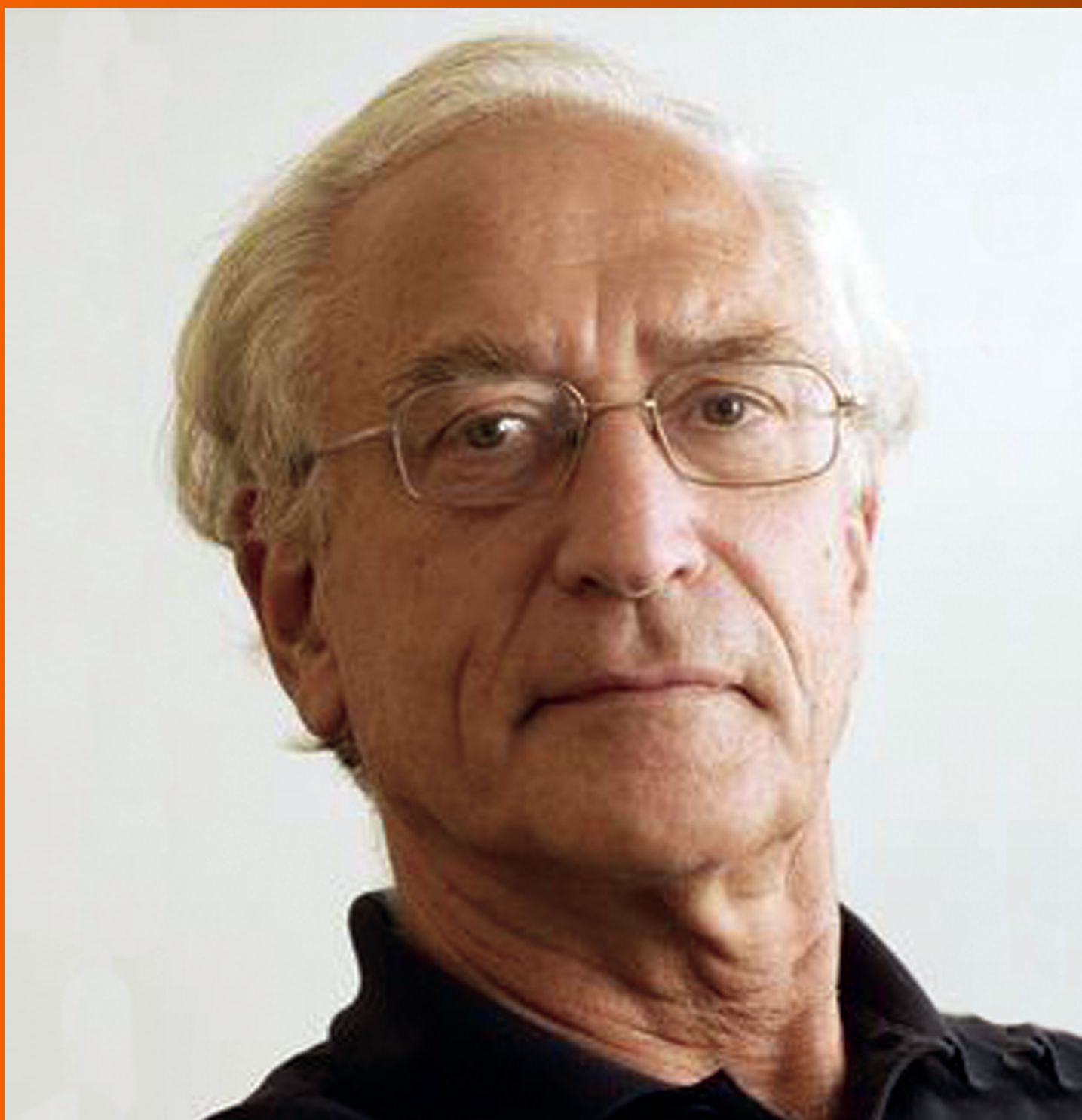


# World Journal of *Gastrointestinal Surgery*

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## Prospective Study

# Learning curve of enhanced recovery after surgery program in open colorectal surgery

Varut Lohsiriwat

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## Abstract

### BACKGROUND

Enhanced recovery after surgery (ERAS) reduces hospitalization and complication following colorectal surgery. Whether the experience of multidisciplinary ERAS team affects patients' outcomes is unknown.

### AIM

To evaluate and establish a learning curve of ERAS program for open colorectal surgery.

### METHODS

This was a review of prospectively collected database of 380 "unselected" patients undergoing elective "open" colectomy and/or proctectomy under ERAS protocol from 2011 (commencing ERAS application) to 2017 in a university hospital. Patients were divided into 5 chronological groups (76 cases per quintile). Surgical outcomes and ERAS compliance among quintiles were compared. Learning curves were calculated based on criteria of optimal recovery: defined as absence of major postoperative complications, discharge by postoperative day 5, and no 30-d readmission.

### RESULTS

Hospitalization more than 5 d occurred in 22.6% ( $n = 86$ ), major complication was present in 2.9% ( $n = 11$ ) and 30-d readmission rate was 2.4% ( $n = 9$ ) accounting for unsuccessful recovery of 25% ( $n = 95$ ). Conversely, the overall rate of optimal recovery was 75%. The optimal recovery significantly increased from 57.9% in 1<sup>st</sup> quintile to 72.4%-85.5% in the following quintiles ( $P < 0.001$ ). Average compliance with ERAS protocol gradually increased over the time - from 68.6% in 1<sup>st</sup> quintile to 75.5% in 5<sup>th</sup> quintile ( $P < 0.001$ ). The application of preoperative counseling, nutrition support, goal-directed fluid therapy, O-ring wound protector and scheduled mobilization significantly increased over the study period.



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## CONCLUSION

A number of 76 colorectal operations are required for a multidisciplinary team to achieve a significantly higher rate of optimal recovery and high compliance with ERAS program for open colorectal surgery.

**Key words:** Enhanced recovery after surgery; ERAS; Colon; Rectum; Surgery; Learning curve; Outcome; Compliance

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**Core tip:** Whether the learning curve of surgeon and multidisciplinary team affects enhanced recovery after surgery (ERAS) outcomes is unknown. This study showed that a number of 76 cases are required for an ERAS team to achieve a high compliance (> 70%) with ERAS program and a significantly higher rate of optimal recovery following open colorectal surgery. The application of preoperative counseling, nutrition support, goal-directed fluid therapy, O-ring wound protector and scheduled mobilization significantly increased over the study period.

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## INTRODUCTION

Enhanced recovery after surgery (ERAS) has been shown to reduce morbidities and length of hospital stay following elective and emergency colorectal surgery<sup>[1,2]</sup>. This multimodal program introduces a number of preoperative, intraoperative and postoperative measures aiming to minimize surgical stress responses and facilitate patient's recovery<sup>[3]</sup>. There have been several reports showing that improved adherence to the ERAS program is significantly associated with improved clinical outcomes after colorectal operations<sup>[4,5]</sup>. However, the effective implementation of ERAS requires close collaboration of multidisciplinary ERAS team comprising surgeons, anesthesiologists, nurses, nutritionists and physiotherapists. The initial stage of ERAS application into surgical practice could be a crucial phase of this patient-centered perioperative pathway because the workflow of health care personals needs to be adopted and the guideline has to assimilate into a daily practice. A prospective study of early implementation of ERAS program in laparoscopic colorectal surgery has demonstrated that at least 30 patients and a period of 6 mo are required to achieve an ERAS compliance of 80% or more<sup>[6]</sup>.

Despite increasing uptake of laparoscopic colorectal surgery worldwide, open surgery still remained the most common approach for colorectal resections<sup>[7,8]</sup>. When comparing laparoscopy and open surgery within an ERAS program for colorectal surgery, the latter had a higher rate of complication and was more difficulty to implement an ERAS program<sup>[9]</sup>. There are several studies on the impact of ERAS compliance on surgical outcomes<sup>[4,5,10,11]</sup>, but little attention is drawn to the analysis of the early stage of ERAS implementation into colorectal operation especially in an open surgery - as a learning curve of a multidisciplinary ERAS team.

The primary objective of the study was to evaluate and establish the learning curve for the implementation of an ERAS program in "open" colorectal operations using defined criteria of optimal recovery (no major postoperative complication, *i.e.*, Clavien-Dindo grade  $\geq$  III, discharge by postoperative day 5, and no 30-d readmission)<sup>[12]</sup>.

## MATERIALS AND METHODS

### Patients

A prospectively collected database has been maintained since the beginning of ERAS program in 2011 for elective colorectal surgery in our Colorectal Unit (Faculty of Medicine Siriraj Hospital, Mahidol University - the largest tertiary referral hospital in

Thailand). All unselected patients undergoing open colectomy and/or proctectomy with this ERAS program from January 2011 to October 2017 were reviewed. Patients undergoing laparoscopic colorectal surgery were excluded because this study focused on the analysis of learning curve for ERAS program - not the that for laparoscopic surgery which may be influenced by surgeon's experience and operative complexity. Moreover, laparoscopy might be a key factor offering independent advantages beyond an ERAS program<sup>[9,10]</sup>. Patients undergoing non-resection surgery (e.g., loop colostomy and colonic bypass procedures) and those with clinical peritonitis or acute colonic obstruction were also excluded. The study was approved by the institutional ethics committee (Si 498/2017) and written informed consent was obtained from each patient.

### ***The development and implementation of our ERAS protocol***

The application of ERAS strategies into elective colorectal surgery in our unit was initiated by a board-certified colorectal surgeon (the author) who learnt the concept of this perioperative care pathway while studying a PhD degree in Gastrointestinal Surgery in the United Kingdom. In late 2010, a multidisciplinary ERAS team was formed by a colorectal surgeon, two anesthesiologists, a nutritionist, ostomy nurses, nursing staffs and surgical residents. At that time, our ERAS protocol for open colorectal operations had 17 core elements (Table 1) which were adopted from the consensus review of ERAS society for elective colorectal surgery<sup>[13]</sup>. In early 2011, the protocol was routinely applied into a daily surgical practice with a regular audition. We set a targeted discharge by postoperative day 5 because in the literature review an ERAS protocol reduced the length of hospital stay by 2-3 d<sup>[1]</sup> and hospital stay after open colorectal operations under a conventional pathway in our unit was about 7-8 d<sup>[14,15]</sup>. Patients would be discharged from the hospital if they met *all* criteria: no fever, satisfactory gastrointestinal recovery, adequate pain control with oral analgesics, and a good level of ambulation. All of the patients were scheduled for follow-up at 7-10 d and 30 d after an operation. Notably, all of the studied patients were operated on and treated by single surgeon (the author) and his multidisciplinary team. Since an ERAS program is a dynamic multimodal care pathway, some elements were added into the program later. These interventions were the administration of synthetic albumin in patients with persistent oliguria after the adequate infusion of crystalloid solution (from June 2015) and the routine postoperative administration of prokinetic agent (from April 2016).

### ***Data collection***

Data including patient characteristics, operative details, and postoperative outcomes were prospectively collected. Patient characteristics included age, gender, body mass index, American Society of Anesthesiologists (ASA) classification, and ColoRectal Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (CR-POSSUM) score<sup>[16]</sup>. Operative details included type of operation, operative time, and estimated blood loss. Postoperative outcomes included postoperative complications (graded I-V according to the Clavien-Dindo classification system)<sup>[17]</sup>, time to tolerate solid food, time to first bowel movement, length of postoperative stay, death and readmission within 30 d after the operation. Overall compliance with ERAS protocol of each patient was determined based on our initial ERAS protocol (17 core elements).

### ***Outcome measures***

Patients were divided into 5 chronological groups (1<sup>st</sup>-5<sup>th</sup> quintile). Surgical outcomes and compliance with ERAS protocol between groups were compared. Learning curves were calculated based on the criteria of optimal recovery (defined as no major postoperative complication, *i.e.*, Clavien-Dindo grade  $\geq$  III, discharge by postoperative day 5, and no 30-d readmission)<sup>[12]</sup>.

### ***Statistical analysis***

All statistical analyzes were performed using the PASW Statistics software (SPSS version 18.0 for Windows, Illinois, United States). Continuous variables were expressed as mean  $\pm$  SD or median (interquartile range; IQR) and were compared among groups using one-way analysis of variance (ANOVA) or the Kruskal-Wallis test. Categorical data were expressed as number (percentage) and were compared using the Pearson Chi-square test or Fisher exact probability test. A *P*-value of  $<0.05$  was considered statistically significant.

## **RESULTS**

**Table 1 Enhanced recovery after surgery protocol for open colorectal surgery**

<b>Preadmission</b>
1 Cessation of smoking and intake of alcohol; 2 Nutrition assessment and nutrition support as needed; 3 Medical optimization of chronic disease
<b>Preoperative</b>
4 Structured preoperative counseling to patients and their relatives; 5 No mechanical bowel preparation; 6 Administration of appropriate prophylactic antibiotics; 7 Prophylaxis of postoperative nausea and vomiting
<b>Intraoperative</b>
8 Use of epidural anesthesia; 9 Use of atraumatic O-ring wound retractor/protector; 10 Avoid hypothermia; 11 Maintaining fluid balance and vasopressors to support blood pressure control; 12 No intraabdominal or pelvic drain
<b>Postoperative</b>
13 Early intake of oral fluids and semi-solid foods (day of surgery); 14 Early ambulation (postoperative day 1); 15 Multimodal approach to opioid-sparing pain control; 16 Removal of urinary catheter by postoperative day 3; 17 Discontinuous intravenous fluid infusion by postoperative day 3

During the study period of 82 mo, 489 colorectal resections were performed by the author and his multidisciplinary team under an ERAS protocol. Of these, 57 operations were for acute colonic obstruction or peritonitis, and 52 operations were laparoscopic surgery. Therefore, there were 380 patients undergoing elective “open” colectomy and/or proctectomy. These patients were divided into 5 chronological groups (76 cases per quintile). Of 380 cases, 75 patients (20%) had ASA classification  $\geq 3$  and a median CR-POSSUM predicting mortality of 1.8 (IQR 1.00-2.58). Colorectal cancer was the most indication for surgery ( $n = 347$ , 91%). Some 165 patients (43%) underwent proctectomy and 82 patients (22%) had temporary or permanent stoma formation. Patients’ characteristic and operative details were comparable among quintiles (Table 2).

Prolonged hospitalization  $> 5$  d occurred in 22.6% ( $n = 86$ ), major postoperative complication was present in 2.9% ( $n = 11$ ) and the rate of 30-d readmission was 2.4% ( $n = 9$ ) - accounting for unsuccessful recovery of 25% ( $n = 95$ ). Accordingly, the overall rate of optimal recovery in this ERAS program was 75%. The rate of optimal recovery significantly increased from 57.9% in 1<sup>st</sup> quintile to 72.4%-85.5% in the following quintiles ( $P < 0.001$ ) (Figure 1). The average compliance with ERAS protocol gradually increased over the time - from 68.6% in the first quintile to 75.5% in the last quintile ( $P < 0.001$ ) (Table 3). Regarding each individual element of our ERAS protocol, the compliance of 5 out of 17 ERAS elements have increased over the study period. These elements were preoperative detailed counseling, perioperative nutrition support, intraoperative goal-directed fluid therapy, intraoperative use of atraumatic O-ring wound protector and postoperative scheduled mobilization (Figure 2).

## DISCUSSION

An ERAS program is an integrated, evidence-based approach that fundamentally changes in perioperative care and surgical practice, and can therefore take time to achieve favorable outcomes. The introduction of ERAS in daily practice could be a learning-by-doing process relying on experiencing as a way for a multidisciplinary ERAS team to acquire skill and familiarize each ERAS element in order to get better surgical outcomes. The learning curve of ERAS implementation is somewhat different from that of a surgical intervention because an ERAS implementation requires both technical maneuvers and non-technical skills such as communication, collaboration and commitment from both patients and all members of multidisciplinary ERAS team.

The first step in determining the learning curve of ERAS program in colorectal surgery is the selection of an appropriate outcome measure. In this regard, we use a composite endpoint of three relevant clinical outcomes (no major postoperative complication, discharge by postoperative day 5, and no 30-d readmission) to determine an optimal recovery. These surgical outcomes have commonly been used as a proxy in the measurement of successful ERAS implementation in the literature<sup>[6,11,12]</sup>. Based on our prospectively collected database of colorectal surgery in a university hospital, this study demonstrated that a number of 76 colorectal operations are required for a multidisciplinary team to achieve a high rate of ERAS compliance and a high rate of optimal recovery following an open colorectal resection. It is worth noting that the 3<sup>rd</sup> quintile had the highest rate of 30-d readmission although it did not reach a statistical significance. There are several possible explanations on these findings such as the 3<sup>rd</sup> quintile had the highest percentage of patients with ASA classification  $\geq 3$ . High ASA classification has been shown to be an independent

Table 2 Patients' characteristics and operative details

	Overall (n = 380)	1 <sup>st</sup> quintile (n = 76)	2 <sup>nd</sup> quintile (n = 76)	3 <sup>rd</sup> quintile (n = 76)	4 <sup>th</sup> quintile (n = 76)	5 <sup>th</sup> quintile (n = 76)	P value
Age (yr)	62.8 ± 12.7	60.9 ± 14.8	65.2 ± 11.2	63.7 ± 12.4	61.6 ± 12.9	62.4 ± 11.5	0.227
Male	206 (54)	43 (57)	40 (53)	41 (54)	44 (51)	38 (50)	0.877
BMI (kg/m <sup>2</sup> )	23.0 ± 4.1	23.7 ± 4.5	23.0 ± 3.8	23.2 ± 3.8	22.3 ± 4.2	23.1 ± 3.9	0.371
ASA classification ≥ 3	75 (20)	9 (12)	19 (25)	20 (26)	13 (17)	14 (18)	0.146
CR-POSSUM	1.80	1.77	1.88	1.75	1.80	1.90	0.675
Predicting mortality	(1.00-2.58)	(0.96-2.58)	(0.98-3.18)	(0.95-2.58)	(1.30-3.28)	(1.30-2.50)	
Hematocrit (%)	36.8 ± 5.4	36.6 ± 5.5	36.1 ± 5.1	37.3 ± 5.5	37.4 ± 5.6	36.5 ± 5.3	0.548
Cancer surgery	347 (91)	70 (92)	68 (90)	69 (91)	71 (93)	69 (91)	0.930
Rectal surgery	165 (43)	34 (45)	30 (40)	39 (38)	40 (53)	32 (42)	0.397
Stoma formation	82 (22)	19 (25)	20 (26)	13 (17)	20 (26)	10 (13)	0.157
Multi-organ Resection <sup>1</sup>	36 (10)	9 (12)	10 (13)	5 (7)	9 (12)	3 (4)	0.227
Blood loss (mL)	150 (73-300)	200 (100-425)	200 (100-400)	150 (90-300)	150 (55-385)	140 (55-200)	0.067

Data are presented as mean ± SD, median (IQR) or number (percentage).

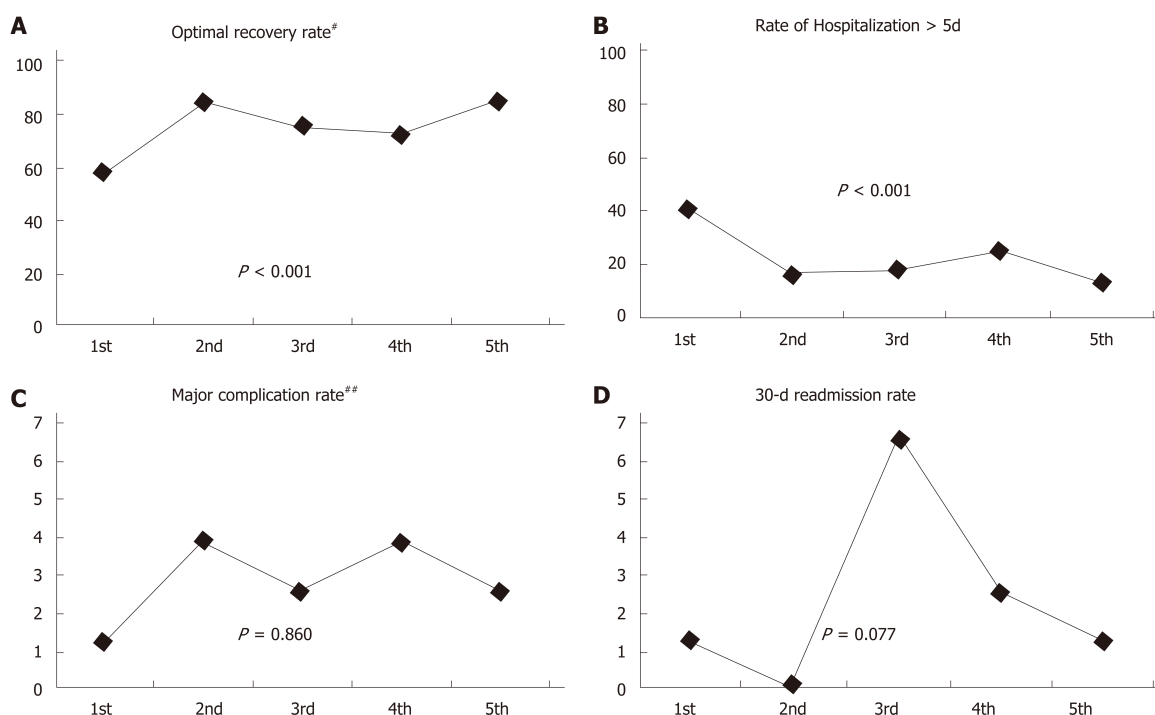
<sup>1</sup>Multi-organ resection excluded the resection of appendix, gallbladder, ovaries and fallopian tubes, small bowel, and part of urinary bladder (partial cystectomy). ASA: American Society of Anesthesiologists; BMI: Body mass index; CR-POSSUM: ColoRectal Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity.

predictor of readmission after major traumatic injury and general surgery<sup>[18,19]</sup>.

It would appear that the implementation of ERAS program in open colorectal surgery may have a longer learning curve (*i.e.*, more patients and a longer period of time) to achieve an optimal recovery than that in laparoscopic surgery. Pedziwiatr *et al*<sup>[6]</sup> showed that at least 30 patients over a period of 6 mo were required before their multidisciplinary team can effectively integrate an ERAS protocol into laparoscopic colorectal surgery. In this European study, there was a significant increase in some ERAS elements implemented over the study period such as no drains, use of epidural analgesia, early feeding and early ambulation. In the Alberta Health Services Canada, Gramlich *et al*<sup>[20]</sup> reported that the active phase of ERAS implementation took 9-12 mo and recommended to use data on a baseline cohort of 50 patients in pre- and post-implementation period to define compliance with ERAS program. A possible explanation for a longer learning curve of successful ERAS implementation in open colorectal surgery is the fact that open surgery is associated with a higher systemic stress response and more surgical trauma than laparoscopic surgery<sup>[21,22]</sup>. Therefore, patients undergoing open surgery could have a higher rate of postoperative complication and are more difficulty to follow an ERAS protocol<sup>[9,23]</sup>, especially for postoperative compliance with an ERAS protocol<sup>[12]</sup>. Although it may take more times to achieve a successful ERAS program in open colorectal surgery, a recent report from 15 academic hospitals in Canada has suggested that ERAS has more positive effect in patients undergoing open surgery than those with laparoscopic approach<sup>[12]</sup>.

The introduction of the ERAS program required a closed collaboration and communication among surgical team members and other health care professionals as well as the continuous monitoring of its outcomes. Since not all elements could be introduced immediately, the ERAS compliance was lower than 70% in the early period of ERAS implementation in our institute. However, the rate of ERAS compliance significantly increased after our multidisciplinary ERAS team experienced the application of this program in 76 patients. A high ERAS compliance was then maintained thereafter at approximately 75%. Increasing ERAS compliance has been shown to be associated with a successful improved outcome including fewer complications, shorter hospital stay<sup>[4,5]</sup> and better oncological outcomes<sup>[24]</sup>. Two large European studies have suggested a cut-off point at 70% compliance with ERAS protocol to be correlated with a significant improvement in short-term and long-term outcomes following colorectal surgery<sup>[24,25]</sup>. It is arguable that full implementation of ERAS program may be not required to achieve better clinical outcomes.

Some components of our ERAS protocol encountered difficulties in their initial implementation, partly, due to the habit of conventional care and the lack of knowledge or instruments. Thanks to the cooperation of our multidisciplinary ERAS team and the support of hospital authorities, many components of our ERAS protocol increasingly implemented over the study period including preoperative detailed counseling, perioperative nutrition support, intraoperative goal-directed fluid



**Figure 1 Enhanced recovery after surgery outcomes among each quintile (by chronological order).** A: Optimal recovery rate; B: Rate of hospitalization longer than 5 d; C: Major complication rate; D: 30-d readmission rate. X-axis shows 5 quintile groups and y-axis indicates a percentage. <sup>#</sup>Optimal recovery was defined as no major postoperative complication, discharge by postoperative day 5, and no 30-d readmission; <sup>##</sup>Clavien-Dindo grade  $\geq$  III.

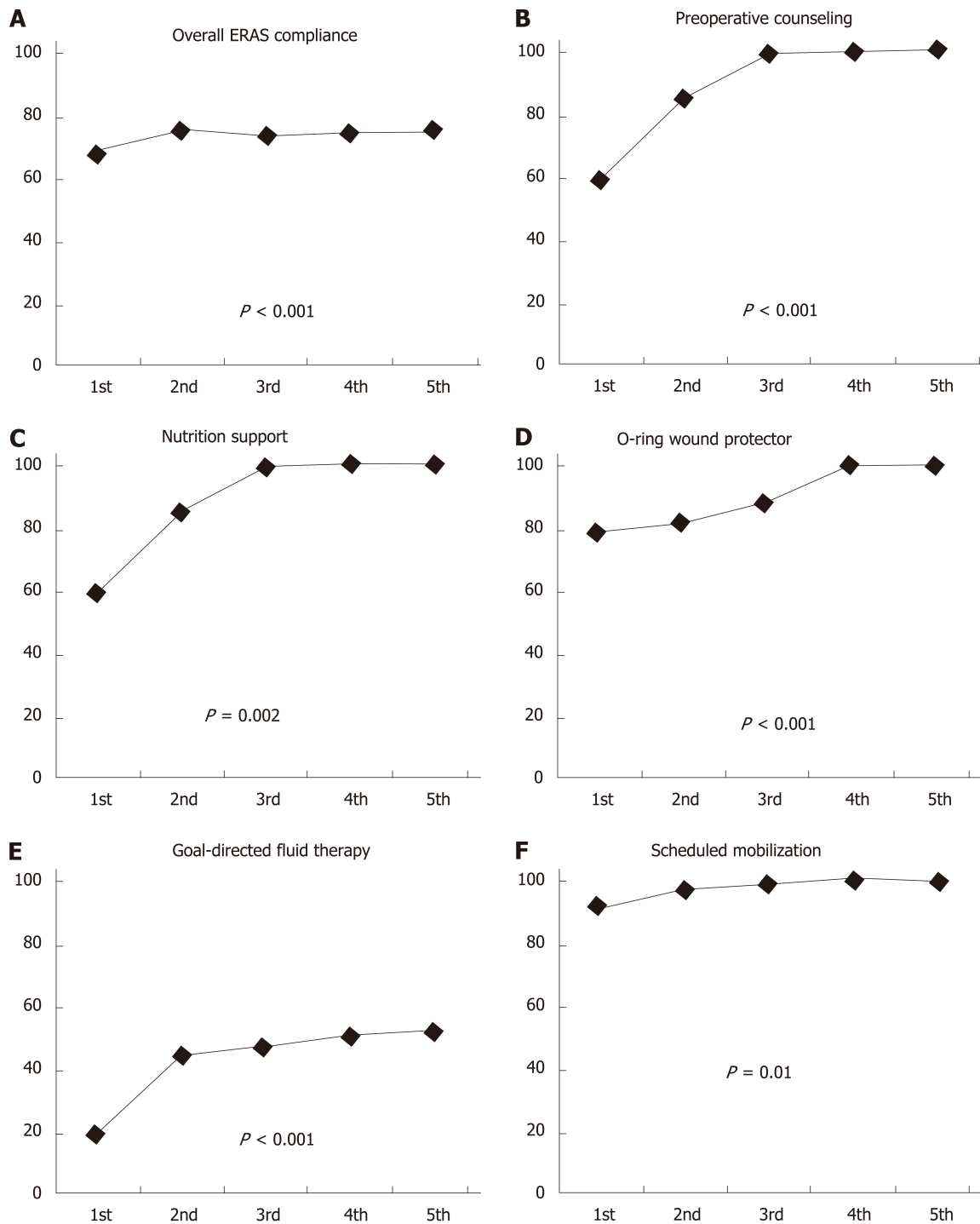
therapy, intraoperative use of atraumatic O-ring wound protector and postoperative scheduled mobilization. A recent multi-center observational study in Ontario suggested that postoperative ERAS interventions had the greatest impact on optimal recovery after colorectal surgery<sup>[12]</sup>.

This study has three major strengths. First, the data was extracted from a prospectively collected database of unselected patients undergoing open colectomy and/or proctectomy with an ERAS protocol. All patients were operated on and taken care of by the same surgeon and his multidisciplinary team thus resulting in minimizing bias. Second, to determine an optimal recovery, this study used a composite endpoint of three clinical outcomes (no major postoperative complication, discharge by postoperative day 5, and no 30-d readmission) which have commonly been used as a proxy in the measurement of successful ERAS implementation<sup>[6,11,12]</sup>. Third, this study provided detailed data on compliance with ERAS protocol and its individual elements.

The limitations of this study include the fact that it included only open colorectal operation. Whether the learning curve in this study is applicable to laparoscopic colorectal surgery or other intra-abdominal operations needs to be determined. Second, this study used only common clinical outcomes (*i.e.*, major complication, hospital stay and readmission) as representatives for optimal recovery<sup>[6,11,12]</sup>. It did not assess any patient-reported outcomes such as time to return to normal activities and quality of life – which could be other important outcome measures for optimal recovery in the future study. Last, we acknowledged that there are several methods to quantify learning curve such as a simple linear regression and various curve fitting methods, a cumulative sum analysis and a chronological division of consecutive cases (data splitting method)<sup>[26]</sup> – each has its pros and cons. We used the latter design because it was evident that data splitting method can be used to identify a change over time even in case of case-mix complexity<sup>[27]</sup>. As a result, it was the most common method used to measure the learning curve effect in health technology<sup>[27]</sup>. However, the cut-off point of consecutive cases is arbitrary and information derived from the underlying learning curve may be limited.

This study showed that a number of 76 colorectal operations are required for a multidisciplinary team to achieve a significantly higher rate of optimal recovery and compliance with an ERAS protocol for open colorectal operation. These findings could call surgical communities to find the best ways to shorten the learning curve of ERAS program – especially in open laparotomy. It may include a structured program of education, training, cooperation and experience sharing between surgeons and





**Figure 2 Compliance with enhanced recovery after surgery protocol.** A: Overall compliance with 17 core elements; B: Compliance with preoperative counseling; C: Compliance with nutrition support; D: Compliance with O-ring wound protector; E: Compliance with goal-directed fluid therapy; F: Compliance with scheduled mobilization. X-axis shows 5 quintile groups and Y-axis indicates the percentage of its application.

non-surgical health care personals as an integrated ERAS team, or between a well-established ERAS center and a newly-implied ERAS hospital. The regular audition of relevant outcomes and closed collaboration between many different stakeholders, including patients and their family, are also required to achieve the best care and optimal recovery of surgical patients.

Table 3 Surgical outcomes

	Overall (n = 380)	1 <sup>st</sup> quintile (n = 76)	2 <sup>nd</sup> quintile (n = 76)	3 <sup>rd</sup> quintile (n = 76)	4 <sup>th</sup> quintile (n = 76)	5 <sup>th</sup> quintile (n = 76)	P value
Time to resume normal diet (d)	2 (1-3)	2 (1-3)	1 (0-2) <sup>a</sup>	2 (0-2.8)	2 (1-3)	2 (1-2)	< 0.001 <sup>a</sup>
Time to first bowel movement (d)	3 (2-3)	3 (2-3)	3 (2-3)	3 (2-3)	2 (2-4)	3 (2-3)	0.848
Overall complication	83 (21.8)	18 (23.7)	20 (26.3)	16 (21.1)	18 (23.7)	11 (14.5)	0.457
Major complication <sup>1</sup>	11 (2.9)	1 (1.3)	3 (3.9)	2 (2.6)	3 (3.9)	2 (2.6)	0.860
Hospital stay (d)	4 (4-5)	5 (4-7) <sup>b</sup>	4 (4-5)	4 (4-5)	5 (4-5.8)	4 (3-5)	0.015 <sup>a</sup>
Hospital stay >5 d	86 (22.6)	31 (40.8) <sup>c</sup>	12 (15.8)	15 (18.4)	19 (25.0)	10 (13.2)	< 0.001 <sup>a</sup>
30-d readmission	9 (2.4)	1 (1.3)	0	5 (6.6)	2 (2.6)	1 (1.3)	0.077
30-d mortality	1 (0.3)	0	1 (1.3)	0	0	0	0.405
ERAS compliance %	73.5 ± 11.8	68.6 ± 16 <sup>d</sup>	75.4 ± 11.1	73.7 ± 9.9	74.3 ± 10.2	75.5 ± 9.5	< 0.001 <sup>a</sup>
Optimal recovery <sup>2</sup>	288 (75.0)	44 (57.9) <sup>e</sup>	64 (84.2)	57 (75.0)	55 (72.4)	65 (85.5)	< 0.001 <sup>a</sup>

Data are presented as mean ± standard deviation, median (IQR) or number (percentage).

<sup>a</sup> $P < 0.05$ . 2<sup>nd</sup> quintile had a shorter period of time to resume normal diet than 1<sup>st</sup> and 4<sup>th</sup> quintile; 1<sup>st</sup> quintile had a longer length of postoperative stay than 5<sup>th</sup> quintile; 1<sup>st</sup> quintile had a higher number of patients discharged after postoperative day 5 than the others; 1<sup>st</sup> quintile had a lower compliance rate of ERAS protocol than 2<sup>nd</sup>, 4<sup>th</sup> and 5<sup>th</sup> quintile; 1<sup>st</sup> quintile had a higher rate of composite unfavorable outcomes than 2<sup>nd</sup>, 4<sup>th</sup> and 5<sup>th</sup> quintile.

<sup>1</sup>Clavien-Dindo grade ≥ III (the most severe complication was registered for patients with more than one complication);

<sup>2</sup>Optimal recovery was defined as no major postoperative complication, discharge by postoperative day 5, and no 30-d readmission.

ERAS: Enhanced recovery after surgery.

## ARTICLE HIGHLIGHTS

### Research background

Enhanced recovery after surgery (ERAS) reduces hospitalization and complication following colorectal surgery. Whether the experience of multidisciplinary ERAS team affects patients' outcomes is unknown especially for open colorectal surgery – which is known to be associated with higher rates of complication and more difficulty to implement an ERAS program than laparoscopic surgery.

### Research motivation

The initial stage of ERAS application into surgical practice, *i.e.*, learning curve, could be a crucial phase of this patient-centered perioperative pathway because the workflow of health care personals needs to be adopted and the guideline has to assimilate into a daily practice.

### Research objectives

This study aimed to evaluate and establish a learning curve of ERAS program for open colorectal surgery.

### Research methods

This was a review of prospectively collected database of 380 “unselected” patients undergoing elective “open” colectomy and/or proctectomy under ERAS protocol from 2011 (commencing ERAS application) to 2017 in a university hospital. Patients were divided into 5 chronological groups (76 cases per quintile). Surgical outcomes and ERAS compliance among quintiles were compared. Learning curves were calculated based on criteria of optimal recovery: defined as absence of major postoperative complications, discharge by postoperative day 5, and no 30-d readmission.

### Research results

Hospitalization more than 5 d occurred in 22.6% ( $n = 86$ ), major complication was present in 2.9% ( $n = 11$ ) and 30-d readmission rate was 2.4% ( $n = 9$ ) accounting for unsuccessful recovery of 25% ( $n = 95$ ). Conversely, the overall rate of optimal recovery was 75%. The optimal recovery significantly increased from 57.9% in 1<sup>st</sup> quintile to 72.4%-85.5% in the following quintiles ( $P < 0.001$ ). Average compliance with ERAS protocol gradually increased over the time - from 68.6% in 1<sup>st</sup> quintile to 75.5% in 5<sup>th</sup> quintile ( $P < 0.001$ ). The application of preoperative counseling, nutrition support, goal-directed fluid therapy, O-ring wound protector and scheduled mobilization significantly increased over the study period.

### Research conclusions

A number of 76 colorectal operations are required for a multidisciplinary team to achieve a significantly higher rate of optimal recovery and high compliance with ERAS program for open colorectal surgery.

### Research perspectives

These findings could call surgical communities to find the best ways to shorten the learning curve of ERAS program – especially in open laparotomy. The barriers to the conduct, application and maintenance of ERAS program for colorectal surgery should be identified and solved systematically in order to achieve the best care and optimal recovery of surgical patients.

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