations for elective colon surgery [8]. Notably, laparoscopic surgery and any form of bowel preparation were not used in this study. Patients would be discharged from the hospital if they had no fever, ability to resume diet with adequate calories intake, satisfactory gastrointestinal recovery and a good level of ambulation. All of the patients were scheduled for follow-up at 10 days, 30 days and 60 days after an operation.

### Data collection

Data collection included patients' characteristics, operative details, and postoperative outcomes. Patients' characteristics involved age, gender, body mass index, American Society of Anesthesiologists (ASA) classification, indication for surgery and ColoRectal Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (CR-POSSUM) score [10]. Operative details included type of operation, operative time, and estimated blood loss. Overall compliance with ERAS protocol of each patient was determined based on our ERAS protocol for emergency colorectal surgery shown in Table 1. Postoperative outcomes included postoperative complications (graded I–V according to the Clavien–Dindo classification system) [11], severe complication (defined as Clavien–Dindo grade  $\geq$  III), time to first defecation, time to resume solid diet, length of postoperative stay, death and readmission within 60 days after an operation.

### Outcome measures

The primary objective of the study was to evaluate the outcomes of ERAS protocol for emergency colorectal surgery. The primary end-points were postoperative complication, length of postoperative stay, 60-day mortality, 60-day readmission, postoperative gastrointestinal recovery and adherence to ERAS protocol. The secondary objective of the study was to compare compliance and clinical outcomes of ERAS program for emergency colorectal surgery between patients with intra-abdominal infection and those without such a condition. Of note, intra-abdominal infection was defined as peritoneal inflammation in response to microbial contamination through a perforation, laceration or necrotic segment of the gastrointestinal tract [12]. Gross appearance of intra-abdominal infection was described together with the Mannheim Peritonitis Index (maximum score of 47) for determining the severity of intra-abdominal infection [13].

**Table 1** Comparison of enhanced recovery after surgery (ERAS) protocol for colorectal surgery between elective and emergency setting.

Element	Elective setting	Emergency setting
Preoperative counseling	Detailed counseling including stoma education and siting, methods of surgery and pain control, and estimated length of hospitalization	Stoma education and siting
Preoperative optimization	Nutrition therapy in malnourished patients, iron supplement in anemic patients, cessation of alcohol consumption and smoking at least 2 weeks prior to surgery, optimization of general medical conditions, and prehabilitation	Supplement oxygen if O <sub>2</sub> saturation < 95%, and blood transfusion if hematocrit < 30%
Bowel preparation	Applied to left-sided colon and rectal surgery	Not applicable
Preoperative CBH loading	400 mL of glucose-rich fluid drink on the morning of surgery	Not applicable
Pre-anesthetic medication	No except oral selective cyclooxygenase-2 inhibitor and/or paracetamol as a preventive analgesia	Not applicable
VTE prophylaxis	Pharmacological and non-pharmacological measures based on patient's risk profiles	Used only intermittent pneumatic compressive device
ATB prophylaxis	Always	Same, but may extend for a longer period in case of intra-abdominal infection
Standard anesthetic protocol	Balanced general anesthesia with opioid-sparing regimen with or without epidural analgesia. Oxygen supplement for 12–24 hours after an operation in NON-ICU cases	Same except the administration of epidural analgesia
PONV prophylaxis	Always (according to the Apfel's risk score)	Same
Surgical access/incision	Laparoscopic approach if feasible. Otherwise, midline laparotomy or right transverse incision (for right hemicolectomy) with the application of O-ring wound retractor	Midline laparotomy or right transverse incision (for right hemicolectomy) with the application of O-ring wound retractor
NGT insertion	No routine use	Yes and schedule to remove NGT on POD2-3 except NGT content > 800 mL/d
Avoiding hypothermia	Active warming protocol	Same
Fluid management	Goal-directed fluid therapy (near-zero balance) with the administration of colloid or synthetic albumin and vasopressor (if indicated). Allowing intraoperative permissive oliguria	Same
Intra-abdominal drainage	No except abdominoperineal resection	No routine use
Urinary drainage	Yes and schedule to remove urinary catheter on POD2-3 (if no contraindication)	Same
Prevention of POI	Prophylaxis administration of prokinetic drugs e.g. metoclopramide (IV), domperidone (o), mosapride (o)	Same
Postoperative analgesia	Infiltration of 0.5% bupivacaine into facial layer and skin before wound closure. Opioid-sparing multimodal analgesia	Same
Perioperative nutritional care	Early feeding and perioperative nutrition therapy in malnourished patients and those with inadequate intake	Postoperative oral nutrition supplement if patient's calories intake < 60% of targeted goal
Glucose control	Targeted blood sugar 80–200 mg/dL	Same
Early mobilization	Scheduled ambulation from POD1 by trained nursing staff with daily physiotherapy Aim to discharge patients on POD3	Same with aim to discharge patients on POD5

CBH: carbohydrate; NGT: nasogastric tube; POD: postoperative day; POI: postoperative ileus; PONV: postoperative nausea and vomiting; VTE: venous thromboembolism.

## Statistical analysis

All statistical analyses were performed using the PASW Statistics software (SPSS version 18.0 for Windows, Illinois, USA). Continuous variables were expressed as mean  $\pm$  standard deviation or median [interquartile range (IQR)], and were compared using the Student *t*-test or Mann–Whitney U test. One-way analysis of variance was used to compare means among groups. Categorical data were expressed as number (percentage) and were compared using the Pearson  $\chi^2$  test or Fisher exact probability test. A *P*-value  $< 0.05$  was considered statistically significant.

## Results

### Patients' characteristics

During the study period of over 6 years, 490 patients were underwent colorectal resection by the author and 60 patients (12.2%) met criteria for emergency colorectal operation. The average age of eligible patients was 62.6 years (range: 23–102). Of these patients, 37 (62%) were male and 14 (23%) underwent emergency colorectal operations for intra-abdominal infection (3 localized peritonitis, 3 fecal peritonitis and 8 generalized peritonitis) – with median Mannheim Peritonitis Index score of 22 (range: 10–34).

Acutely obstructed colorectal cancer with/without bowel perforation was the most common indication for emergency surgery ( $n = 49$ , 82%). Right-sided colon resection was the most common operation performed ( $n = 21$ , 35%) followed by Hartmann procedure ( $n = 12$ , 20%). Indications for surgery and types of operation are shown in Tables 2 and 3, respectively. Details of patients' characteristics and operative data are shown in Table 4.

### Overall outcomes

The ERAS protocol was applied to all patients with a median compliance rate of 75% (IQR: 63–83). Rates of overall postoperative complication and severe complication were 35% ( $n = 21$ ) and 15% ( $n = 9$ ), respectively. Two patients required re-operation (1 colorectal anastomotic leakage and 1 undetected ureter injury). One patient required percutaneous drainage of intra-abdominal collection. Four patients died

**Table 3** Type of operation.

	Number (percentage)
(Extended) right hemicolectomy	21 (35)
Transverse colectomy	2 (3)
Left hemicolectomy	4 (7)
Sigmoidectomy	6 (10)
Hartmann procedure	12 (20)
(Low) anterior resection	7 (12)
Subtotal colectomy	7 (12)
Abdominoperineal resection	1 (2)

(2 sepsis, 1 perioperative acute myocardial infarction and 1 ventilator-associated pneumonia) accounting for a 60-day mortality of 6.7%. Median time to first bowel movement and time to resume solid diet was 3 days (IQR: 2–4). The median length of postoperative stay was 5 days (IQR: 4–8). Thirty-three patients (55%) achieved the targeted discharge within postoperative day 5. There was no 60-day readmission. High adherence to ERAS protocol was associated with lower postoperative morbidity ( $P < 0.001$ ) and shorter postoperative stay ( $P = 0.006$ ) (Fig. 1). The high ERAS compliance tended to have a lower rate of severe complication ( $P = 0.063$ ).

### Compliance and clinical outcomes of ERAS protocol between patients with intra-abdominal infection and those without such a condition

The two groups were comparable with respect to their age, gender, body mass index, preoperative hematocrit level and operative details. However, patients undergoing colorectal surgery for intra-abdominal infection had a higher proportion of ASA classification  $\geq 3$ , a fewer cases of cancer operation and a higher CR-POSSUM predicting mortality (Table 4). The median compliance rate with ERAS protocol was significantly less in patients with intra-abdominal infection (50% vs. 78%;  $P < 0.001$ ) – especially the ERAS elements of preoperative optimization, scheduled removal of urinary catheter and early mobilization. Percentage of patients adhering to each element of ERAS for emergency colorectal surgery between those with intra-abdominal infection and those without is shown in Fig. 2.

Regarding clinical outcomes, patients with intra-abdominal infection had a higher rates of overall complication (64% vs. 26%;  $P = 0.009$ ), more 60-day mortality (21% vs. 2%;  $P = 0.036$ ), and longer time to first bowel movement (4 days vs. 3 days;  $P = 0.049$ ). Median length of postoperative stay also tended to be longer in this group of patients (9 days vs. 5 days;  $P = 0.127$ ) (Table 5).

## Discussion

This study showed that ERAS program is applicable in cases of emergency colorectal surgery and a higher compliance with ERAS protocol is associated with better clinical outcomes. In patients with intra-abdominal infection, the ERAS compliance was lower and the complications rate was higher – highlighting a challenge in the implementation of ERAS program in patients with intra-abdominal sepsis. Notably, our ERAS compliance rates of 75% in all individuals

**Table 2** Indications for surgery.

	Number (percentage)
Obstructed colorectal cancer	42 (70)
Obstructed colorectal cancer with bowel perforation	7 (12)
Endoscopic-related colonic perforation	2 (3)
Ruptured sigmoid diverticulitis	2 (3)
Massive lower gastrointestinal bleeding	2 (3)
Benign colonic obstruction	2 (3)
Other <sup>a</sup>	3 (5)

<sup>a</sup> Perforated cecal tuberculosis (1 case), perforated cecal lymphoma (1 case), and sigmoid volvulus with cecal perforation (1 case).

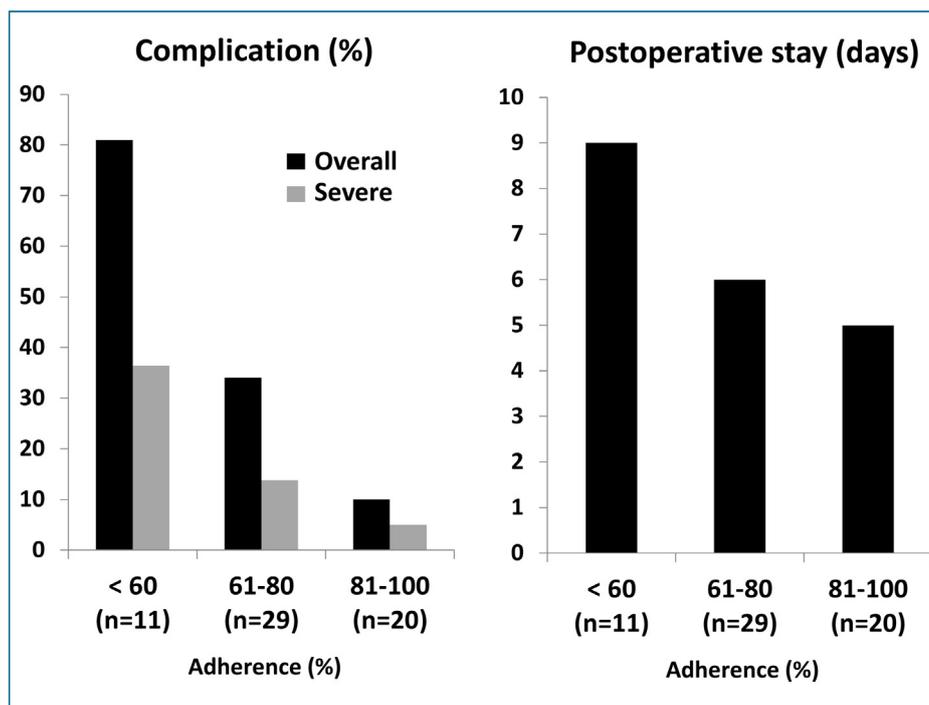
**Table 4** Patient characteristics and operative details. Data are shown as number (percentage), mean  $\pm$  standard deviation, or median (interquartile range).

	All (n = 60)	No IAI (n = 46)	IAI (n = 14)	P-value
Age (years)	62.6 $\pm$ 15.2	60.1 $\pm$ 14.9	68.6 $\pm$ 15.3	0.094
Male	37 (62)	28 (61)	9 (64)	0.818
BMI (kg/m <sup>2</sup> )	21.8 $\pm$ 3.5	21.7 $\pm$ 3.3	21.9 $\pm$ 4.4	0.911
ASA classification $\geq$ 3	22 (37)	11 (24)	11 (79)	< 0.001 <sup>a</sup>
CR-POSSUM predicting mortality	3.3 (1.4–6.4)	2.9 (1.3–6.3)	7.3 (2.6–26)	0.041 <sup>a</sup>
Preoperative hematocrit (%)	35.3 $\pm$ 5.9	35.9 $\pm$ 5.7	33.4 $\pm$ 6.6	0.179
Preoperative serum albumin (g/dL)	3.4 $\pm$ 0.7	3.6 $\pm$ 0.6	3.1 $\pm$ 0.7	0.012 <sup>a</sup>
CRC-related complication <sup>b</sup>	49 (82)	42 (91)	7 (50)	0.002 <sup>a</sup>
Rectal surgery	19 (32)	16 (35)	3 (21)	0.515
Resection with stoma formation	13 (22)	10 (22)	3 (21)	0.980
Multi-visceral organ resection	5 (8)	4 (9)	1 (7)	0.854
Operative time (minutes)	210 $\pm$ 76	208 $\pm$ 72	219 $\pm$ 90	0.617
Estimated blood loss (mL)	200 (55–350)	200 (65–313)	150 (50–538)	0.519

ASA: American Society of Anesthesiologists; BMI: body mass index; CRC: colorectal cancer; CR-POSSUM: ColoRectal Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity; IAI: intra-abdominal infection.

<sup>a</sup> P-value < 0.05.

<sup>b</sup> Colorectal cancer-related complication included acutely obstructed colorectal cancer with/without bowel perforation.

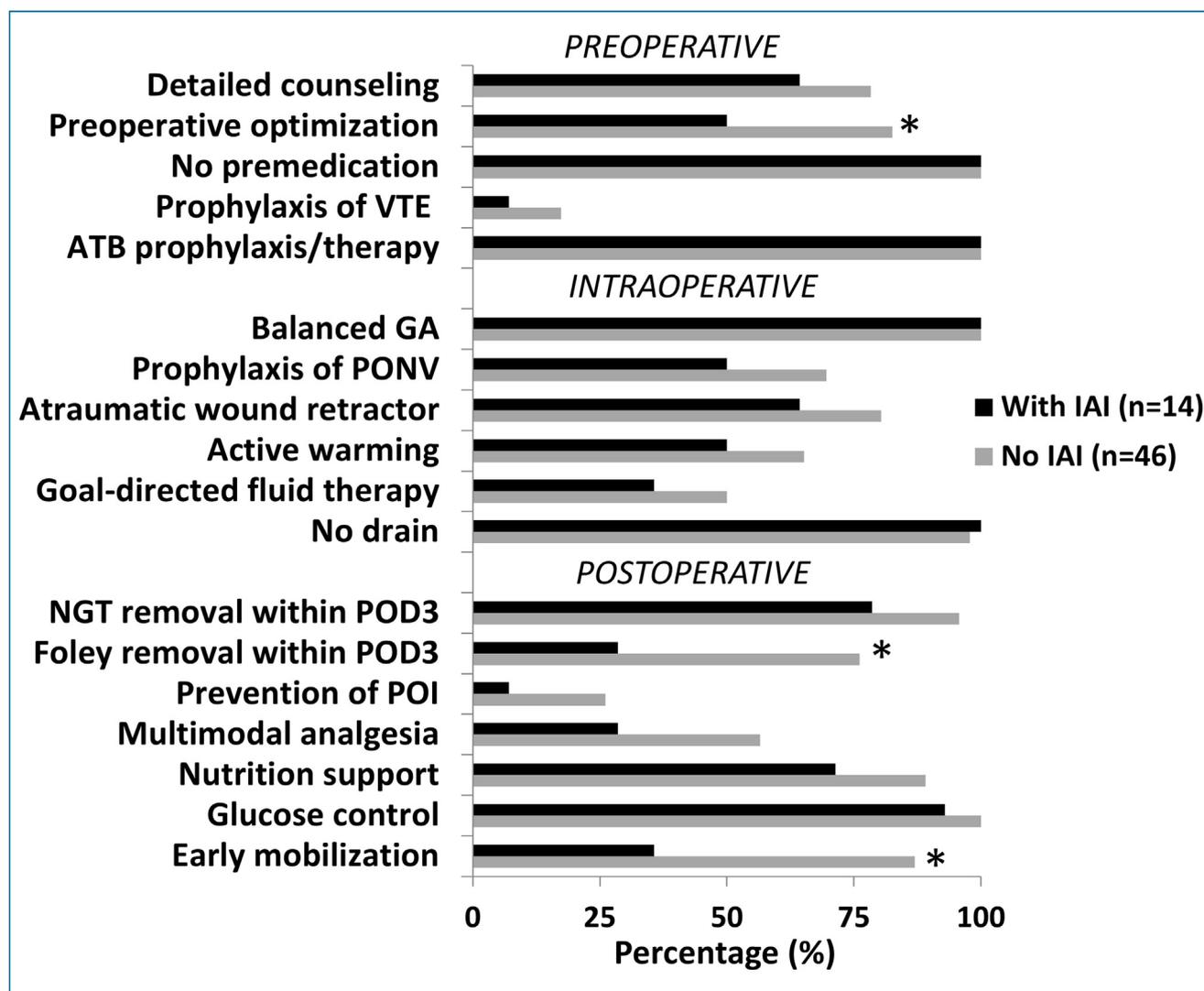


**Figure 1.** Association between adherence to the enhanced recovery after surgery (ERAS) protocol and overall postoperative complication ( $P < 0.001$ ), severe complication ( $P = 0.063$ ) and median length of postoperative stay ( $P = 0.006$ ). Note: adherence to the ERAS protocol was divided into 3 groups (<60%, 61–80% and 81–100%) based on the percentages of ERAS items applied.

and 50% in patients with intra-abdominal sepsis were rather high for an emergency setting. This might be due to our modified approach towards emergency surgery.

Several parameters were measured to determine the outcomes of ERAS program for emergency colorectal surgery including morbidity, mortality, length of hospital stay and readmission. First, we found an overall complication rate of 35%. In our institute the complications following emergency colorectal operations was as high as 48% in the setting of conventional perioperative care [4]. The present rates of overall and severe complications were about 50%

lower than those reported from another study of ERAS program for urgent colectomy [6]. These findings could be explained by the fact that overall compliance with ERAS protocol in our study (75%) was higher than that in the latter study (57%). However, the actual 60-day mortality ( $n = 4$ ; 6.7%) in this study was slightly higher than CR-POSSUM predicting mortality (3.3%). It is possible that the increased mortality is related to the deterioration of patients' general status (2 sepsis, 1 fatal acute myocardial infarction and 1 ventilator-associated pneumonia) – rather than the surgical procedure or ERAS program per se. Second, the



**Figure 2.** Percentage of patients adhering to each element of enhanced recovery after surgery protocol for emergency colorectal surgery between those with intra-abdominal infection (IAI) and those without IAI. \* Statistical significance at  $P < 0.05$ . Abbreviations: ATB: antibiotics; GA: general anesthesia; NGT: nasogastric tube; IAI: intra-abdominal infection; POD: postoperative day; POI: postoperative ileus; PONV: postoperative nausea and vomiting; VTE: venous thromboembolism.

**Table 5** Outcome measures. Data are shown as number (percentage) or median (interquartile range).

	All (n=60)	No IAI (n=46)	IAI (n=14)	P-value
Time to resume normal diet (days)	3 (2–4)	3 (2–4)	3 (2–6)	0.394
Time to first defecation (days)	3 (2–4)	3 (2–4)	4 (3–6)	0.049 <sup>a</sup>
Overall complication	21 (35)	12 (26)	9 (64)	0.009 <sup>a</sup>
Severe complication <sup>b</sup>	9 (15)	5 (11)	4 (29)	0.193
Length of postoperative stay (days)	5 (4–8)	5 (4–6)	9 (5–15)	0.127
60-day mortality	4 (6.7)	1 (2)	3 (21)	0.036 <sup>a</sup>
Unplanned 60-day readmission	0	0	0	N/A
Adherence to ERAS protocol (%)	75 (63–83)	78 (67–89)	50 (61–72)	<0.001 <sup>a</sup>

ERAS: enhanced recovery after surgery; IAI: intra-abdominal infection; N/A: not applicable.

<sup>a</sup>  $P$ -value < 0.05.

<sup>b</sup> Clavien–Dindo grade  $\geq$  III complication (note: the most severe complication was registered for patients with more than one complication).

median length of postoperative stay in this study was 5 days without 60-day readmission. The targeted discharge within postoperative day 5 was achieved in 55% of total cases although about a quarter of our patients had a clinical

peritonitis and one-third underwent emergency rectal operation.

The median length of hospitalization after emergency colorectal operation in this study (5 days) was slightly

shorter than that reported from Japan (7 days) [5] and Switzerland (8 days) [6], but was comparable to that from our previous report in 2014 [4] – showing a consistent effect of ERAS program on shortening the length of hospital stay in our institute. It is unclear what an impact of each ERAS component on the length of hospital stay is, but it is very likely that a combination of several interventions is pertinent. A pragmatic approach to prophylaxis of postoperative nausea and vomiting, scheduled removal of nasogastric tube (& early feeding), application of opioid-sparing multimodal analgesia, selective use of abdominal/pelvic drain, and early mobilization was used in our ERAS program. This may contribute to faster gastrointestinal recovery, quicker return of patients' autonomy and shorter length of hospitalization. As expected, due to the nature of diseases and its difficulty in perioperative care, patients with intra-abdominal infection had significant lower adherence to preoperative optimization, scheduled removal of urinary catheter and early mobilization than the other group.

Since increasing ERAS compliance was correlated with fewer complications and shorter hospital admission as shown in this study and in a large international registry of elective colorectal cancer resection (the ERAS compliance group) [14], the lower compliance with some of ERAS elements needed to be adapted on an individual basis to these emergency surgical patients with high-risk operations. The ERAS implementation in emergency setting is a challenge for everyone in a multidisciplinary team due to several reasons – such as acute patient's condition, time constraints, and out-of-hour limited resources of equipment and personnel. The application of laparoscopic surgery, which independently improved outcome in elective colorectal surgery [14], may be not applicable to all patients with emergency colorectal conditions and skillful laparoscopic surgeons are required [15]. However, if applicable (e.g. patients with localized peritonitis), laparoscopic approach to emergency colorectal surgery offered lower complication rates and shorter length of hospital stay than open surgery [16].

As an alternative in our modified ERAS protocol, we performed emergency right hemicolectomy through a right transverse skin-crease incision (if possible) since we reported that transverse laparotomy offered some advantages over midline laparotomy [17] and had comparable outcomes with laparoscopic hemicolectomy [18]. Also, the application of atraumatic O-ring wound protector/retractor in laparotomy reduced postoperative pain and opioid consumption thus resulting in shorter gastrointestinal recovery [19]. We have omitted to use an intra-abdominal or pelvic drainage in our ERAS protocol because we have demonstrated the safety and feasibility of no drain in elective proctectomy [20] and emergency surgery for perforated hollow viscus organ [21].

Patients with intra-abdominal infection had less adherence to the ERAS protocol and had poorer outcomes than those without. It is conceivable that patients undergoing emergency laparotomy due to diffuse peritonitis have a higher morbidity and mortality than those without [22]. Factors such as patient age, comorbidity, hemodynamic status and severity of peritonitis may be more important than the application of ERAS in determining surgical outcomes. Since one of the key principles of ERAS is to minimize stress responses to surgical insults in a controllable setting of elective surgery, preexisting intra-abdominal infection may trigger an overwhelming systemic inflammatory response and could be difficult to control. Moreover, low

ERAS compliance might be a sequence of complications especially in patients with intra-abdominal sepsis.

Despite difficulty in managing patients with intra-abdominal sepsis, ERAS program could reduce the stress of surgery and maximize the potential for recovery [23]. The beneficial effect of ERAS program in emergency surgery for generalized peritonitis has been shown in a randomized-controlled trial [24]. This study showed that ERAS pathway significantly reduced the length of hospital stay by 3 days after laparoscopic repair for peptic ulcer perforation. A more recent retrospective study also showed a significant reduction in the rates of major and minor complications after emergency laparotomies in patients with ERAS application [7].

This study has two major strengths. First, the data was extracted from a prospectively collected database in a university hospital with a well-established ERAS program. Second, this study provided detailed data on compliance and clinical outcomes of ERAS protocol in patients undergoing emergency colectomy and/or proctectomy for various indications including acute colonic obstruction and purulent/feculent peritonitis – which are usually excluded from previous reports of ERAS outcomes.

Some limitations of this study needed to be addressed. First, the lacking of a comparative group of patients undergoing emergency colorectal operation with non-ERAS protocol is probably the greatest limitation of this study. We trusted that it is unethical to subject such patients to a less-effective traditional care since we have adopted an ERAS program for many years with significantly better outcomes in ERAS group [4]. A historic comparison may yield some bias. Instead, by using a prospectively collected database, we were able to provide more data on the outcomes and compliance of ERAS program for emergency colorectal surgery in a real-life surgical practice. Second, our studied population had a very high rate of obstructed cancer (82%) and a very low rate of perforated diverticulitis (3%). This might be due to the lack of screening program for colorectal cancer and a lower incidence of diverticular disease in Thailand. Nevertheless, these results could represent a framework towards the development and implementation of both evidence-based and tailor-made ERAS program for emergency colorectal operations for various indications including acute colonic obstruction and intra-abdominal sepsis.

Third, we did not analyze the impact of individual ERAS elements on postoperative outcomes due to a small sample size of this study. Instead, we examined the correlation between overall adherence to the ERAS program and clinical results since the level of compliance with ERAS protocol strongly impacted the outcomes [14,25]. We acknowledged that more studies are required to identify which ERAS element(s) might have greater impact on favorable outcomes in the setting of emergency colorectal operations. Fourth, we did not examine whether management strategies or intraoperative procedures would affect the application of ERAS program and its outcomes. For example, colonic stent as bridge to surgery or several-stage procedure for acute colonic obstruction may help implementing the ERAS program more easily and more effectively. Last, since this study included only patients undergoing emergency colectomy and/or proctectomy, the study population may be physically fitter to surgery than general population as shown by a relatively low CR-POSSUM predicting mortality. The outcome of ERAS for more vulnerable patients or other types of operation (e.g. proximal colostomy and bypass surgery) may be different.

## Conclusion

This study provided further evidence that ERAS program can be applicable for patients undergoing emergency colorectal surgery. However, the application of ERAS program in emergency colorectal operations remains challenging especially in patients with intra-abdominal sepsis – in which the ERAS compliance was lower and the complications rate was higher. We believe that an ERAS program could be considered as a viable potential to improve and revolutionize the perioperative care of emergency colorectal surgery.

## Author contribution

V.L. solely contributed to this study and wrote the manuscript.

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None.

## Disclosure of interest

The author declares that he has no competing interest.

## References

- [1] Bardram L, Funch-Jensen P, Jensen P, Crawford ME, Kehlet H. Recovery after laparoscopic colonic surgery with epidural analgesia, and early oral nutrition and mobilisation. *Lancet* 1995;345:763–4.
- [2] Zhuang CL, Ye XZ, Zhang XD, Chen BC, Yu Z. Enhanced recovery after surgery programs versus traditional care for colorectal surgery: a meta-analysis of randomized-controlled trials. *Dis Colon Rectum* 2013;56:667–78.
- [3] Spanjersberg WR, van Sambeek JD, Bremers A, Rosman C, van Laarhoven CJ. Systematic review and meta-analysis for laparoscopic versus open colon surgery with or without an ERAS programme. *Surg Endosc* 2015;29:3443–53.
- [4] Lohsiriwat V. Enhanced recovery after surgery vs. conventional care in emergency colorectal surgery. *World J Gastroenterol* 2014;20:13950–5.
- [5] Shida D, Tagawa K, Inada K, et al. Modified enhanced recovery after surgery (ERAS) protocols for patients with obstructive colorectal cancer. *BMC Surg* 2017;17:18.
- [6] Roulin D, Blanc C, Muradbegovic M, Hahnloser D, Demartines N, Hubner M. Enhanced recovery pathway for urgent colectomy. *World J Surg* 2014;38:2153–9.
- [7] Wisely JC, Barclay KL. Effects of an enhanced recovery after surgery programme on emergency surgical patients. *ANZ J Surg* 2016;86:883–8.
- [8] Gustafsson UO, Scott MJ, Schwenk W, et al. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS) Society recommendations. *World J Surg* 2013;37:259–84.
- [9] Nygren J, Thacker J, Carli F, et al. Guidelines for perioperative care in elective rectal/pelvic surgery: Enhanced Recovery After Surgery (ERAS) Society recommendations. *World J Surg* 2013;37:285–305.
- [10] Tekkis PP, Prytherch DR, Kocher HM, et al. Development of a dedicated risk-adjustment scoring system for colorectal surgery (colorectal POSSUM). *Br J Surg* 2004;91:1174–82.
- [11] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205–13.
- [12] Lopez N, Kobayashi L, Coimbra R. A comprehensive review of abdominal infections. *World J Emerg Surg* 2011;6:7.
- [13] Linder MM, Wacha H, Feldmann U, Wesch G, Streifensand RA, Gundlach E. The Mannheim peritonitis index. An instrument for the intraoperative prognosis of peritonitis. *Chirurgie* 1987;58:84–92.
- [14] ERAS Compliance Group. The impact of enhanced recovery protocol compliance on elective colorectal cancer resection: results from an International Registry. *Ann Surg* 2015;261:1153–9.
- [15] Koh FH, Tan KK, Tsang CB, Koh DC. Laparoscopic versus an open colectomy in an emergency setting: a case-controlled study. *Ann Coloproctol* 2013;29:12–6.
- [16] Vallance AE, Keller DS, Hill J, et al. Role of emergency laparoscopic colectomy for colorectal cancer: a population-based study in England. *Ann Surg* 2018, <http://dx.doi.org/10.1097/SLA.0000000000002752> [Epub ahead of print].
- [17] Lohsiriwat V, Lohsiriwat D, Boonnuch W, et al. Comparison between midline and right transverse incision in right hemicolectomy for right-sided colon cancer: a retrospective study. *J Med Assoc Thai* 2009;92:1003–8.
- [18] Lohsiriwat V, Lohsiriwat D, Chinswangwatanakul V, Akaraviputh T, Lert-Akyamanee N. Comparison of short-term outcomes between laparoscopically-assisted vs. transverse incision open right hemicolectomy for right-sided colon cancer: a retrospective study. *World J Surg Oncol* 2007;5:49.
- [19] Lohsiriwat V, Lohsiriwat D. Atraumatic O-ring wound retractor reduces postoperative pain. *Tech Coloproctol* 2014;18:1177–8.
- [20] Lohsiriwat V, Lohsiriwat D, Boonnuch W, et al. Outcomes of sphincter-saving operation for rectal cancer without protective stoma and pelvic drain, and risk factors for anastomotic leakage. *Dig Surg* 2008;25:191–7.
- [21] Lohsiriwat V, Prapasrivorakul S, Lohsiriwat D. Perforated peptic ulcer: clinical presentation, surgical outcomes, and the accuracy of the Boey scoring system in predicting postoperative morbidity and mortality. *World J Surg* 2009;33:80–5.
- [22] Symons NR, Moorthy K, Almoudaris AM, et al. Mortality in high-risk emergency general surgical admissions. *Br J Surg* 2013;100:1318–25.
- [23] Kehlet H, Slim K. The future of fast-track surgery. *Br J Surg* 2012;99:1025–6.
- [24] Gonenc M, Dural AC, Celik F, et al. Enhanced postoperative recovery pathways in emergency surgery: a randomised controlled clinical trial. *Am J Surg* 2014;207:807–14.
- [25] Gustafsson UO, Hausel J, Thorell A, et al. Adherence to the enhanced recovery after surgery protocol and outcomes after colorectal cancer surgery. *Arch Surg* 2011;146:571–7.