Cost-effectiveness of the implementation of an enhanced recovery protocol for colorectal surgery

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Background: Enhanced recovery protocols may reduce postoperative complications and length of hospital stay. However, the implementation of these protocols requires time and financial investment. This study evaluated the cost-effectiveness of enhanced recovery implementation.

Methods: The first 50 consecutive patients treated during implementation of an enhanced recovery programme were compared with 50 consecutive patients treated in the year before its introduction. The enhanced recovery protocol principally implemented preoperative counselling, reduced preoperative fasting, preoperative carbohydrate loading, avoidance of premedication, optimized fluid balance, standardized postoperative analgesia, use of a no-drain policy, as well as early nutrition and mobilization. Length of stay, readmissions and complications within 30 days were compared. A cost-minimization analysis was performed.

Results: Hospital stay was significantly shorter in the enhanced recovery group: median 7 (interquartile range 5–12) versus 10 (7–18) days ($P = 0.003$); two patients were readmitted in each group. The rate of severe complications was lower in the enhanced recovery group (12 versus 20 per cent), but there was no difference in overall morbidity. The mean saving per patient in the enhanced recovery group was €1651.

Conclusion: Enhanced recovery is cost-effective, with savings evident even in the initial implementation period.

Presented to the 99th Annual Congress of the Swiss Surgical Society, Davos, Switzerland, June 2012, and the Seventh Annual Meeting of the European Society of Coloproctology, Vienna, Austria, September 2012; published in abstract form as *Swiss Knife* 2012; 9: 21 and *Colorectal Dis* 2012; 14: 39

Paper accepted 24 April 2013

Published online in Wiley Online Library (www.bjs.co.uk). DOI: 10.1002/bjs.9184

Introduction

Enhanced recovery is a multimodal perioperative approach aiming to attenuate the patient's stress response in order to achieve low complication rates and hence a more rapid postoperative recovery¹. Based on the available evidence, standardized clinical pathways have been developed covering all areas of a patient's journey through the surgical process^{2,3}. The current enhanced recovery protocol for colorectal surgery includes more than 20 interventions, ranging from reduced preoperative fasting to an optimized fluid balance and use of a no-drain policy⁴. It has been demonstrated that postoperative complications may be reduced, with faster postoperative recovery^{5–8}. Despite these encouraging results, uptake of perioperative enhanced recovery programmes in colorectal surgery has

been slow in Europe and the USA^{9–12}. This might be related to the fact that successful clinical implementation requires considerable effort to assemble an interdisciplinary team, as well as some financial investment³.

Previous studies have not detailed costs of implementation of the protocol^{13–15}, or included mostly open colonic surgery¹⁶. The present study aimed to assess the cost-effectiveness of implementation of an enhanced recovery programme with a defined protocol for laparoscopic and open colorectal surgery.

Methods

An enhanced recovery protocol for colorectal surgery was developed and implemented at the university hospital of

Table 1 Perioperative care elements for colorectal surgery

	Enhanced recovery	Standard care
Patient counselling*	Preadmission counselling + written information	No standardized information
Fasting	Clear fluids until 2 h, solids 6 h before surgery	Solid and fluid fasting from midnight
Carbohydrate drinks*	800 ml on evening and 400 ml 2 h before surgery	No carbohydrate drinks
Premedication*	No premedication	Premedication with oral midazolam 7.5 mg
Thromboprophylaxis*	LMW heparin 12 h before surgery, IPC	LMW heparin 12 h before surgery
PONV prophylaxis*	PONV prophylaxis†	No PONV prophylaxis
Balanced intravenous fluids*	Intraoperative crystalloids 500–1000 ml for surgery < 3 h; otherwise crystalloids 1500 ml and colloids 500–1000 ml. Postoperative crystalloids 500 ml during the first 24 h, then stop	No guidance
Postoperative analgesia	Thoracic epidural analgesia for laparotomy. Epidural or PCA for laparoscopy‡. Paracetamol, ibuprofen and oxycodone–naloxone only for breakthrough pain	No standardized postoperative analgesia
Abdominal drains	No routine abdominal drainage§	Abdominal drainage at surgeon's discretion
Bladder catheter*	Removal on postoperative day 1	Removal at surgeon's discretion
Nutrition*	Free fluid 4 h after surgery. Normal diet from day of surgery. Two nutritional supplements per day	No standardized reintroduction of fluid and food
Systematic laxatives*	Oral magnesium hydroxide	No systematic laxatives
Mobilization*	Out of bed at least 15 min on the day of surgery; at least 6 h per day thereafter	No mobilization objectives
Systematic audit	Systematic audit; bimonthly meeting	No audit
Bowel preparation*	Avoidance of bowel preparation	
Antibiotic prophylaxis*	Cefuroxime 1.5 g + metronidazole 500 mg¶	
Hypothermia prevention*	Active warming (air blanket)	
Nasogastric tubes*	No routine postoperative gastric tube	

*Items used to calculate mean compliance rate. †Droperidol 1 mg at induction; ondansetron 4 mg with or without betamethasone 4 mg at the end of operation; betamethasone only for women or non-smokers or those with previous history of postoperative nausea and vomiting (PONV). ‡Removal after 48 h for colonic and 72 h for rectal surgery. §Except for rectal resection below peritoneal reflection. ¶30 min before incision. LMW, low molecular weight; IPC, intermittent pneumatic compression; PCA, patient-controlled analgesia.

Lausanne, a tertiary referral centre for colorectal surgery. A local interdisciplinary team of surgeons, anaesthetists, nutritionists, nurses and administrators underwent the formal training provided by the ERAS® Society. All protocols, including patient information and clinical pathways, as well as the database, the *ERAS® Interactive Audit System*, were provided by the ERAS® Society. From February 2011, the local team attended the first seminars and adapted the protocols provided to the local needs of the university hospital of Lausanne. In June 2011, the first patients subjected to the enhanced recovery pathway were included, and the implementation period ended in November 2011. During the first 2 months, only elective colonic resections were included in order to allow familiarization with this new protocol. Afterwards, all patients scheduled for elective laparoscopic or open colonic or rectal operations were included. Exclusion criteria were: age below 18 years and emergency operations within 24 h after admission.

Consecutive patients treated during implementation of the enhanced recovery programme were compared with those treated in the year before its introduction. Patients were identified from a hospital database. Inclusion and exclusion criteria were similar for both groups. Informed

consent was obtained from all patients before surgery. The study was approved by the institutional review board.

The protocol is outlined on *Table 1*. Of note, the following discharge criteria in the enhanced recovery group were used: sufficient postoperative pain control with oral analgesia, tolerance of solid food, passage of flatus or faeces, and independent ambulation. A dedicated study nurse contacted all patients 5 days after discharge from hospital, and a clinical assessment was performed in the outpatient department after 30 days. Patients in the control group received standard postoperative care and were discharged from hospital at the surgeon's discretion.

Assessment of postoperative morbidity and mortality

Postoperative complications were graded according to severity on a validated five-point scale¹⁷. Grades IIIa to IVb were defined as severe complications. More than one complication per patient was possible, but only the highest ranked complication was used for final analysis. Postoperative mortality (grade V) was defined as death during the first 30 days after surgery or during the hospital stay after the index operation.

Cost-minimization analysis

The cost-minimization analysis was performed from a healthcare provider's perspective to assess savings per patient in hospital. Costs were obtained in Swiss francs (CHF), and then converted to euros (€). The exchange rate used was €1 = 1.20 CHF, which was the official rate on 22 June 2012.

Implementation costs

The protocol implementation costs included variable costs (patient's logbook, carbohydrate drinks and nutritional supplements) and fixed costs (enhanced recovery implementation costs, travel and lunch expenses of multidisciplinary team training, and cost of full-time dedicated nurse recruited in June 2011).

Direct in-hospital costs included all costs that could be attributed to any resource consumption during the hospital stay for the index operation and, if applicable, a readmission stay. For each patient, inpatient costs were those incurred from the day of admission until the day of discharge, with cost allocations provided by the university hospital accounting database. Anaesthesia costs were calculated per minute based on the duration of anaesthesia (including costs of anaesthetists, nurse anaesthetists, materials and drugs). Operating room costs were calculated per minute based on duration of occupation. Surgeon's costs were included under medical care. Intensive and intermediate

care unit costs were calculated per day based on the Project Research in Nursing (PRN) score¹⁸. Medical care costs included all clinical activities performed by doctors, including surgeons, but not costs incurred by anaesthetists, radiologists and pathologists. Nursing care costs were those incurred per day outside intensive and intermediate care units, based on the PRN score. Costs of housing were accounted per day and administration costs were accounted per patient admission.

Sensitivity analysis

When fixed costs, which are independent of the number of patients, are allocated on an individual level, they show large variation in relation to the number of patients treated within the study period. Therefore, a sensitivity analysis of the costs of enhanced recovery implementation was carried out. The number of patients treated within the study period was varied (± 50 per cent) in order to assess its impact on the cost-minimization results.

Statistical analysis

Continuous variables were compared using two-tailed Mann–Whitney or Student's *t* test, as appropriate. Categorical variables were analysed by means of Fisher's exact test or χ^2 test. Despite an imbalance in the distribution of cost data, the arithmetic mean was considered as the

Table 2 Baseline characteristics of patients undergoing colorectal surgery

	Enhanced recovery (<i>n</i> = 50)	Standard care (<i>n</i> = 50)	<i>P</i> †
Age (years)*	65.0(17.9)	65.0(13.6)	0.995
Sex ratio (M:F)	28:22	25:25	0.689‡
Body mass index (kg/m ²)*	26.7(5.0)	27.3(4.1)	0.357
ASA grade			0.265‡
I–II	39	33	
III	11	17	
P-POSSUM*			
Physiological	18(6)	19(4)	0.341
Operative	13(4)	13(4)	0.557
Surgical approach			0.016‡
Laparoscopic	33	20	
Open	17	30	
Type of operation			0.528§
Colectomy	27	33	
Anterior resection of rectum	14	9	
Abdominoperineal resection	2	3	
Other	7	5	
Diagnosis			0.294§
Adenocarcinoma	36	29	
Diverticular disease	6	11	
Other	8	10	

*Values are mean(s.d.). ASA, American Society of Anesthesiologists; P-POSSUM, Portsmouth modification of the Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity²⁰. †Unpaired *t* test, except ‡Fisher's exact test and § χ^2 test.

Table 3 Clinical outcomes of patients undergoing colorectal surgery

	Enhanced recovery (n = 50)	Standard care (n = 50)	P†
Mean compliance with enhanced recovery protocol (%)	71	36	
Time to first passage of flatus (days)*	2 (1–2)	3 (2–4)	0.005
Time to first passage of stool (days)*	3 (2–4)	4 (3–5)	< 0.001
Patients with a complication within 30 days			
Grade I–II	24	19	0.414‡
Grade IIIa–IVb	6	10	0.287‡
Postoperative stay (days)*	7 (5–12)	10 (7–18)	0.003

*Values are median (interquartile range). †Mann–Whitney *U* test, except ‡Fisher's exact test.

Table 4 Total individual costs of primary hospital stay

	Mean cost per patient (€)*		Mean difference (€)†	P‡
	Enhanced recovery (n = 50)	Standard care (n = 50)		
Total intraoperative costs	10 573 (9563, 11 667)	8801 (7822, 10 083)	1772 (–5, 3633)	0.031
Disposable materials	2494 (2183, 2808)	1639 (1368, 1951)	855 (409, 1258)	0.002
Anaesthesia and operating room	8079 (7144, 9262)	7162 (6336, 8263)	917 (–651, 2600)	0.212
Total preoperative + postoperative costs	13 735 (11 453, 16 448)	18 169 (14 058, 23 118)	–4434 (–1028, 644)	0.102
Intensive and intermediate care	2045 (1367, 2936)	3077 (1864, 4566)	–1032 (–2803, –420)	0.249
Medical care	3122 (2650, 3721)	3653 (3083, 4338)	–531 (–1406, 372)	0.224
Nursing care	4368 (3409, 5663)	5538 (4129, 7458)	–1170 (–3449, 1255)	0.304
Physiotherapy	194 (135, 271)	338 (228, 468)	–144 (–286, –14)	0.058
Medication	588 (455, 760)	966 (663, 1313)	–378 (–713, –76)	0.048
Blood transfusion and testing	261 (163, 373)	393 (223, 583)	–132 (–373, 93)	0.261
Laboratory	476 (367, 592)	993 (718, 1334)	–517 (–845, –238)	0.006
Radiology	143 (77, 214)	422 (265, 611)	–279 (–475, –93)	0.012
Housing and administration	2538 (2219, 2893)	2789 (2358, 3357)	–251 (–891, –388)	0.429

*Values are means, derived from 1000 non-parametric bootstrap replicates, with 95 per cent confidence intervals. †Enhanced recovery *minus* standard care. ‡Bootstrapped *t* test.

most informative measure from the decision-makers' perspective. The non-parametric bootstrap test, which was described for pharmacoeconomic cost analysis with moderate sample sizes¹⁹, was used for the cost analysis in the present study. $P < 0.050$ was considered statistically significant. All analyses were performed using SPSS® 20 (IBM, Armonk, New York, USA).

Results

The first 50 consecutive patients treated during implementation of an enhanced recovery programme were compared with 50 consecutive patients treated in the year before its introduction. The two groups were similar regarding age, sex, body mass index, American Society of Anesthesiologists physical status grade, Portsmouth modification of the Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity (P-POSSUM)²⁰, diagnosis and type of operation (Table 2). Of note, there were significantly more laparoscopic operations in the enhanced recovery group ($P = 0.016$). The number of conversions from laparoscopy to open surgery was comparable: six and eight patients in the enhanced recovery and

standard groups respectively ($P = 0.774$). The mean(s.d.) duration of operation was 261(101) min in the enhanced recovery group and 238(98) min in the standard group ($P = 0.248$).

Postoperative outcomes

The mean rate of adherence to the protocol, defined as the numbers of elements fulfilled divided by the total number of items (Table 1), was 71 per cent in the enhanced recovery group compared with 36 per cent in the standard group. Adherence to each perioperative care element is detailed in Table S1 (supporting information).

Postoperative recovery was significantly faster among patients treated within the enhanced recovery protocol (Table 3). Overall, there were 48 complications in the enhanced recovery group and 60 in the standard group, but the difference did not reach statistical significance ($P = 0.640$). Only one patient in the standard group died within 30 days of surgery (mortality rate 2 per cent). Postoperative stay was significantly shorter in the enhanced recovery group, with a reduction in median stay of 3 days ($P = 0.003$). There were two readmissions within 30 postoperative days

Table 5 Summary of cost-minimization analysis

	Mean cost per patient (€)		Mean difference (€)*
	Enhanced recovery (n = 50)	Standard care (n = 50)	
Enhanced recovery implementation	1011	0	1011
Intraoperative cost	10 573	8801	1772
Preoperative + postoperative costs	13 735	18 169	– 4434
Total costs	25 319	26 970	–1651

*Enhanced recovery *minus* standard care.

in each group. The total readmission length of stay was 13 days in the enhanced recovery group and 36 days in the standard group.

Cost-minimization analysis

The variable costs for carbohydrate drinks and nutritional supplements for each patient in the enhanced recovery group were €75, and that for the patient's logbook was €4. Fixed costs for implementation of the enhanced recovery programme and travel and lunch expenses of the multidisciplinary team were €15 000 and €4108 respectively. A full-time study nurse was recruited at €27 500 for the 6 months during which the first 50 patients were recruited to the enhanced recovery programme. By distributing the fixed costs among these 50 patients and adding the individual variable costs, €1011 was attributed to each patient.

Operative costs per patient were significantly higher in the enhanced recovery group, with a difference of €1772 ($P = 0.031$). More disposable materials, such as staplers, trocars and dissection instruments, were used during laparoscopy. As a higher proportion of patients in the enhanced recovery group underwent laparoscopic colorectal surgery, overall costs of disposable materials were increased. Furthermore, laparoscopic surgery took slightly longer than open surgery. However, there was an overall cost saving of €4434 per patient in the enhanced recovery group regarding total preoperative and postoperative costs (Table 4). Accounting for all the different costs, a mean overall saving of €1651 per patient was observed in favour of the enhanced recovery group (Table 5).

Sensitivity analysis

As most of the enhanced recovery implementation costs were fixed, the mean costs per patient were closely related to the number of patients treated in the study period. By varying the number of patients by ± 50 per cent, the mean implementation costs were €1943 per patient for 25

patients and €700 per patient for 75 patients. The total cost balance remained in favour of the enhanced recovery group, estimated at €718 and €1961 for 25 and 75 patients respectively.

Discussion

This study found that implementation of an enhanced recovery programme for colorectal surgery in a Swiss university hospital led to cost savings. Standardization of perioperative patient management and a significantly shortened hospital stay contributed to this economic benefit. Commonly raised criticisms of cost analysis studies are the lack of complete cost data, which restricts conclusions, and that only overall economic effects can be shown; savings or losses per patient are rarely depicted. The present study included all direct costs related to perioperative management as well as all costs of the protocol, including its implementation, charged to the number of included patients.

The significant reduction in length of stay might explain the cost reduction observed, as has been shown previously after implementation of a clinical pathway²¹. However, the length of stay has a limited impact on overall costs because hospital days are not equivalent economically. The first few postoperative days are generally more costly than those just before discharge²². Moreover, postoperative complications have a major impact on hospital costs, and complications and their severity are the strongest indicator of hospital charges²³. In the present study, there was only a small difference in the overall number of complications between groups, but complications in the enhanced recovery group were less severe.

Available data on cost-minimization of enhanced recovery protocols in colorectal surgery are sparse. A previous study, which did not include implementation costs, reported a comparable decrease of €1782 following the implementation of a clinical pathway for elective open colonic surgery²⁴. Complication rates were similar before and after introduction of the clinical pathway, and readmission rates increased from 2 to 10 per cent

with the accelerated pathway. A recent randomized clinical trial in China reported a statistically significant total cost reduction of €263 per patient in an enhanced recovery programme¹⁴. However, there was no detailed cost-minimization analysis and the development costs were not considered. The only study on colonic surgery to include costs of implementation of such a programme was performed in New Zealand; an overall cost saving of approximately €4521 was reported¹⁶. In contrast to the present study, only 10 per cent of all interventions were carried out laparoscopically. The LAParoscopy and/or FAsT track multimodal management *versus* standard care (LAFA) study found laparoscopy in combination with a dedicated enhanced recovery programme to be the optimal perioperative approach, with similar in-hospital costs in the four groups¹⁵.

The present study has some limitations. First, retrospective data collection for the standard group could have led to incomplete identification of postoperative events. Despite the higher rate of laparoscopic operation associated with higher intraoperative costs in the enhanced recovery group, implementation of the programme was still cost-effective. Thus, if the rate of laparoscopy had been similar in both groups, the cost reduction in the enhanced recovery group would have been even greater²⁵. Finally, as the enhanced recovery protocol resulted in reduced length of stay, there may have been a transfer of costs from the hospital to the community. These costs, including loss of productivity, were not evaluated in the present study.

Acknowledgements

The authors acknowledge the support provided by all members of the enhanced recovery team in Lausanne, including the Nutrition Unit led by P. Coti Bertrand, as well as charge nurses, A. Jannot and L. Cudre, and the senior ward manager, A. Cotillard. Special thanks go to V. Addor, the enhanced recovery-dedicated clinical nurse.

Disclosure: The authors declare no conflict of interest.

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Supporting information

Additional supporting information may be found in the online version of this article:

Table S1 Adherence to each perioperative care element (Word document)