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A programme of Enhanced Recovery After Surgery (ERAS) is a cost-effective intervention in elective colonic surgery

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Aim There are few published ERAS cost-analyses in colorectal surgery. The aim of this paper is to evaluate whether costs saved by reduced postoperative resource utilisation would offset the financial burden of setting up and maintaining such an ERAS programme.

Methods A cost-effectiveness analysis from a healthcare provider perspective using a case-control model. The study group consisted of patients enrolled in the ERAS program for elective colonic surgery at Manukau Surgical Centre between December 2005 and March 2007. The control group consisted of consecutive patients from September 2004 to September 2005 (before the start of ERAS). Groups were matched with respect to operation, BMI, ASA, and Cr-POSSUM score.

Results Data were available for 50 patients in each group. There was a significant reduction in total hospital stay, intravenous fluid use, and duration of epidural use in the ERAS group. There were significantly fewer complications in the ERAS group. Implementation of ERAS cost approximately $NZ102,000, but this has been more than offset by costs saved in reduced postoperative resource utilisation, with an overall cost-saving of approximately NZ$6900 per patient.

Conclusion Implementing an ERAS program is cost-effective in the medium term, with costs offset by those recovered by reduced resource utilisation in the postoperative period.

Background

There has been a rise in popularity in Enhanced Recovery After Surgery (ERAS) programmes in developed countries, but uptake has been varied, and inter-protocol consistency sketchy at best.[1] A major challenge in the implementation of a multimodal care pathway is adequate resourcing, particularly in context of the current healthcare environment which dictates the provision of financial justification prior to the adoption of any new intervention.

Cost-analyses of ERAS protocols in colorectal surgery have been limited to early clinical pathway studies,[2,3] one study focussing solely on ileal-pouch anal anastomoses,[4] and a study incorporating a very heterogeneous group of patients, some of whom were part of a unrelated international trial.[5] None of these studies addressed the set-up costs of an ERAS protocol nor provided a detailed breakdown of where cost savings were achieved in the postoperative recovery phase.

In December 2005, an ERAS programme was implemented for elective colonic resections at the Manukau Surgical Centre in Auckland, New Zealand.[6] This programme emphasises structured nursing care pathways within an environment

focusing on early recovery, and incorporates a number of perioperative strategies within the ERAS framework. We have previously published data outlining a significant reduction in intravenous fluid requirement, total day-stay and postoperative complications,[7] as well as improved patient functional recovery[8] as a direct result of instituting this programme.

A considerable investment was required in order to setup this programme and ensure its success. The aim of this paper is to evaluate whether the costs saved by reduced postoperative resource utilisation would offset the financial burden of setting up and maintaining an ERAS programme in elective colonic surgery.

Methods

ERAS Protocol—The ERAS programme was developed in a multidisciplinary fashion and received appropriate institutional approval for implementation. A consultant surgeon, a ward charge nurse, and a colorectal nurse specialist visited an institution in Denmark with an established ERAS programme, and an equivalent programme tailored to the Manukau Surgical Centre was developed. A full-time ward-based junior doctor was then employed as a research fellow in enhanced recovery, to be responsible for the overall running of the programme as well as prospective auditing of safety and effectiveness. The ERAS protocol used in our institution is outlined in Table 1.

All elective colonic resections in patients >15 years old were included in the ERAS programme. Exclusion criteria were: patients requiring a stoma, ASA (American Society of Anaesthesiologists) score ≥IV, significant cognitive impairment, inability to communicate in English, and patients declining consent.

Cost analysis—A cost-effectiveness analysis from a healthcare provider perspective was performed comparing a study group of ERAS patients with a historical group of case-matched controls. Total cost of protocol development, as well as the cost of ward stay at the Manukau Surgical Centre, outpatient clinic time, and patient booklet production was obtained from hospital management budget records. The research fellow yearly salary was obtained from the University of Auckland (Auckland, New Zealand). Costs of oral supplements, non-steroidal anti-inflammatory medications, and intravenous fluids were obtained from the hospital pharmacy, and epidural costs from the hospital anaesthetic department. Costs of readmission and estimates of specific costs associated with postoperative complications were supplied by a hospital clinical analyst (complication costs were determined by calculating the cost of index hospital stay with and without a given complication, excluding cost of day stay and readmission)

Patient groups—The study (ERAS) group consisted of consecutive patients enrolled in the ERAS programme for elective colonic surgery at Manukau Surgical Centre between December 2005 and March 2007. Data for this group were collected prospectively.

The control group consisted of a comparable, consecutive series of patients identified through a hospital electronic database search from September 2004 to September 2005 (before the start of the ERAS programme). Control patients were individually matched with those in the study group with respect to the operation performed, BMI (Body Mass Index), ASA score, and Cr-POSSUM score (Colorectal Physiological and Operative Severity Score for the enumeration of Mortality).[9] Furthermore, these patients all met the inclusion criteria used for the ERAS group and their operations were performed by the same specialist surgeons. Patients in the control group received conventional, non-structured perioperative care. Discharge was left to the discretion of the senior members of the surgical team with no specified discharge criteria in place. Data for this group were collected retrospectively.

Table 1. Enhanced Recovery After Surgery (ERAS) protocol

Timing	Intervention
Preadmission	Preoperative assessment in a dedicated outpatient session. Programme information given, including specific daily milestones. Social issues are identified and addressed. Preoperative ward visit and orientation.
Preop	Preoperative carbohydrate loading (PreOP®, Nutricia; Numico, Zoetermeer, Netherlands). 4 drinks day before surgery, and 2 drinks 2 hours before surgery. Patients admitted to hospital on the morning of their surgery. Left-sided operations receive a phosphate enema on arrival at the hospital. Mechanical bowel preparation is avoided.
Intraop	Thoracic epidural inserted and bupivacaine epidural infusion started (Polybag®, AstraZeneca Theatre Pack®, AstraZenenca Ltd, Auckland, NZ). Limited intraop intravenous fluids (1–2L crystalloids / colloids). Transverse incisions for right-sided open surgery if appropriate. Prophylactic nasogastric tubes not used. Intra-abdominal drains not used. Calf stockings applied at the end of surgery.
Recovery room	Vasopressor agents in preference to intravenous fluids to treat epidural-related hypotension. Intravenous morphine / fentanyl PCA initiated.
Day of surgery	Patients are mobilised to a chair. Oral intake of fluids is started, aiming for > 800 ml of oral intake on the day of surgery. Pre-emptive regular antiemetics (5-HT3 antagonists as first line). Subcutanous low molecular weight heparin started for thrombo-prophylaxis (Clexane® 20mg once daily until discharge, Sanofi-aventis Ltd, Auckland, NZ).
Day 1	Urinary catheter removed. Full solid oral diet. Resource supplement drinks (2–3 per day until discharge). Active mobilisation with nursing and physiotherapy input.
Day 2	Epidural infusion is stopped, and epidural catheter removed. Regular oral non-steroidal anti-inflammatory drugs (Tenoxicam 20mg orally twice daily until discharge, Tilcotil tabs®, Roche, Auckland, NZ). Oral opiates for break-through pain only.
Day 3	Discharged home if fulfill following criteria: Tolerating full oral diet Passing flatus Adequate analgesia on oral medication Ambulating independently Satisfactory support at home
After discharge	Patient given a phone number for contacting the ward if required. Nursing staff contact the patients three days after discharge for a phone interview. Follow up outpatient clinic appointment within 7 days of discharge.

Preop: Preoperative; Intraop: Intraoperative

Data collection—Data were collected from patient records including physical and electronic clinical, radiology, and laboratory records. Data included patient demographics, ASA score, Cr-POSSUM score, surgical indication, operating surgeon, operation performed, epidural use, intravenous fluid use, cancer staging, postoperative day stay, total day stay, complications and readmission. To ensure that recorded complications were comparable in both groups, specific complications were documented according to previously defined and published criteria.[7] All patients were followed for 30 days after surgery.

Results

Data were available for 50 patients in each group. During the recruitment period, ten patients had been excluded from the ERAS programme; two had significant renal impairment, two had significant cardiac comorbidity, two were cognitively impaired, two could not speak sufficient English, and two declined consent. Eight patients treated from September 2004 to September 2005 were excluded from the conventional treatment control group; two patients had significant renal impairment, two had dementia, one had Addison's disease, and three had hematologic disorders.

Baseline characteristics—The ERAS and conventional groups were comparable with respect to sex, BMI, ASA score, Cr-POSSUM score, operation performed, and indication for surgery (Table 2). The ERAS group was marginally younger than the conventional group (65.6 vs 70.7 years, p=0.021).

Table 2. Baseline characteristics

Variables	ERAS group (n=50)	Control group (n=50)	P value
Age (mean, range)	65.6 (39–92)	70.7 (40–85)	0.021
Sex			
Male	26	28	0.688‡
Female	24	22	0.688‡
ASA score			
I	8	8	1.00‡
II	29	31	0.683‡
III	13	11	0.640‡
BMI	28.6	27.4	0.588†
CR-POSSUM			
Physiologic	10.3	9.7	0.524†
Operative	9.2	8.3	0.061†
Operation			
Open R hemicolectomy	26	29	0.546‡
Open L hemicolectomy	19	14	0.288‡
Lap L hemicolectomy	4	7	0.525‡
Open Total colectomy	1	0	1.000‡
Diagnosis			
Diverticulosis	2	4	0.674‡
IBD	1	1	1.000‡
Adenoma	4	2	0.674‡
Dukes A	6	5	0.749‡
Dukes B	15	8	0.096‡
Dukes C	19	21	0.683‡
Dukes D	3	9	0.124‡

ASA: American Society of Anesthesiologists; BMI: Body mass index; CR-POSSUM: Colorectal Physiologic and Operative Severity Score for the enUmeration of Mortality; ERAS: Enhanced Recovery After Surgery; IBD: Inflammatory bowel disease; R: Right, L: Left, Lap: Laparoscopic.

†Mann–Whitney U test, ‡Chi-squared test.

Postoperative recovery—As we have previously shown[7] there was a significant reduction in postoperative hospital stay, total hospital stay, intravenous fluid use (both

intraoperative and day 1 to day 3 postoperative), and duration of epidural use in the ERAS group compared to the control group (Table 3). There was also a one day reduction in the median time to first full solid meal and passage of flatus, and patients mobilised a median of 2 days earlier.

Table 3. Postoperative recovery data.

Variables	ERAS Group (n=50)	Control Group (n=50)	P Value
Intravenous fluids			
Intraoperative	2 (1–8)	3 (1–7.5)	<0.0001†
First 3 days	2 (1–10)	6.5 (1–12)	<0.0001†
Epidural analgesia			
No. of patients	44 (89%)	38 (76%)	0.223‡
Duration of use (days)	2 (0–3)	3 (0–4)	<0.0001†
Recovery			
Days to 1st full meal	1 (1–3)	2 (1–15)	<0.0001†
Days to passage of flatus	2 (0–8)	3 (0–18)	<0.0001†
Days to independent mobilisation	1 (1–3)	3 (1–7)	<0.0001†
Complications			
No. of patients with ≥ 1 complication	27	33	0.221‡
Breakdown of complication events			
Death	0	2	0.495‡
Reoperation	4	4	1.000‡
Anastomotic leak	4	3	1.000‡
Intra-abdominal collection	1	1	1.000‡
Ileus	5	18	0.005‡
Wound complication	6	10	0.275‡
Urinary tract infection	2	12	0.008‡
Urinary retention	5	3	0.715‡
Cardiopulmonary	11	21	0.032‡
Day stay			
No. admitted > 1 day before surgery	12 (24%)	29 (58%)	<0.0001‡
Postoperative stay (days)	4 (3–34)	6.5 (3–18)	<0.0001†
Total hospital stay (days)	4 (3–34)	8 (4–29)	<0.0001†
Readmissions			
No. patients readmitted	6	7	0.766‡
Total day stay added (days)	73	44	0.772†

ERAS: enhanced recovery after surgery; No.: number; %: percentage.

Data are medians with ranges in parentheses, unless otherwise stated. †Mann–Whitney U test, ‡ Chi-squared test.

Complications are also presented in Table 3. Overall 54% of patients in the ERAS group had at least one complication recorded versus 66% of patients in the control group. There were significantly fewer urinary tract infections, cardiopulmonary complications, and episodes of postoperative ileus in the ERAS group. There was no difference in re-operation rate, with 4 patients in each group requiring an unplanned return to the theatre. Anastomotic leak resulted in three emergency laparotomies in the ERAS group and two in the conventional group, and wound dehiscence led to one re-operation in the ERAS group and two in the conventional group.

Cost analysis—A breakdown of ERAS protocol implementation and maintenance costs, offset against differential cost savings in the postoperative period is shown in Table 4. As can be seen, implementation of the ERAS programme cost approximately NZ$102,000 for the first 50 patients when one-off setup costs are taken into account. However, this has been more than matched by costs saved in reduced resource utilisation in the postoperative period with an overall cost-saving of approximately NZ$6900 per patient in the ERAS group compared to the control group.

Table 4. Cost analysis

Item	Cost of one unit	ERAS (units)	Control (units)	ERAS (NZD)	Control (NZD)
Denmark visit (3 airfare tickets + accommodation)	10561.39	1	0	10561.39	0
Research Fellow salary for 15 months (1 year salary × 1.25)	84143.75	1	0	84143.75	0
ERAS patient booklet	4.20	50	0	210.00	0
Supplements drinks				1475.95	0
Preop carbohydrate	1.50	300	0	450.00	0
Resource supplement	1.42	722.5	0	1025.95	0
Tenoxicam	0.2375	300	0	71.25	0
Outpatient clinic slot	115.77	50	0	5788.50	0
Fluids				8738.10	16758.00
Intraoperative	34.20	124.5	174.5	4257.90	5967.90
Postoperative	34.20	131	315.5	4480.20	10790.10
Epidural				6921.20	7831.80
Bupivacaine infusion	48.80	88	114	4294.40	5563.20
Apparatus and tubing	59.70	44	38	2626.80	2268.60
Complications				470356.75	746326.32
Leak / collection	34853.26	5	4	174266.30	139413.04
Ileus	6517.37	5	18	32586.85	117312.66
Wound complication	19703.81	6	10	118222.86	197038.10
Urinary tract infection	4615.13	2	12	9230.26	55381.56
Urinary retention	3445.41	5	3	17227.05	10336.23
Cardiopulmonary	10802.13	11	21	118823.43	226844.73
Ward stay				214350.61	375570.94
Index admission	881.63	200	400	176326.00	352652.00
Re-admission	520.885	73	44	38024.61	22918.94
Total cost				802617.50	1146487.06
Cost per patient				**16052.35**	**22929.74**

NZD: New Zealand Dollars.

Discussion

This cost-effectiveness analysis has shown that an ERAS programme is a very cost-effective intervention in elective colonic surgery in the setting of an elective hospital in New Zealand. While the programme incurred an additional cost of approximately NZ$2000 per patient in the study group to implement, these costs were recouped after

only 15 patients had gone through, with an overall saving per patient of just under NZ$7000.

The majority of the cost was saved by halving the total postoperative day stay, and reducing postoperative complication costs. While the rate of readmission was not significantly different between the groups, day stay cost of readmission for the ERAS group was higher, with patients being readmitted for a longer period of time. This is because 3 patients in the ERAS group were readmitted with a major complication requiring day stay of 10 days or more (2 anastomotic leaks and 1 intra-abdominal abscess), versus 1 in the control group (intra-abdominal abscess).[7]

It should be emphasised that while more patients in the ERAS group were readmitted with intra-abdominal complications, the overall rate of these complications was not significantly different, with patients in the control group manifesting these complications during their relatively longer index admission.

Care pathway cost-analyses have been undertaken for a variety of surgical indications, from vascular access surgery to paediatric urology, and almost invariably demonstrate cost savings.[2–5,10–17] This is largely because these pathways focus on perioperative process of care to prevent or reduce morbidity and mortality, resulting in an improvement of resource utilisation.[18]

In colorectal surgery, cost-analyses of enhanced recovery protocols are limited. Two early clinical pathway programmes proved useful in standardising patient care and reducing costs,[2,3] and were probably instrumental in the development of modern ERAS protocols. However, there has been a huge paradigm shift in postoperative care principles in colorectal surgery since that time, making the cost-analyses reported in those studies inapplicable to current programmes.

More recently Kariv et al published results of a case-control cost analysis comparing patients undergoing ileal pouch-anal anastomosis in a “Fast Track” postoperative care pathway versus case-matched controls.[4] A significant reduction in median direct hospital costs per patient within 30 days was reported. However, the study was considerably weakened by a significant surgeon confounder with a different group of surgeons performing the surgery in the study group and the control group. This was highlighted in the reduced operating time in the Fast Track arm of the study. Also, the lack of epidural use in the treatment arm may not be consistent with current enhanced recovery recommendations, and the study did not account for costs incurred in protocol development.[19]

Another case-control study by King et al focussing on quality-of-life after colonic and rectal surgery, reported a health-economic analysis estimated on an individual patient level by adding in-hospital costs and postoperative costs derived using a health economics questionnaire.[5]

While this study was successful in demonstrating that implementation of a rigorous and well-designed ERAS programme did not result in transfer of costs to another component of the healthcare service (with an overall trend towards lower costs in the ERAS group), the difference in costs between the groups did not reach statistical significance. However, conclusions were limited by the heterogeneity of the patient cohorts (with significantly higher number of laparoscopic conversions and stomas in the control group) made up of patients enrolled in an unrelated national randomised

control trial which specified a 2:1 randomisation to laparoscopic versus open surgery.[20] This in itself may have introduced significant bias. Also, the health economic questionnaire used was not outlined (this may have not been a validated measure), and the costs of protocol development were not included in the analysis.

A further general criticism of cost analyses in surgery is the gross under-estimation of readmission costs,[21] as patients often represent to other services and hospitals, and this was not easily identified (or necessarily accounted for) in this study or that of Kariv et al.[4,5]

The value of our study is in the uniformity of the patient cohorts. All patients underwent their treatment in the same facility and were operated on by the same surgeons. Both cohorts were also comparable with respect to sex, BMI, ASA score, Cr-POSSUM score, operation performed, and indication for surgery. The electronic hospital records system which we used allowed complete follow-up for all patients in the study arm for 30 days, and identification of any re-presentation to any service (including the emergency departments) of all three public hospitals in the Auckland region. In addition, we isolated specific costs in the analysis, namely those involved in development and maintenance of the ERAS programme at our unit.

This study has several limitations. Our estimate represents a differential cost-effectiveness analysis based on the identification of areas of difference between the two groups. While this serves our comparison well, it is not an individualised cost-analysis and it is possible that unanticipated cost differences between the groups were un-accounted for.

Secondly, use of historical controls carries an inherent bias, with interval changes in costs or surgical practice (unrelated to the advent of the ERAS programme) potentially occurring during the intervening time. Also, certain development costs which could not be directly measured, such as time invested by the lead surgeon and costs of ward staff training, could not be accounted for in the analysis. Costs of non-hospital medical visits, at after hours emergency care or primary physicians for example, were also unobtainable.

Conclusion

Implementing an ERAS programme in the setting of elective colonic surgery is cost-effective in the medium term, with set-up and maintenance costs more than offset by costs recovered by reduced resource utilisation in the postoperative period.

Competing interests: None known.

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