original article

Eur Surg (2019) 51:183–188
https://doi.org/10.1007/s10353-019-0595-8

european surgery
ACA Acta Chirurgica Austriaca

Enhanced recovery after colorectal surgery: the clinical and economic benefit in elderly patients

Petr Kocián · Adam Whitley · Petr Přikryl · Markéta Bocková · Daniel Hodyc · Blanka Čermáková · Tomáš Vymazal · Jiří Hoch

Received: 25 October 2018 / Accepted: 15 April 2019 / Published online: 14 May 2019

Summary
Background We performed this study to investigate the feasibility and clinical and financial benefit of an enhanced recovery after surgery (ERAS) protocol in elderly patients undergoing colorectal resections.
Methods Patients over the age of 65 undergoing open colorectal resections at the department of surgery of the Motol University Hospital in Prague between January 2015 and August 2017 were included in the study. Patients who received ERAS perioperative care formed the ERAS group and patients who received standard perioperative care formed the control group. Adherence to the ERAS protocol, hospitalisation length, readmission rate, 30-day postoperative morbidity and mortality, and treatment costs were analysed.
Results Seventy-four patients were included in the ERAS group and sixty-one in the control group. Patient and surgical characteristics were similar in the two groups. An adherence of 83.8% to the ERAS protocol was achieved. Recovery parameters were improved and hospital stay length was shortened, while readmission rate, morbidity and mortality. Although not statistically significant, treatment costs were reduced by an average of €1187 per patient.
Conclusion We showed that our enhanced recovery after colorectal surgery protocol in elderly patients is feasible, effective, safe and reduces treatment costs.

Keywords Colorectal surgery · Aged · Perioperative care · Postoperative complications · Cost–benefit analysis

Main novel aspects

- This is the first study focused on ERAS in elderly patients from the Czech Republic.
- This paper brings further evidence that the ERAS protocol is beneficial both clinically and financially in elderly patients undergoing colorectal surgery.

Introduction

Kehlet et al. introduced the enhanced recovery after surgery (ERAS) protocol for perioperative care in 1997 as a way to accelerate recovery after surgery [1]. This protocol has been shown in various randomised controlled clinical trials, systematic reviews and meta-analyses to decrease length of hospitalisation, postoperative morbidity and to reduce treatment costs [2–8]. The ERAS protocol rapidly gained international recognition and been implemented in many colorectal centres worldwide and is expanding into other surgical disciplines [9]. Although it has been shown to be beneficial to patients in the general population, less is known about its benefit in elderly patients. A systematic review on the effect of the ERAS protocol in elderly patients concluded that the protocol is safe, yet

P. Kocián, M.D. Ph.D. (✉) · M. Bocková, M.D. · J. Hoch, M.D. Ph.D.
Department of Surgery, Second Faculty of Medicine, Charles University and Motol University Hospital, V Úvalu 84, 150 06 Prague, Czech Republic
petr.kocian@fnmotol.cz

A. Whitley, M.D.
Department of Surgery, University Hospital Královské Vinohrady, Prague, Czech Republic

Department of Anatomy, Second Faculty of Medicine, Charles University, Prague, Czech Republic

P. Přikryl, M.D. · T. Vymazal, M.D. Ph.D.
Department of Anaesthesiology and ICM, Second Faculty of Medicine, Charles University and Motol University Hospital, Prague, Czech Republic

D. Hodyc, M.D. Ph.D. · B. Čermáková, M.Phil.
Advance Healthcare Management Institute, Prague, Czech Republic

further studies should be performed to evaluate adherence and clinical benefit in this subset of patients [10]. Even though the majority of new cases of CRC occur in patients over the age of 65, there are few studies focused solely on this age group and as far as we know there have been no published cost–benefit analyses in this specific subgroup of patients [11]. Elderly patients have more comorbidities, are frailer and have a higher risk of surgical complications than younger patients [12, 13]. Thus, the extent to which elderly patients can adhere to and benefit from ERAS programs is not certain [10]. The goal of this study was to evaluate whether elderly patients can achieve high adherence to ERAS protocols and whether these protocols are clinically and financially beneficial when compared to standard perioperative care.

Methods

Patient selection

Patients undergoing colorectal resection at the department of surgery of the Motol University Hospital in Prague between January 2015 and August 2017 were assessed for eligibility to be included in the study. After a trial period of 3 months, the ERAS protocol was fully implemented in July 2016. Patients in the ERAS group underwent surgery between July 2016 and August 2017. The control group consisted of patients who underwent colorectal surgery before implementation of ERAS. We selected patients who underwent colorectal surgery between January 2015 and March 2016 to create the control group. All patient information was recorded in a prospectively managed database. Inclusion criteria were age above 65 years, informed consent and open colorectal resection. Exclusion criteria were multivisceral resection, transanal resection, postoperative intensive care. The study was approved by the institutional ethical board (reference no. EK-760/18).

Outcome measures

All data were collected prospectively in a computerised database. Outcome measures consisted of recovery parameters, hospitalisation length, readmission within the first 30 days after discharge, 30-day postoperative morbidity and mortality, and treatment costs. Recovery parameters recorded were postoperative nausea and vomiting occurring within the first 24 hours after surgery, full mobilization on the first postoperative day, tolerance of solid diet by the fourth postoperative day, amount of intravenous fluids received on the day of surgery and administration of parenteral nutrition. Paralytic postoperative ileus was diagnosed if any two of the following items were met on or after the third postoperative day: nausea or vomiting, intolerance of solid or semisolid food, abdominal distension, absence of bowel movements or flatulence, or radiological evidence of ileus. 30-day postoperative morbidity and mortality were defined according to the Clavien–Dindo classification. Minor complications were defined as Clavien–Dindo grades I and II, major complications as Clavien–Dindo grades III and IV, and deaths as Clavien–Dindo grade V.

Cost of treatment was defined as the sum of the cost of hospital bed stay, interventions and medical materials. Costs of treatment were calculated from administrative data compiled from hospital claims reported to health funds. Both costs of hospital bed stay and interventions were assigned using the list of procedures and reimbursement decree issued annually by the Ministry of Health. Costs of medical materials were assigned using the list of reimbursed materials and pharmaceuticals issued annually by the main public health insurance company of the Czech Republic and the State Institute for Drug Control.

ERAS protocol

The ERAS protocol consisted of 16 items divided into three groups: preoperative, perioperative and postoperative periods. A list of all the items and the adherence to each item are shown in Table 1. Mechanical bowel preparation was used for left-sided and rectal resection and when intraoperative colonoscopy was indicated. Goal-directed fluid therapy was performed

Table 1 Adherence to the ERAS protocol

	ERAS ($n=74$)
Preoperative period	
Preoperative counselling	70 (94.6)
Nutritional screening	70 (94.6)
No fasting, oral carbohydrates	48 (64.9)
Selective bowel preparation	69 (93.2)
Antithrombotic prophylaxis	74 (100.0)
Antibiotic prophylaxis	74 (100.0)
Perioperative period	
Prevention of hypothermia	74 (100.0)
Goal-directed fluid therapy (LiDCORapid™)	65 (87.8)
Early removal of the thoracic epidural catheter[a]	36 (50.0)
No abdominal drain	44 (48.6)
No nasogastric tubes immediately after surgery	74 (100.0)
Prevention of nausea	73 (98.6)
Postoperative period	
Early feeding	63 (85.1)
Enhanced postoperative mobilization	69 (93.2)
Multimodal (opioid-sparing) analgesia	71 (95.9)
Foley catheter removal (until 48 hours)	17 (23.0)
Overall adherence, percentage	
Mean ± SD	83.8 ± 9.5

Data presented as *n* (%), unless stated otherwise
SD standard deviation, *TEA* thoracic epidural catheter, *ERAS* early recovery after surgery
[a]16 patients did not achieve this item because they did not have TEA. In 22 patients the TEA was removed beyond 72 hours after surgery

Fig. 1 Goal-directed fluid therapy (LiDCORapid™, LiDCO, London, United Kingdom) and intraoperative patient warming. *Triangle arrow* hemodynamic monitoring system, *dashed arrow* convective air warming system, *unbroken arrow* fluid warmer

using the LiDCORapid™ (LiDCO, London, United Kingdom) hemodynamic monitoring. Thermoregulation was achieved by intraoperative patient warming using a convective air warming system (Bair Hugger; 3M-Switzerland, Rüschlikon, Switzerland) and warming intravenous fluids (Biegler Fluid Warmer; Biegler GmbH, Mauerbach, Austria) (Fig. 1). Epidural catheters were removed by the first 72 hours after surgery. Abdominal drains were not used in colonic resection, and when used in rectal surgery, they were removed within the first 72 hours. A nasogastric tube was not used during surgery or removed immediately at the end of the surgery. Multimodal opioid-sparing analgesia consisted of a combination of paracetamol with nonsteroidal anti-inflammatory drugs; this item was considered fulfilled when patients received no more than one dose of opioids per day. When following the protocol, we expected to discharge patients within the first 9 days after surgery. When patient discharge was delayed longer than 9 days the reasons for delayed discharge were recorded.

Table 2 Patient and surgical characteristics

	ERAS group ($n=74$)	Control group ($n=61$)	P-value
Age, years			
65–74	55 (74.3)	40 (65.6)	0.434
75–84	17 (23.0)	20 (32.8)	
≥85	2 (2.7)	1 (1.6)	
Median (range)	70 (65–88)	71 (65–86)	
Gender ratio			
Male/female	42/32	32/29	0.728
ASA score			
I	0	0	0.422
II	26 (35.1)	27 (44.3)	
III	47 (63.5)	34 (55.7)	
IV	1 (1.4)	0	
Type of procedure			
Ileocecal resection	3 (4.1)	1 (1.6)	0.152
Right hemicolectomy	27 (36.5)	12 (19.7)	
Transverse resection	1 (1.4)	2 (3.3)	
Left hemicolectomy	2 (2.7)	6 (9.8)	
Sigmoid resection	25 (33.8)	23 (37.7)	
Anterior resection	4 (5.4)	2 (3.3)	
Low anterior resection	11 (14.9)	11 (18.0)	
Abdominoperineal resection	1 (1.4)	4 (6.6)	
Colon/rectum	58/16	44/17	
Histopathology			
Malignant/benign	68/6	53/8	0.402
Duration of surgery, minutes			
Median (1st and 3rd quartiles)	90 (75–112)	100 (75–125)	0.260
Blood loss (ml)			
Median (1st and 3rd quartiles)	30 (10–100)	50 (20–150)	0.062
Type of general anaesthesia			
Combined	58 (78.4)	48 (78.7)	0.982
Balanced	16 (21.6)	13 (21.3)	

Data presented as *n* (%), unless stated otherwise
ERAS early recovery after surgery, *ASA* American Society of Anesthesiologists

Statistical analysis

Statistics were performed in the program R (R core team 2018). Categorical variables were compared using Fisher's test and continuous variables were quantile normalised and compared using t-tests. P-values of less than 0.05 were taken to be statistically significant.

Results

Patient and surgical characteristics

Seventy-four patients were included in the ERAS group and sixty-one in the control group. Patient and

Table 3 Outcome measures

	ERAS group ($n=74$)	Control group ($n=61$)	P-value
Recovery parameters			
Postoperative nausea and vomiting[a]	14 (20.3)	16 (26.2)	0.718
Full mobilization on the first postoperative day	64 (86.5)	10 (16.4)	**<0.001**
Feeding tolerance	36 (48.6)	3 (4.9)	**<0.001**
Intravenous fluids[b] (ml), mean ± SD	2932.2 ± 631.2	3318.3 ± 841.3	**0.009**
Parenteral nutrition	20 (27.0)	60 (98.4)	**<0.001**
Length of postoperative hospital stay and readmission rate			
Postoperative length of stay at intermediate care unit	4.2 ± 2.4	5.3 ± 3.3	**0.018**
Postoperative length of stay at surgical ward	6.1 ± 5.9	6.6 ± 2.8	**0.006**
Total postoperative length of stay	10.3 ± 7.1	11.9 ± 4.8	**<0.001**
Readmission	2 (2.7)	1 (1.6)	1.000
30-day morbidity and mortality			
All complications			
Minor complications	36 (48.6)	26 (42.6)	0.607
Major complications	4 (5.4)	6 (9.8)	0.544
Mortality	0	2 (3.3)	0.202
Surgical complications			
Postoperative bleeding	0	1 (1.6)	0.452
Anastomotic leak[c]	2 (2.8)	2 (3.6)	0.776
Surgical site infection	7 (9.5)	3 (4.9)	0.511
Paralytic postoperative ileus	13 (17.6)	13 (21.3)	0.663
Nonsurgical complications			
Urinary infection	4 (5.4)	2 (3.3)	0.689
Pneumonia	2 (2.7)	2 (3.3)	1.000
Cardiac arrhythmia	4 (5.4)	9 (14.8)	0.083

Data presented as *n* (%), unless stated otherwise
Length of postoperative hospital stay presented as mean and standard deviation
Readmission presented as number with percentage in brackets
P-values less than 0.05 are highlighted bold
SD standard deviation
[a]Missing data in ERAS group ($n=5$).
[b]Total amount of intravenous fluids given on the day of surgery
[c]Anastomotic leak was evaluated in all patients who underwent colon/rectal resection with creation of an anastomosis (71 patients in the ERAS group and 55 patients in the control group)

surgical characteristics were similar in the two groups. Details can be seen in Table 2.

Protocol adherence

A high overall adherence to the ERAS protocol was achieved; the average adherence was 83.8% with a standard deviation of 9.5. Full adherence was achieved in antithrombotic and antibiotic prophylaxis, intraoperative thermoregulation and avoidance of nasogastric tubes. The items with the lowest adherences were early removal of Foley catheters (23.0%), not using abdominal drains (48.6%), early removal of epidural catheters (50.0%) and preoperative fasting (64.9%). Adherence of over 80% was achieved in all other items.

Outcome measures

Outcome measures are shown in Table 3. A significant improvement in all recovery parameters apart from postoperative nausea and vomiting was achieved. Length of hospital stay was reduced by the ERAS protocol ($P<0.001$) while readmission rate remained unchanged. The total length of hospital stay was reduced by 1.6 days; the length of stay in the intermediate care unit by 1.1 days and in the standard department by 0.5 days. Our target of discharging patients within the first postoperative 9 days was reached in 48 patients (64.9%). Delayed discharges were most often due to minor complications and social reasons (see Table 4). There were no significant differences in morbidity and mortality.

Table 4 Reasons for delayed discharges in ERAS

	Social reasons	Minor complications	Major complications
Discharges beyond 9 days after surgery	9 (34.6)	13 (50.0)	4 (15.4)
Data presented as *n* (%)			

Table 5 Cost impact of implementation of the ERAS protocol

	ERAS group (*n* = 74)	Control group (*n* = 61)	P-value
Cost of hospital bed stay			
Ward	236	276	**0.049**
Intermediate care unit	1,459	2,251	**0.018**
Total	1,695	2,527	**0.008**
Intervention costs			
Anaesthesia	426	452	0.746
Prevention of hypothermia	9	0	**<0.01**
Goal-directed fluid therapy (LiDCORapid™)	131	0	**<0.01**
Surgery	705	676	0.309
Laboratory tests	208	349	**0.033**
Imaging methods	5	28	0.198
Parenteral nutrition	33	56	**<0.01**
Physiotherapy	36	46	0.290
Endoscopy	29	19	0.985
Other interventions[a]	40	78	0.064
Total	1,622	1,704	0.678
Cost of medical material			
Medical devices	325	483	0.465
Pharmaceuticals and blood products	66	181	0.284
Total	391	664	0.353
Total costs	*3,708*	*4,895*	*0.165*

Average cost per person given in euros. P-values less than 0.05 are highlighted bold
[a]Other interventions included in-hospital consultations and investigations from other departments (internal medicine, cardiology, neurology, haematology, urology, gynaecology, etc.)

Cost–benefit analysis

The cost–benefit analysis revealed that ERAS reduced the total treatment costs per patient by an average of €1187 (Table 5). Significant cost reductions were seen in cost of hospital bed stay (P = 0.008), both in the intermediate care unit (P = 0.018) and on the ward (P = 0.049), laboratory tests (P = 0.033) and parenteral nutrition (P < 0.01). The use of hemodynamic monitoring and intraoperative thermoregulation naturally resulted in increased cost in the ERAS group, but did not increase the overall treatment costs.

Discussion

We showed that our enhanced recovery after colorectal surgery protocol in elderly patients is feasible, effective and safe; we achieved an adherence rate of more than 80%, improved recovery parameters and shortened LOS without increasing readmission rate, morbidity or mortality. The ERAS protocol was associated with a reduction in treatment costs. However, probably due to the small study size, this reduction was not statistically significant.

Total adherence in our study was 83.8%, with a range between 23 and 100%, which fares well when compared to other studies. Venara et al. reported a range of adherence to the ERAS items from 25 to 100% [14]. In a multicentre study, from Gonzales et al., the total adherence to an ERAS protocol in elderly patients was 56% [15]. When comparing these studies and others, there seems to be no correlation between low adherence and specific ERAS protocol items [14–16]. We believe low adherence is more likely due to resistance to change in standard practise than patient intolerance.

Our target of dismissal within the first 9 days after surgery was achieved in 64.9%. When compared to young patients, social reasons for delaying discharge, such as lack of space in nursing homes and rehabilitation centres, are much more predominant. Additionally, minor complications, which may be managed in an outpatient setting in younger patients, may require lengthened hospitalisation in elderly patients [16]. Indeed, in our cohort, hospital discharge was delayed due to social reasons in 9 patients and due to minor complications in 13 patients. Despite the length of hospital stay being potentially prolonged for non-

surgical reasons, we believe these patients can still benefit from the accelerated recovery and should be included in ERAS protocols.

To the best of our knowledge, this is the first study on the cost–benefit analysis of elderly patients undergoing colorectal resections in an ERAS protocol. Cost–benefit analyses have been performed in the general population and have positive results. Our results show that, despite the fact certain aspects of the ERAS protocol increased treatment costs, particular hemodynamic monitoring and intraoperative thermoregulation, the overall average cost was reduced by €1187 per patient. As this result was not proven to be statistically significant, further larger studies and meta-analyses on this topic should be performed.

Limitations of the study

The study was limited by its non-randomized single-centre design and small study size. The cost analysis was limited by using a cost model based on administrative data from claims, rather than real costs. However, the results show a decrease in the use of resources, which indicates a decline in real costs.

Conclusion

We have demonstrated successful integration of ERAS for elective colorectal surgery in elderly patients. A high rate of adherence to the protocol was achieved and length of hospital stay was reduced, while readmission rate, morbidity and mortality remained unchanged and the cost of treatments were reduced.

Acknowledgements We would like to thank the doctors and nursing staff of the Department of Surgery of the Second Faculty of Medicine, Charles University and Motol University Hospital for their devoted care of our patients.

Compliance with ethical guidelines

Conflict of interest P. Kocián, A. Whitley, P. Přikryl, M. Bocková, D. Hodyc, B. Čermáková, T. Vymazal and J. Hoch declare that they have no competing interests.

Ethical approval The study was approved by the institutional ethical board (reference no. EK-760/18).

References

1. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. Br J Anaesth. 1997;78:606–17.
2. Greco M, Capretti G, Beretta L, et al. Enhanced recovery program in colorectal surgery: A meta-analysis of randomized controlled trials. World J Surg. 2014;38:1531–41.
3. Lemanu DP, Singh PP, Stowers MD, et al. A systematic review to assess cost effectiveness of enhanced recovery after surgery programmes in colorectal surgery. Colorectal Dis. 2014;16:338–46.
4. Nelson G, Kiyang LN, Chuck A, et al. Cost impact analysis of enhanced recovery after surgery program implementation in Alberta colon cancer patients. Curr Oncol. 2016;23:e221–e7.
5. Thanh NX, Chuck AW, Wasylak T, et al. An economic evaluation of the enhanced recovery after surgery (ERAS) multisite implementation program for colorectal surgery in Alberta. Can J Surg. 2016;59:415–21.
6. Zhuang CL, Ye XZ, Zhang XD, et al. 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.
7. Wang Q, Suo J, Jiang J, et al. Effectiveness of fast-track rehabilitation vs conventional care in laparoscopic colorectal resection for elderly patients: A randomized trial. Colorectal Dis. 2012;14:1009–13.
8. Lau CS, Chamberlain RS. Enhanced recovery after surgery programs improve patient outcomes and recovery: A meta-analysis. World J Surg. 2017;41:899–913.
9. Bugada D, Bellini V, Fanelli A, et al. Future perspectives of ERAS: A narrative review on the new applications of an established approach. Surg Res Pract. 2016; https://doi.org/10.1155/2016/3561249.
10. Bagnall NM, Malietzis G, Kennedy RH, et al. A systematic review of enhanced recovery care after colorectal surgery in elderly patients. Colorectal Dis. 2014;16:947–56.
11. Siegel RL, Miller KD, Fedewa SA, et al. Colorectal cancer statistics. CA Cancer J Clin. 2017;2017(67):177–93.
12. Saxton A, Velanovich V. Preoperative frailty and quality of life as predictors of postoperative complications. Ann Surg. 2011;253:1223–9.
13. Sandini M, Pinotti E, Persico I, et al. Systematic review and meta-analysis of frailty as a predictor of morbidity and mortality after major abdominal surgery. BJS Open. 2017;1:128–37.
14. Venara A, Barbieux J, Mucci S, et al. Short-term outcomes of colorectal resection for cancer in elderly in the era of enhanced recovery. Scand J Surg. 2018;107:31–7.
15. Gonzalez-Ayora S, Pastor C, Guadalajara H, et al. Enhanced recovery care after colorectal surgery in elderly patients. Compliance and outcomes of a multicenter study from the Spanish working group on ERAS. Int J Colorectal Dis. 2016;31:1625–31.
16. Forsmo HM, Erichsen C, Rasdal A, et al. Enhanced recovery after colorectal surgery (ERAS) in elderly patients is feasible and achieves similar results as in younger patients. Gerontol Geriatr Med. 2017; https://doi.org/10.1177/2333721417706299.