Enhanced recovery pathways optimize health outcomes and resource utilization: A meta-analysis of randomized controlled trials in colorectal surgery

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Background. Health care systems provide care to increasingly complex and elderly patients. Colorectal surgery is a prime example, with high volumes of major procedures, significant morbidity, prolonged hospital stays, and unplanned readmissions. This situation is exacerbated by an exponential rise in costs that threatens the stability of health care systems. Enhanced recovery pathways (ERP) have been proposed as a means to reduce morbidity and improve effectiveness of care. We have reviewed the evidence supporting the implementation of ERP in clinical practice.

Methods. Medline, Embase, and the Cochrane library were searched for randomized, controlled trials comparing ERP with traditional care in colorectal surgery. Systematic reviews and papers on ERP based on data published in major surgical and anesthesiology journals were critically reviewed by international contributors, experienced in the development and implementation of ERP.

Results. A random-effect Bayesian meta-analysis was performed, including 6 randomized, controlled trials totaling 452 patients. For patients adhering to ERP, length of stay decreased by 2.5 days (95% credible interval [CrI] −3.92 to −1.11), whereas 30-day morbidity was halved (relative risk, 0.52; 95% CrI, 0.36–0.73) and readmission was not increased (relative risk, 0.59; 95% CrI, 0.14–1.43) when compared with patients undergoing traditional care.

Conclusion. Adherence to ERP achieves a reproducible improvement in the quality of care by enabling standardization of health care processes. Thus, while accelerating recovery and safely reducing hospital stay, ERPs optimize utilization of health care resources. ERPs can and should be routinely used in care after colorectal and other major gastrointestinal procedures. (Surgery 2011;149:830-40.)

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Health care spending is rising at an unsustainable rate, with projections in the US showing National Health Expenditures doubling from 2.6 to 5.2 trillion US$ and accounting for 20% of the Gross Domestic Product by 2020.1 Medical needs grow with the expansion of an aging population, yet we are faced with reduced bed availability and fewer health care workers. Optimization of health care practice is therefore urgent, particularly in colectomy, where complications occur at a disproportionately high rate compared with all other operative procedures.2 In effect, although approximately 10% of operative procedures are colectomies, colectomy accounts for one quarter of all operative complication.2,3
Enhanced recovery pathways (ERP) have proven efficacious in improving the quality and efficiency of surgical care. ERP encompass a systematic and evidence-based appraisal of all interventions performed in an episode of care. They have been associated with a reduction in duration of hospital stay, readmissions, and reoperations, together with decreased mortality and morbidity, improved pain control, better cost containment, and improved patient satisfaction. Although ERP have the potential to make an important contribution to distressed health care systems, they are yet used in fewer than one third of surgical practices in the US and the UK.

The purpose of this study was to provide the best evidence to support the implementation of ERP in clinical practice, starting from clinical outcomes and looking into economic implications, based on an international experience in the successful development of care pathways in colorectal surgery.

**COMPONENTS OF ERP**

ERP include standardized preoperative, in-hospital and postoperative care (Table I) rooted in an evidence-based approach to the surgical patient. They aim for a stress-free operation with minimal pain. Successful ERP are simple to apply and team driven, including all health care providers involved in an episode of care.

Patients and relatives are informed at the preoperative visit about the care process and expected outcomes. Early ambulation and feeding, pain control, and discharge criteria are reviewed. Postdischarge care plans are discussed so that any patient-specific needs are accounted for and do not unnecessarily delay discharge. Written information is provided, summarizing all steps of the care process in plain language, including contact and follow-up information.

The evening before the operation, a carbohydrate solution may be considered to reduce postoperative insulin resistance and catabolism, and preemptive, multimodal, nonopioid analgesia may be initiated with a nonsteroidal anti-inflammatory medication together with acetaminophen and gabapentin. Mechanical bowel preparation is selectively used to facilitate bowel handling for laparoscopic procedures, although systematic reviews found no difference in leakage rate of colorectal anastomosis, surgical site infection, reoperation, or mortality with or without bowel preparation.

Systematic reviews and meta-analyses have demonstrated that avoidance of fluid excess reduces the morbidity of colorectal surgery by up to two thirds, and improves the performance of ER. Fluid management can be optimized using transesophageal monitoring of the cardiac stroke volume with goal-directed administration of fluid boluses. In this context, a recent, prospective, randomized trial found that patients managed with crystalloid received lower total amounts of intravenous fluid and had fewer complications than patients managed with colloid. Even simple restriction of fluids aiming at an unchanged body weight significantly reduced complications after colorectal operations.

Intra-abdominal drains are used in the presence of an abscess, or selectively for coloanal anastomosis. Gastric decompression is solely required for the duration of the operative procedure. Routine use of abdominal drainage and nasogastric tubes increases gastrointestinal and infectious morbidity without benefit for the patient. Urinary catheters are removed on the first and second postoperative day after laparoscopic and open colorectal procedures, respectively.

### Table I. Five key components of a successful ERPs

<table>
<thead>
<tr>
<th>Patient information</th>
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<tbody>
<tr>
<td>1. Oral and written information of patient and relatives about all aspects of perioperative care</td>
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<tr>
<td>2. Preset discharge criteria</td>
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<tr>
<td>3. Early scheduled follow-up and readmission pathway</td>
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<tr>
<td>Preservation of gastrointestinal function</td>
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<td>4. Carbohydrate solution allowed until 2 hours before surgery</td>
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<td>5. Pharmacological prophylaxis of postoperative nausea or vomiting</td>
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<td>6. Enforced early enteral feeding</td>
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<td>7. Liberal use of chewing gum and laxatives</td>
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<tr>
<td>Minimizing organ dysfunction</td>
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<tr>
<td>8. Avoidance of mechanical bowel preparation</td>
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<tr>
<td>9. Goal-directed fluid therapy; minimizing fluid overload</td>
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<tr>
<td>10. Avoidance of drains and nasogastric tube</td>
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<td>11. Transverse abdominal incision or laparotomy</td>
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<tr>
<td>Active pain control</td>
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<tr>
<td>12. Preemptive analgesia initiated before surgery</td>
</tr>
<tr>
<td>13. Opioid-sparing anesthesia and analgesia, including a thoracic epidural with local anesthetic or intravenous patient-controlled analgesia</td>
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<tr>
<td>14. Infiltration of all incisions with local anesthetic</td>
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<tr>
<td>15. Peripheral opioid antagonist, intravenous local anesthetic</td>
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<tr>
<td>Promotion of patient’s autonomy</td>
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<tr>
<td>16. Preservation of sleep pattern by liberal use of night-time sedative</td>
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<td>17. Enforced early ambulation</td>
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<tr>
<td>18. Breathing exercises</td>
</tr>
<tr>
<td>19. Avoidance or early removal of urinary catheter</td>
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<tr>
<td>20. Early withdrawal of intravenous fluid therapy</td>
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Opioid-sparing analgesia, including a thoracic epidural (PDA) provides the best postoperative analgesia. For laparoscopic colectomy, prospective, randomized trials assessing the role of PDA versus patient-controlled analgesia found an identical duration of stay with either technique. A meta-analysis and systematic review of thoracic PDA with local anesthetic compared with patient-controlled analgesia demonstrated a significant reduction in pain and postoperative ileus (POI). However, no reduction in duration of stay was observed, likely because ERP were not implemented.

POI is an undesirable stress response to major abdominal operations, resulting in discomfort, morbidity, and prolonged duration of stay. Recent evidence from several randomized trials has shown the following techniques to reduce duration of POI: Thoracic PDA with local anesthetics, peripheral opioid antagonists, laxatives, chewing gum, intravenous and incisional local anesthetics, and avoidance of routine nasogastric intubation and fluid excess. When some of these techniques are combined in an ERP program, duration of POI after open or laparoscopic colonic resection can be reduced to 24–48 hours in >90% of patients, compared with 96–120 hours in traditional care. Use of laparoscopy with these techniques further reduces ileus.

Patients are encouraged to ambulate on the day of the operation and to sit in a chair for 6 hours per day. Starting on the first postoperative day, 5 walks outside the room are requested. Nursing or physical therapy support is beneficial.

Liquids are started immediately postoperatively, and no restriction is put on dietary intake starting 24 hours after both open and laparoscopic procedures. Intravenous fluids are stopped when patients are able to tolerate oral intake. A randomized, controlled trial demonstrated that early complete oral nutrition along an ERP was associated with minimal insulin resistance and balanced nitrogen losses. Moreover, a meta-analysis concluded that early oral nutrition reduced catabolism and morbidity.

Standardized, preset discharge criteria include the ability to tolerate a diet for 3 meals, adequate oral analgesia (pain visual analog scale <4), passage of flatus or stool, and the patient feeling ready for discharge with adequate social support. Routine follow-up consists in a phone call within 48 hours of discharge and a clinic visit within 6 weeks.

**ERP IN PRACTICE**

Current data from the United States suggest a national mean duration of stay of 11.6 days for major gastrointestinal operative procedure (colectomies and gastrectomies). Patients are discharged at 8.1 days (US) to 11 days (UK) after elective open segmental colectomy, and 7 (US) to 9 (Germany) days after laparoscopic colectomy. ERP have reduced duration of stay in Europe and in the United States, and minimally invasive approaches offer the prospect of further improvements.

Several prospective studies, including 6 randomized controlled trials, have reported a reduced duration of stay when ERP was compared with traditional operative care. Tolerance of a normal diet and time of first bowel movement were decreased by >1 day in all randomized series, and morbidity was halved. Pain, fatigue, quality of life, and patient satisfaction all improved when ERP were compared with traditional care in randomized, controlled trials. Patients >70 years of age, and patients with relevant baseline morbidity also benefited from ERP, again demonstrating a marked reduction in morbidity and duration of stay. The positive impact of ERP on patients' recovery seen for segmental colectomies was confirmed for minor procedures, such as ileostomy closure, as well as for more complex procedures, namely, reoperative pelvic surgery, rectal operations, and proctocolectomy with ileal reconstruction.

**Readmission risk.** Concerns about early readmissions, delays in diagnosis of complications, and increased nursing workload are frequently voiced when considering the implementation of ERP. However, consistent data show that discharging patients from the third day after open or laparoscopic segmental colectomy was associated with approximately a 10% readmission rate, similar to the 10–15% readmission observed after colorectal resections with traditional care. In fact, ERP patients discharged earlier had fewer readmissions than those with a longer primary stay.

Factors independently associated with a readmission included low preoperative functional capacity and nonadherence to the ERP. Most important, complications requiring readmission had similar outcomes and duration compared with those identified during the initial hospital stay.

**Nursing and paramedical support.** Another concern faced when initiating an ERP is increased nursing utilization, for example, to promote ambulation and incentive spirometer use. Available data suggest the opposite, with early restoration of organ function and recovery actually decreasing nursing care. A prospective, controlled study of 160 patients who underwent open colorectal procedures showed that ERP patients regained
functional capabilities earlier, with less fatigue and need for sleep than patients receiving traditional care. Early discharge was not associated with an increased burden to relatives, family doctors, or referrals to a skilled nursing facility.63

META-ANALYSIS OF RANDOMIZED, CONTROLLED TRIALS

Systematic review. A systematic literature search was performed in Medline, Embase, and the Cochrane Library (January 1966–June 2010) using the following keywords: enhanced, recovery, accelerated, rehabilitation, fast-track, multimodal perioperative care, combined with colo*, sigm*, colectom*, and rect*. Two investigators independently performed the literature search. The search was restricted to publications in English, German, French, Spanish, or Danish, as well as to adult populations. Randomized trials comparing an ERP with traditional care were included regardless of indication for surgery. Included trials had a minimum follow-up of 30 days and documented compliance to ≥4 out of 5 key ERP components as described by Kehlet and Wilmore14 (Table I). The methodologic quality of retrieved articles was assessed according to validated criteria.64,65 Any disagreement was resolved by consensus. Outcome measures were duration of stay, morbidity, and readmission rates. In addition, systematic reviews and meta-analysis of ERP based on data published in major surgical and anesthesiology journals were reviewed. Electronic links and reference lists of selected papers were hand searched for further relevant publications. Last, international contributors expert in the implementation of ERP were consulted to ensure no pertinent work was omitted. Data were extracted independently by 2 investigators.

Statistical analysis. A Bayesian random-effects meta-analysis was performed. In the presence of heterogeneity among clinical trials, a Bayesian random-effects model provides a fuller representation of this variability than a classical random-effects model. Moreover, a Bayesian framework allows the calculation of the direct probability of a treatment effect and allows for future cost-effectiveness analysis.66,67 A 95% credible interval (CrI) for a treatment effect means that there is a 95% probability that the true effect lies in the interval. Continuous outcomes were analyzed by using a linear random-effects model, whereas binary outcomes were modeled by using a random-effects logistic model. Diffuse priors were used for the underlying treatment effects so that the results were determined by the data. The meta-analysis was performed using WinBUGS version 1.4 (Imperial College of School of Medicine, London, UK), in which Markov chains Monte Carlo with Gibbs sampling are used to make inferences.

<table>
<thead>
<tr>
<th>Length of stay</th>
<th>Readmission rate; total hospital stay</th>
<th>Morbidity</th>
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<tr>
<td></td>
<td>ERP</td>
<td>Traditional</td>
</tr>
<tr>
<td>Andersen et al48</td>
<td>3 Md</td>
<td>7 Md*</td>
</tr>
<tr>
<td>UK, 2003</td>
<td>3.96 mn</td>
<td>6.99 mn*</td>
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<tr>
<td>11 TC/14 ERP</td>
<td></td>
<td></td>
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<tr>
<td>Delaney et al43†</td>
<td>5.2 mn</td>
<td>5.8 mn</td>
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<tr>
<td>USA, 2003</td>
<td>5.4 mn</td>
<td>7.1 mn**</td>
</tr>
<tr>
<td>33 TC/31 ERP</td>
<td></td>
<td></td>
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<tr>
<td>Gatt et al49†</td>
<td>5 Md</td>
<td>7.5 Md***</td>
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<tr>
<td>UK, 2005</td>
<td>6.6 mn</td>
<td>9 mn</td>
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<tr>
<td>20 TC/19 ERP</td>
<td></td>
<td></td>
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<tr>
<td>Khoo et al51†</td>
<td>5 Md</td>
<td>7 Md****</td>
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<tr>
<td>UK, 2007</td>
<td>5 mn</td>
<td>7 mn</td>
</tr>
<tr>
<td>35 TC/35 ERP</td>
<td></td>
<td></td>
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<tr>
<td>Serclova et al51</td>
<td>7 Md</td>
<td>9 Md****</td>
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<tr>
<td>CZ, 2009</td>
<td>7.4 mn</td>
<td>10.4 mn****</td>
</tr>
<tr>
<td>52 TC/51 ERP</td>
<td></td>
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<tr>
<td>Muller et al57</td>
<td>5 Md</td>
<td>9 Md******</td>
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<tr>
<td>CH, 2009</td>
<td>6.7 mn</td>
<td>10.3******</td>
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<tr>
<td>75 TC/76 ERP</td>
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†Includes low rectum.

Differences are not statistically significant, unless indicated: *P = .002; **P = .02; ***P = .027; ****P = .001; *****P = .003; ******P = .0001.

CH, Switzerland; CZ, Czech Republic; ERP, enhanced recovery pathway; Md, median; mn, mean; N/A, not available; TC, traditional care; UK, United Kingdom; USA, United States of America.
 Eligible studies. We retrieved 389 abstracts, of which 375 did not meet the inclusion criteria. Of 14 remaining studies, 6 of them were excluded for absence of true randomization and 5 studies were discussed separately because they were comparing a laparoscopic versus an open approach within an ERP. Six randomized, controlled trials were included in the meta-analysis for a total of 452 patients, 226 in each arm. The overall quality of those 6 trials was good. All studies took advantage of the 5 key elements of successful ERP (Table I), although the focus on 1 or the other subcomponents varied according to institutional preferences.

RESULTS

Patients undergoing major colorectal surgery and adhering to an ERP had duration of stay shortened by 2.5 days (95% CrI, −3.92 to −1.11). The probability that ERP led to any reduction in duration of stay was 99.4%. The probability was 96.7% that the reduction in duration of stay was >1 day, and 78.5% that it was >2 days.

The 30-day morbidity was halved (relative risk, 0.52; 95% CrI, 0.36–0.73) in patients managed in ERP when compared with traditional care. The probability that ERP led to any reduction in morbidity was 99.8%, whereas there was a 96.4% probability of a decrease in morbidity >30%. In fact, for every 4.5 patients (95% CrI, 2.9–9.3) following an ERP, 1 complication was avoided. Four deaths were reported during the 30-day follow-up. One patient died from pulmonary embolism, and 2 and 1 patients died from myocardial infarction in the ERP and in the traditional care groups, respectively.

The readmission rate for patients managed by an ERP was not increased (relative risk; 0.59; 95% CrI, 0.14–1.43) when compared with patients managed traditionally. In fact, the probability that adherence to an ERP decreased readmission was 90.9%, and the probability that ERP led to a reduction in readmission >20% was 81.6%.

Is there a role for laparoscopy in the era of ERP? Meta-analyses and systematic reviews of randomized controlled trials have established consistent benefits of a laparoscopic approach compared with laparotomy for colorectal procedures in the era preceding the implementation of ERP. Bowel function and resumption of a normal diet occurred earlier, and duration of stay was reduced by 2 days, to about 5 days. Laparoscopy halved surgical blood loss and reduced major morbidity by two thirds to about 10%. Decreased postoperative pain, endogenous morphine levels, and consumption of opioids were demonstrated, together with improved quality of life and recovery. The benefits of laparoscopy were maintained in patients ≥70 years of age. A nationwide series of 32,733 elective colectomies showed that laparoscopic patients were 30% more likely to be discharged home without nursing care when compared with open colectomies. Furthermore, rates of small bowel obstruction and of incisional hernias may decrease.

Although the benefits of both ERP and laparoscopy are generally accepted in colorectal surgery, the vast majority of reports and clinical trials have not combined ERP and laparoscopy. In fact, there are only 2 small, randomized, controlled trials and 3 controlled clinical trials that evaluated laparoscopic and open colorectal surgery within an ERP (Table III).

The randomized controlled trials included 60 patients each (Table III); the first trial showed equivalent morbidity, functional recovery and a median duration of stay of 2 days for both groups. However, >20% of the patients were readmitted; since then, the investigators have halved their readmission rate by enforcing a 3-day hospital stay. The second trial concluded in favor of laparoscopic surgery with a 2-day reduction in duration of stay, to 5.2 days, and readmission decreased to <5%.

The 3 controlled clinical trials included 57, 80, and 147 patients (Table III). The smaller trials showed equivalent duration of stay and readmission for both groups, whereas the larger trial demonstrated a significant reduction in morbidity and duration of stay in favor of laparoscopy.

Do ERP translate into improved cost effectiveness and resource utilization? Duration of stay morbidity, and readmission are important determinants of hospital costs, which all improve by adherence to an ERP, potentially leading to cost containment. Indeed, an analysis from the University of Michigan National Surgical Quality Improvement Program looking at 1,008 patients who underwent a general or vascular surgery documented increased total hospital costs of $11,626 for a major complication, after adjusting for patients’ characteristics and complexity of surgery. Both minor and major complications were associated with increases in duration of stay of 4.1 and 5.3 days, respectively, in the adjusted analysis.

A study from the Massachusetts General hospital compared 52 and 86 patients operated on before and after introduction of an ERP for colorectal surgery. The average cost per patient including readmission costs decreased significantly.
from $9,310 to $7,070 after implementation of an ERP, whereas a reduction in duration of stay from 6.9 to 4.2 days after adjusting for age, gender, diagnosis, procedure, and readmission was achieved.

A further study assessed cost-effectiveness for ileoanal anastomosis, which is among the most complex colorectal procedures. Ninety-seven ERP patients were matched for age, gender, diagnosis, and presence of a diverting ileostomy with 97 patients receiving traditional care. Hospital direct costs and global resource utilization within 30 days of surgery were significantly reduced by $980 per patient in favor of ERP. Readmission and complication rates were similar, while median duration of stay was reduced from 5 to 4 days.

Economic evaluations of laparoscopic colorectal surgery abound, although their results and quality are inconsistent. The treatment costs for 210 patients enrolled in the COLOR trial were assessed for 12 weeks, including readmission, complication, reoperation, and time off work. The total cost to society did not differ significantly between open and laparoscopic procedures. However, health care costs were higher by $3,123 for laparoscopic surgery, as were the reoperation (8% vs 4%) and complication rates (21% vs 16.1%) compared with open surgery. This economic evaluation might be confounded by the learning curve for the surgeons; a laparoscopic experience of 20 colectomies was deemed sufficient to participate, possibly translating into higher-than-usual morbidity. Several other major, randomized, controlled trials demonstrated equal or lower costs for laparoscopy. The CLASSICC trial showed a reduction in median duration of stay from 14 to 12 days with laparoscopy, with similar complication and reoperation rates. Both hospital and 3-month costs were similar. Two Dutch, randomized, controlled trials compared laparoscopic and open surgery for restorative proctocolectomy and ileocolic resections for Crohn’s disease. There were no significant differences in terms of overall costs, morbidity, and duration of stay of restorative proctocolectomy, whereas for ileocolic resection costs, duration of stay, and complications were significantly lower for laparoscopy.

Finally, 2 case-matched studies compared 150 and 200 laparoscopic and open colectomies. The first study found no differences in morbidity or readmission, but a significant reduction in median duration of stay from 6 to 3 days for laparoscopic colectomies. Although operating room costs were significantly higher for laparoscopic procedures ($1,785 vs $1,022), total hospital direct costs were significantly lower ($3,209 vs $3,655), including pharmacy, laboratory, nursing, physiotherapy, and radiology costs. These findings underline

| Table III. ERP series assessing a laparoscopic approach versus an open approach |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| **Length of stay**              | **Readmission rate (%)**        | **Total hospital stay**         | **Morbidity (%)**               |
| **Lap**                         | **Open**                        | **Lap**                         | **Open**                        | **Lap**                         | **Open**                        | **Lap**                         | **Open**                        |
| Randomized controlled trials    |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Basse et al<sup>45</sup> DK, 2005 | 2 Md                            | 2 Md                            | 20%                             | 26.6%                           | 26.6%                           | 20%                             |
| King et al<sup>72</sup> UK, 2006 | 3.5 Md                          | 6 Md                            | 26.3%                           | 4.9%***                         | 26.3%                           | 14.6%                           |
| MacKay et al<sup>70</sup> UK, 2007 | 6.1 Md                          | 6.2 Md                          | 0%                              | 3.4%                            | 27.3%                           | 22.4%                           |
| Polle et al<sup>71</sup> NL, 2007 | 4 Md                            | 4.5 Md                          | 10.3%                           | 11.5%                           | 31%                             | 23.1%                           |
| Cohort series                   |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
| Junghans et al<sup>69</sup> D, 2006 | 4 Md                            | 6 Md****                        | N/A                             | N/A                             | 13%                             | 28%****                         |
| MacKay et al<sup>70</sup> UK, 2007 | 6.1 Md                          | 6.2 Md                          | 0%                              | 3.4%                            | 27.3%                           | 22.4%                           |
| Polle et al<sup>71</sup> NL, 2007 | 4 Md                            | 4.5 Md                          | 10.3%                           | 11.5%                           | 31%                             | 23.1%                           |

*Includes low rectum.

All differences are not statistically significant, unless indicated: *P = .018; **P = .027; ***P = .036; ****P = .01; *****P = .05.

D, Germany; DK, Denmark; ERP, enhanced recovery pathway; gmn, geometric mean; Lap, laparoscopic colectomy; Md, median; mn, mean; N/A, not available; NL, The Netherlands; Open, open colectomy; TC, traditional care; UK, United Kingdom.
that the potential reduction in hospital costs observed with laparoscopy requires a reduction in overall resource consumption as well as a shortened duration of stay. The second study\(^1\) also confirmed significantly lower total hospital costs ($3,971 vs $5,997) for laparoscopy; the duration of stay was reduced from 6.3 to 2.1 days. Considering hospital reimbursement in the DRG-based system used by many providers in the United States, twice as many open colectomy patients migrated from DRG 149 (colectomy without complications) to DRG 148 (colectomy with complication). Those additional complications meant a loss of revenue of $239,620 for the hospital and increased payer’s expenses, while consuming 420 extra patient bed days.

A single, randomized trial evaluated the cost effectiveness of laparoscopic and open procedures for colorectal cancer within an ERP.\(^7\) A significant reduction in duration of stay was noted in favor of laparoscopy (5.2 vs 7.4 days). Higher operating room costs ($4016 vs $2871) were offset by the combined reduction of duration of stay, postoperative costs including readmission (4.9% vs 26.3%), and follow-up costs estimated for 3 months after surgery. At the level of the payer, opting for laparoscopic surgery within an ERP saved $517 per patient ($9405 vs $9922).

**DISCUSSION**

The routine use of ERP seems a logical step to optimize the quality and effectiveness of health care. Randomized, controlled trials and prospective studies have demonstrated that ERP markedly improve health outcomes and patient satisfaction. This meta-analysis of 6 randomized controlled trials demonstrates that adhering to an ERP reduces 30-day morbidity by 52% and duration of stay by 2.5 days with no increase in readmission rate.

In addition to being an important contribution to a pain and complication-free operative procedures, ERP contribute to cost containment. This is achieved by providing optimal care with the most efficient practice. The rise of pay per performance\(^1\) compensation schemes and the withholding of payments for many complications by Medicare\(^2\) may provide strong incentives toward optimized pathways of care, both in terms of process efficiency and quality of care. The increasing application of evidence-based surgery\(^3\) has the potential to improve patients’ outcomes and quality of life, while saving a significant share of our limited health care resources. Organizational improvements driven by the implementation of ERP can provide additional benefits, such as performing elective colectomies on Monday and Tuesday with planned discharge on Thursday or Friday, may allow closing the nursing floor for the weekend, or may free beds for other diagnoses and emergency admissions. Indeed, a pilot study of 10 patients using an ERP recently demonstrated the feasibility of discharging patients within 24 hours of laparoscopic colectomy, with no readmission, no morbidity, and high patient satisfaction.\(^4\)

Although increasing data\(^5\,6\) support the incremental benefits of laparoscopic procedures within an ERP, larger randomized, controlled studies are required to define the potential synergies of a laparoscopic approach to an ERP.\(^6\) An answer may soon be provided by a large, randomized, controlled trial comparing open and laparoscopic colorectal procedures with or without ERP.\(^7\) This Dutch trial is powered to detect a 1-day difference in duration of stay, and a 10% change in the Short-Form 36 quality-of-life index.

Randomized, controlled trials have shown that costs to society and institutions are similar for laparoscopic and open colorectal operations. Greater laparoscopic procedure costs driven by a combination of longer operative times and increased equipment costs were offset by a reduction in durations of stay and in-hospital resource utilization in a process similar to the cost-containment effect of ERP. Interestingly, a decrease in postoperative complications may shift hospital reimbursement to a lower DRG compensation. However, the hospital balance remained positive because care was provided at a lower cost, and bed days were freed up by the reduction in durations of stay and postdischarge care to provide opportunity for other cases. Although most economic evaluations were limited by a 30-day horizon, the improved resource utilization ascribed to ERP are linked to early cost determinants (duration of stay, morbidity, readmission). Likewise, health economy evaluations adopting a 3-month time horizon and a societal or payer’s point of view confirmed cost benefit in favor of ERP and laparoscopy.

Unfortunately, while although evidence-based surgery and economic evaluations support the use of ERP and laparoscopy, the uptake of these innovations has been slow, denying significant benefits to patients and struggling health care systems alike.\(^8\) Practice surveys in Europe reported excessive sedation, suboptimal stress reduction, and fluid overload. European and American data revealed a wide use of potentially unnecessary bowel preparation, fasting, and nasogastric tube and drain, thus translating into prolonged POI and mean duration of stay of 7–10 days.\(^9\)
The fate of laparoscopy is no better; <5% of 21,721 German patients with colon cancer underwent laparoscopic colectomy, and only one third of elective colectomies were attempted laparoscopically in the US. Arguably, the complexity of some ERP including up to 17 components can limit their implementation. Adherence to a median of 13 of 17 elements was noted in specialized units, whereas just half of the ERP components were observed in general units. Moreover, a study across 5 European countries reported that, despite meeting preset discharge criteria, local perceptions and institutional factors initially delayed the actual discharge by 2 days. Nonetheless, compliance with ERP improves over time, confirming a learning curve for the individual institutions and achieving the anticipated reduction in morbidity and duration of stay during the first year of implementation. Not surprisingly, adherence to ERP principles seemed most difficult in the immediate postoperative phase, at a time where participation of nursing and junior medical staff is greatest, and organizational changes are maximal. Indeed, nursing and physician leadership are required and challenged when initiating an ERP. Identification of culture barriers, common goal setting, careful planning and implementation, and continuous evaluation and education are crucial elements of change management. Ultimately, well-communicated pathways endorsed by an entire team translate to safer and more efficient delivery of care.

Rarely, patient factors may prevent the application of an ERP, because active participation and compliance are crucial to a successful ERP. The obtunded, critically ill, or otherwise unable to communicate cannot be expected to cope with an ERP. However, in our experience, this is more the exception than the rule, particularly for elective cases. In fact, as institutional experience grows, many elements of ERP can be successfully introduced for urgent procedures.

In conclusion, ERP are rooted in an evidence-based approach of the entire process of operative care. They represent a much-needed contribution to optimizing resource utilization by their demonstrated ability to improve health outcomes while reducing costs. Colorectal operative procedures should routinely be performed within an ERP, and, where available, laparoscopy offers the possibility of further improvement in outcomes. Significant health care benefits may be expected from a wider application of the principles of ERP to other surgical specialties.

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