# 7
# Optimizing Outcomes with Enhanced Recovery

Conor P. Delaney and Raul Martin Bosio

Key Concepts

- Enhanced recovery pathways (ERPs) include measures for preoperative management, intraoperative care, postoperative recovery, and pathway quality evaluation.
- ERP improves the quality of patient care by establishing standardized care paths based on evidence-based literature and current practice guidelines.
- A modified frailty index (MFI) allows for preoperative risk stratification and identifies patients that will require extra healthcare resources.
- A combination of oral antibiotics administered during the preoperative phase combined with intravenous antibiotics administered within 1 h of surgery appears to be the most efficacious strategy to decrease SSI.
- Measurement of ERP compliance is necessary to make sure the individual stated pathway items are being accomplished.

## Introduction

Among the goals of a successful surgical practice, delivering high-quality patient-centered care while maintaining a low procedure-specific morbidity and readmission rate is of paramount importance. Facilitating a patient's recovery and assisting them to return to their usual activities safely, but also as soon as possible, should be viewed as part of these goals [1]. Accomplishing these goals benefits not only patients, but by decreasing length of hospital stay (LOS) and costs associated with diagnosis and treatments of complications, they also help to improve the efficiency with which healthcare is provided [2–5].

In the era of bundled payment, "pay for performance," and ongoing cuts in healthcare reimbursement, decreasing hospital operating expenses may contribute to increasing or at least maintaining hospitals' financial viability [6]. Cost-analysis data demonstrating that a specific healthcare system is able to deliver comparable patient care at a lower cost may also influence insurance preference to established contracts with a specific healthcare system over another.

Minimally invasive techniques have had a major impact on postoperative recovery, contributing to a reduction in LOS and cost [6]. In many subspecialties, these techniques have now substituted open operations and become the standard of care. However, optimizing patient recovery goes far beyond a particular technical approach. It requires a multidisciplinary approach that includes not only surgeons, anesthesiologists, and nurses, among others but also the patient himself. Enhanced recovery protocols (ERPs) start at the surgeon's office by engaging the patients in this process, managing expectations, and converting them from a passive recipient of care into an active member of this recovery team. Standardization of perioperative care measures combined with minimally invasive colorectal surgery has decreased, in our hands, LOS to an average of 2.6 days, without a significant impact on readmission rate [7–12].

## What Is an ERP?

Traditionally, pre-, intra-, and postoperative management had varied depending on individuals' practice preferences of the various members of the healthcare team involved. This approach creates significant variability throughout the healthcare process, since surgeons, anesthesiologists, hospitalists, and ancillary support to name some managed patients based on past experiences, usually gained during residency or school training. This variability increases complications and healthcare cost as patients are not necessarily managed according to current recommendations [2, 4, 5, 10–33].

In an effort to reduce postoperative complication rates and decrease or contain healthcare costs, the concept of creating specific evidence-based protocols or pathways where the various components of pre-, intra-, and postoperative care are outlined and could, therefore, be followed by all the



S.R. Steele et al. (eds.), *The ASCRS Textbook of Colon and Rectal Surgery*, DOI 10.1007/978-3-319-25970-3_7

members that participate in any given healthcare episode was developed [2, 3, 10, 16, 17, 23].

Initially called fast-track pathways, these care paths are now most commonly called enhanced recovery pathways (ERPs), which refer to the multimodality patients' care approach where patients' orders are clearly established based on evidence-based literature and current practice guidelines. These orders are then routinely followed, minimizing variability among providers with the goals of decreasing morbidity and mortality rates and increasing quality of care as a result. The decrease in healthcare resource utilization achieved as a result of decreased complications, and LOS contribute to decrease costs [10, 15, 21, 23, 25]. As patients progress through a healthcare intervention, specialty-specific order sets clearly outline patients' management at any given point in time, from the preoperative encounter until care is completed, generally at the time of hospital discharge.

The direct consequences of the application of specialty-specific pathways are well documented and include a reduction in morbidity, mortality, and length of hospital stay (LOS). This reduction in LOS is seen both after open and laparoscopic operations when compared to patients that are managed outside a pathway. An even greater reduction in LOS is seen when open versus laparoscopic colorectal procedures coupled to a perioperative pathway are compared. This difference persists even when readmission rates are included into the overall LOS for any given patient [7, 10, 12, 16–18, 21, 22, 27, 30–32, 34–42].

## Components of an ERP

From a practical standpoint, ERP can be divided in four parts: (a) preoperative management, (b) intraoperative care, (c) postoperative recovery, and (d) quality pathway evaluation measures.

Each part includes a series of measures or steps as follows:

(a) *Preoperative management*: (1) preoperative evaluation (i.e., frailty score and pre-habilitation); (2) fasting prior to surgery, mechanical bowel preparation, and preoperative antibiotics usage; (3) patient education; and (4) analgesia (*for practical purposes*, *as it overlaps with pre-*, *intra-, and postoperative management*, *analgesia is addressed as a whole in the intraoperative section*).

(b) *Intraoperative care*: (1) minimally invasive colorectal surgery when possible, (2) standardized intraoperative fluid resuscitation, (3) analgesia, and (4) venous thromboembolism prophylaxis (VTE).

(c) *Postoperative recovery*: (1) analgesia; (2) intravenous fluid management; (3) early oral feeding and ambulation; (4) prevention of postoperative nausea and vomiting (PONV) and postoperative ileus (POI), role of nasogastric tube and motility agents; (5) venous thromboembolism prophylaxis (VTE); and (6) discharge planning, follow-up, and coordination of care.

(d) *Quality pathway evaluation measures*: (1) electronic order sets creation and updates to comply with best practice parameter guidelines and evidence-based literature, (2) implementation and monitoring of pathway application, and (3) quality improvement measures.

## Enhanced Recovery Pathways (ERPs) After Surgery: Challenging "Traditional" Patients' Care Management

Traditionally, postoperative care varies depending on surgeon's preferences and his understanding of patients' clinical condition. In general, perioperative management practices learned during training tend to be maintained once in practice despite evidence that would suggest that new available pathways may help decrease postoperative complications, length of stay, and the associated healthcare cost. Furthermore, compliance with ERP application has been associated with improved outcomes, decreased LOS, and cost reduction [19, 43].

Multiple factors may impact the application of new models of care. Limited time to interact with patients both in the preoperative setting and during the inpatient stay leads to a feeling of lack of control when attempting to implement changes. As surgeons adjust to the demands of current practice styles, and the implementation of electronic medical records, providing coverage to multiple hospitals and to increase productivity, modifying patient care patterns learned through personal experience during training in favor of new care pathways described on medical literature, but without any clinical experience is difficult [44–46].

However, as teaching hospitals expose trainees to these new models of care, a new generation of surgeons is entering the working force with the knowledge and experience to implement and lead these changes.

Electronic medical records, with the capability of creating order sets, also play an important role in eliminating variability in patients' management as they provide a blue print that is easily reproduced from patient to patient.

Successful implementation of these new models of care depends not only on the surgeon; on the contrary, they required significant institutional support as multiple teams across the healthcare spectrum are necessary in order to improve patients' care and reduce costs [47, 48]. As pathways are developed and implemented, full potential can be achieved with active participation from anesthesiologists, nursing staff, physical therapists, and ostomy teams. This increase in resource utilization may contribute to a perception of increased cost and healthcare expenditure and lead to a lack of support from hospitals' administration. Although there is an initial increase in cost, the increased healthcare expenditure is offset through a reduction in patients' morbidity and length of hospital stay [49–51].

TABLE 7-1. Quality measures between patients managed within and outside an established enhanced recovery pathway (ERP)

| Author | Within ERP | Outside ERP | Morbidity (ERP vs. non-ERP) | LOS (days) (ERP vs. non-ERP) | Readmission rates (ERPs vs. non-ERP) |
|---|---|---|---|---|---|
| Bradshaw et al. [155] | 36 | 36 | 8% vs. 11% | 4.9 vs. 6 | 3% vs. 3% |
| Basse et al. [157] | 130 | 130 | 25% vs. 55% | 3.3 vs. 10 | 21% vs. 12% |
| Anderson et al. [158] | 14 | 11 | 28% vs. 45% | 3.9 vs. 6.9[a] | 0% vs. 0% |
| Raue et al. [156] | 23 | 29 | 17% vs. 24% | 4 vs. 7 | 4 % vs. 7 % |
| Delaney et al. [15] | 33 | 31 | 22% vs. 30% | 5.2 vs. 5.8[a] | 9.7% vs. 18.2% |
| Gatt et al. [159] | 19 | 20 | 47% vs. 75% | 6.6 vs. 9[a] | 5.3% vs. 20% |
| Khoo et al. [59] | 35 | 35 | 25% vs. 51% | 5 vs. 7[a] | 9% vs. 3% |
| Serclova et al. [160] | 52 | 51 | 21% vs. 48% | 7.4 vs. 10.4[a] | 0% vs. 0% |
| Muller et al. 2009 [161] | 75 | 76 | 21% vs. 49% | 6.7 vs. 10.3[a] | 3.9% vs. 2.6% |
| LAFA 2011 laparoscopic [153] | 100 | 109 | 34% vs. 37% | 5 vs. 6 | 6% vs. 6.4% |
| LAFA 2011 open [154] | 93 | 98 | 43% vs. 41% | 6 vs. 7 | 7.4 % vs. 7.1 % |

[a]Mean length of stay (LOS)
Data obtained and combined into current table from Wind et al. [153], Vlug et al. [154], and Adamina et al. [1]

The concept of "team" is key to the success of these changes in patients care practices, as surgeons alone without the appropriate supportive environment may encounter difficulties in improving patient experience. Monitoring adherence to a given pathway allows for quality control measures to be periodically evaluated, ensuring participation of the various teams involved and allows for modifications to the pathway to be implemented as necessary [52–54].

At the end, incorporating an enhanced recovery pathway (ERP) into a practice or hospital system should lead to improve patient care, decreased morbidity and mortality, reduced length of hospital stay (LOS) and healthcare cost, while maintaining or even decreasing readmission rates (Table 7-1) [1].

## Where Does the Pathway Start?

The answer to this question needs to be considered both from the surgeon and from an institutional viewpoint.

From a surgeons' perspective, in its simplest form, an ERP starts with a surgeon implementing a specialty-specific order set. As the use of ERP is applicable to most specialties across the board and affects hospitals' expenditure and therefore profit margins, more advanced setups require the participation of multiple teams (surgery, anesthesia, nursing, etc.) [55].

As specialty-specific ERPs are created, institutional support facilitates their introduction and use. Creation of specialty-/department-specific committees allows for input from these teams to be incorporated into the ERP. There is no point in modifying preoperative fasting time to 2 h for liquids, to cite an example, if the individual anesthesiologist will not accept and be willing to anesthetize a patient due to his own practice preferences, despite the fact that guidelines indicate that such practice is safe [56–58]. Multiple examples like this one can be described, and consensus is necessary among healthcare providers and ancillary teams as the institution moves forward in the development of these pathways. Teams usually involved include, but are not limited to, surgeons, nursing staff, physical therapist, information technology personnel, residents, respiratory therapist, and ostomy team members. The configuration of these committees may vary, as pathways have been successfully implemented across multiple specialties and specialty-specific needs are targeted [59].

## Preoperative Management

### Preoperative Evaluation: Frailty Score and Pre-habilitation

Several patient factors can negatively affect the outcome after elective colorectal surgery. Among them, nutritional status has been directly associated with outcomes and should be viewed as part of the preoperative assessment of patients within an ERP program [60]. Several tools can be used to evaluate nutritional status. The subjective global assessment (SGA) tool allows patients to be stratified in well, moderate, and severe malnutrition (SGA-A, SGA-B, and SGA-C, respectively). Postoperative complications after colorectal surgery, as well as LOS, have both increased as patients' nutritional status worsens. Morbidity increases from 11% for SGA-A to 31% and 41% for SGA-B and SGA-C. Length of stay increases as well, with hospital days increasing from 4 to 5 and 7, respectively, for SGA-A, SGA-B, and SGA-C [61]. Prolonged preoperative nutrition, either enteral (whenever use of the gastrointestinal tract is possible) or parenteral, may improve nutrition within 2–3 weeks and decrease complications. Therefore, preoperative nutritional assessment and optimization should be part of an ERP, as both morbidity and LOS improve when appropriate steps are implemented [62, 63].

Frailty, defined as a decrease in physiologic reserve and multisystem impairment independently of the normal aging process, where patients show a combination of decreased muscle mass and functionality, signs of chronic inflammation, and altered metabolism, is also a marker of increased postoperative morbidity and mortality as well as prolonged LOS [64, 65].

A modified frailty index (MFI) allows for preoperative risk stratification and may allow to identify patients that will require extra healthcare resources early on and to plan in accordance. Eleven variables are considered, and some of them can be optimized preoperatively, such as chronic obstructive pulmonary disease or congestive heart failure [66]. Published data has demonstrated a correlation with LOS, and utilization of MFI may allow surgeons to identify patients early on that may require additional healthcare resource utilization. Data suggest that approximately 61% of patients with a MFI of 1 or less had a LOS between 1 and 3 days, while more than 50% of patients with a MFI of 3 or more are hospitalized between 4 and 8 days [61].

Preoperative optimization is recommended when possible, and certain measures such as stopping alcohol or smoking 4 weeks prior to surgery are associated with improved outcomes [60, 61, 64]. Pre-habilitation, a term that refers to a structured process, aims to improve patients' capacity to respond to surgical stress, and decreased postoperative complications are currently an area of research within ERP protocols. Although creation of a structured program that combines preoperative exercise training, nutritional support, and optimization of chronic disease processes appears as a logical progression of preoperative management, there is not sufficient data at this time to support the allocation of resources to the creation of such programs. They represent, however, an avenue for active research with potential to positively impact patients' outcomes and could be considered at the time of creation of an ERP.

## Fasting Prior to Surgery, Mechanical Bowel Preparation, and Preoperative Antibiotics Usage

Classic preoperative management teaching had focus on limitation of oral intake prior to surgery, the role of mechanical bowel preparation, and antibiotics usage [60].

Traditionally, patients are asked to fast from midnight onwards prior to surgery. Published literature has evaluated the role of carbohydrate loading prior to elective surgery. Solid intake is then limited to 6 h prior to surgery and carbohydrate-rich fluids to 2 h. It appears to be of some benefit in terms of decreasing postoperative insulin resistance, LOS, and patient satisfaction (i.e., decreased in thirst); however, the level of evidence is low, and further studies are required to determine how it may affect patient recovery. Some literature suggests that preoperative carbohydrate loading improves PONV and decreases loss of muscle mass. However, further studies are needed, as patient benefits may not be superior when preoperative oral glucose is compared to intravenous glucose infusion during surgery. Independent of potential benefits, reducing fasting times and the usage of preoperative carbohydrate drinks up to 2 h prior to surgery is safe as there is no increased risk of anesthesia complications [67–70].

Mechanical bowel preparation prior to colorectal surgery has also been a topic of debate, with a large body of literature showing that there is no difference in outcomes whether mechanical preparation is used or not [71–74]. A Cochrane review that included 5805 patients demonstrated no difference in wound infection, anastomotic leakage, intra-abdominal infectious complications, or need for reoperation independently of whether a mechanical bowel preparation was used or not [75]. However, colonic manipulation during laparoscopic surgery is easier when a mechanical bowel preparation is used. Jung et al. randomized 1343 patients to mechanical bowel preparation versus no preparation and found similar results. This study, published in 2007, evaluated patients enrolled between 1999 and 2005 [76]. Recently, long-term follow-up data from this study found a change in cancer-specific survival when a mechanical bowel preparation was used. The 10-year cancer-specific survival was 84.1% versus 78% for patient who underwent mechanical bowel preparation versus those who did not [77]. However, Van't Sant et al. reviewed data from 382 patients (median follow-up 7.6 years) and found no difference in survival among groups (bowel preparation vs. none) [78]. Although further studies are now needed in order to evaluate the relationship of mechanical bowel preparation and long-term specific survival, as the authors themselves point out, surgeons should consider reviewing their current practices, as mechanical bowel preparation may not change early postoperative outcomes, but it may impact long-term survival.

It is our practice to use mechanical bowel preparation when a patient will be diverted, for left colon and rectal resections, when an intracorporeal anastomosis is planned, and in those cases that may require an intraoperative colonoscopy. As a result of the data mentioned above, mechanical bowel preparation for right colectomies is being used by part of our team.

The third component of the preoperative management includes the usage of antibiotics prior to surgery. Adequate coverage should include both aerobic and anaerobic flora. Meta-analyses have shown that there is a decrease in surgical wound infection (SSI) when antibiotics usage is compared to placebo. A risk reduction of at least 75% has been found with a decrease in wound infection from 40% to 14–6% [79–82]. As surgeons currently administer antibiotics routinely within 1 h of the surgical starting time as part of compliance with Surgical Care Improvement Project guidelines (SCIP), the decision-making process currently centers in what the ideal regimen is. The ideal regimen should not only control SSI

but also consider cost and adverse effects of a selected regimen. A combination of oral antibiotics administered during the preoperative phase (usually while the patient undergoes mechanical bowel preparation) combined with intravenous antibiotics administered within 1 h of surgery appears to be the most efficacious strategy to decrease SSI (6.5%). Continuation of antibiotics beyond 24 h after elective surgery offers no benefit, and it is not recommended under current guidelines [79, 83]. It is our practice to give antibiotics the day prior to surgery during the bowel preparation, followed by one dose in the operating room. Re-dosing varies depending on the antibiotic used half live and the length of the case.

## Patient Education

From a surgeon-patient interaction perspective, an ERP starts in the first office visit. The concept of early hospital discharge is not new. The first reports are from the 1990s. Although successful implementation was demonstrated back then, they also showed that managing patients' expectations is important, as a significant number of patients felt they were discharged home too early despite meeting discharge criteria, based mainly in their perception of inpatient postoperative recovery times.

Patient education is a key component of an ERP. The concept or view of patients being passive recipients of care should be changed. Patients should be actively engaged in the recovery process and understand that they play a significant role in decreasing complications. A motivated patient, with clear goals to meet in mind, is more likely to comply with perioperative tasks such as ambulating, incentive spirometry usage, and reduction of narcotics intake to name a few [1, 3, 60].

These goals and expectations can be discussed during the preoperative encounter and reinforced by written educational material, preoperative meeting with the ostomy team when necessary, and encouraging the patient to communicate their questions or concerns as needed. Easy patient accessibility to the care team, in many cases through a nurse practitioner or a medical assistant, plays an important role in the development of the patient-physician-healthcare team relationship. From a patient's perspective, being discharged home in postoperative day 2 or 3 after a major abdominal surgery may be perceived as a daunting scenario. Easy accessibility to the healthcare team through healthcare extenders helps develop trust in the system and contributes to improve patient satisfaction. Institutional support plays an important role in this process, as resources need to be available to incorporate, for example, nurse practitioner into the teams. However, having someone available within the team to address patients' questions once discharged, either through phone or email communication, can contribute to decrease readmission rates and should be seen as part of the efforts to improve care and patient satisfaction.

# Intraoperative Pathway

## Minimally Invasive Colorectal Surgery

Current data shows that only 50–70% of colorectal resections in the United States are performed in a minimally invasive fashion. The national average LOS after colorectal surgery reported by Medicare is approximately 9 days; a substantial variability in the quality of care that has been delivered can be seen when LOS of 2–3 days is common after laparoscopic colorectal resections [1, 6, 14, 18, 23, 30, 42, 84]. From an economic point of view, the average cost per inpatient day in the United States varies between $1625 and $2025 (2010 data). This difference in LOS represents gross savings of approximately $9750 per patient per hospital stay.

Minimally invasive colorectal surgery combined with enhanced recovery protocols has shown to decrease LOS to an average as low as 2.6 days, with some patients being safely discharged home within 24 h. At the same time, early hospital discharge has been associated to readmission rates comparable to patients being managed outside an ERP [4, 7–10, 12, 38, 40, 41, 85].

ERP can be successfully applied for patients undergoing open colorectal procedures, with data supporting a decrease in morbidity and LOS compared to non-pathway patients. However, LOS is invariably longer when compared to patients undergoing a minimally invasive procedure. Therefore, procedures performed open, laparoscopic, and in an emergent basis should be managed within the established ERP, with minimally invasive surgery preferred over open when possible [5, 8, 10–12, 17, 24, 26, 31, 38, 40, 41, 43, 86, 87].

## Intraoperative Fluid Administration

Fluid administration during surgery is an area of ongoing debate. As fluid homeostasis is affected by changes in several hormones during the postoperative period, the amount of fluid given during the surgery itself varies significantly based on individual practices. Historically, fluid resuscitation tends to overestimate requirements which translate into early postoperative weight gain secondary to fluid retention and third spacing [55]. Studies using restrictive fluid resuscitation strategies have shown a decrease in cardiopulmonary complications and LOS without an adverse effect in anastomotic leakage or surgical-specific complications. However, the data is not clear regarding the optimal strategy, as different studies had used different regimens, with variations in the type of fluid used (colloid vs. crystalloid) and the option of increasing fluid administration based on intraoperative clinical parameter interpretation by the individual anesthesiologist [88]. These situations make comparison difficult; therefore, there are no clear guidelines as to what the ideal regimen is. By measuring intraoperative "real-time" volume status using transesophageal Doppler to determine stroke

volume and vasopressor medication once normovolemia is achieved, a LOS as low as 2.7 days has been reported, with a subgroup of patients being discharged home within 23 h [55]. This approach, described as a goal-directed therapy, as patients' fluid resuscitation is tailored based on individual needs, has shown similar results to data published by Delaney et al., who has reported a similar LOS without the need of additional intraoperative equipment (i.e., transesophageal Doppler probe) and the need of anesthesiologists with that particular skill set. Both these factors may increase cost without a clear change in outcomes in elective cases or in patients with minimal comorbidities [88–97]. These results are further validated by Senagore et al., who randomized patients undergoing a minimally invasive procedure within an ERP pathway and compared standard versus goal-directed fluid resuscitation. The standard group has a shorter LOS (64.9 h vs. 75.5 h, respectively) [98].

Currently, intraoperative restrictive fluid administration appears to be superior to traditional intraoperative fluid resuscitation protocols, and a standardized anesthesia protocol should be established as part of an ERP. However, further studies are necessary to determine the role of goal-directed therapy, independent of whether intraoperative transesophageal Doppler monitoring or finger-probe monitoring is used, as there may be a subset of patients that could benefit from this technology [55].

## Analgesia

From our standpoint, pain control starts prior to surgery, continues during the procedure and the hospital stay, and adequately maintains based on specific patients' needs after discharge. Pain management is described in this part of the chapter; however, the ERP should address pre-, intra-, and postoperative pain control.

Adequate pain control is of paramount importance after surgery, as patients are more likely to ambulate and resume some routine daily activities sooner when postoperative pain is well managed. The opposite is also true, as patients with inadequate pain control are most likely to remain in bed, to avoid deep breathing and actively engaging in their recovery, as they perceive pain as a limiting factor to what they can do. At the same time, it is considered a patient's right and patients' satisfaction can be negatively affected when pain management is not adequate. It is not only indicative of poor patient management in most cases, but it may also affect hospital reimbursement as patients' satisfaction becomes tied to it [55, 60].

There is no ideal pain regimen, as analgesia requirements vary from patient to patient and type of analgesic used is influenced by patients' history of chronic narcotics usage, liver and kidney function's profiles, and age to name some. Ideally, the selected analgesia regimen will control patients' pain while minimizing the development of adverse effects, such as PONV, POI hypotension, or kidney injury, among others.

Blocking nociceptor activation prior to a painful stimulus, a term described as "preemptive" analgesia, has been extensively discussed in the medical literature. However, high-quality data to support its usage is scarce. Preemptive analgesia includes multiple interventions, from oral analgesic administration starting the day prior to surgery to placement of epidural catheters or spinal analgesia prior to the beginning of the procedure or local infiltration of the surgical sites in the case of laparoscopy. Data supporting these different strategies varies; however, simple measures such as preoperative intake of oral medication should be considered as part of an ERP. Nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen or diclofenac are usually incorporated into the ERP and administered starting 24 h prior or the day of surgery [99–101]. Gabapentin, a central acting agent, can also be started in the preoperative stage, and it is part of the ERP protocol used by the authors. Data regarding the use of short- and long-acting anxiolytic medication has been reported; however, these drugs are currently not recommended by the ERAS society [60, 102–106].

Intraoperatively, local infiltration of the surgical port sites has not shown to decrease postoperative pain requirements. Liposomal bupivacaine may be used; however, there is yet no evidence to support its use. On the contrary, peripheral nerve blocks such as a transverse abdominis muscle pain (TAP) block have shown to decrease postoperative opioid usage. It is a technically simple, low-cost procedure that can easily be performed under laparoscopic or ultrasound guidance [107–109].

Postoperative analgesia has also been subject to extensive debate. The use of epidural analgesia versus a combination of intravenous opioids delivered using patient controlled analgesia (PCA) equipment and scheduled intravenous NSAIDs such as ketorolac and/or paracetamol appears to be similar in controlling pain in most cases. Although the use of epidural catheters may improve pain scores initially, overall pain control, LOS, and patient satisfaction appear to favor the latter [33, 110–115].

The combination of an opioid PCA and intravenous ketorolac or acetaminophen in the initial postoperative phase (postoperative day zero or 1) followed by a combination of these medications by mouth as soon as patients start oral intake is favored by the author and is part of the standard ERP protocol and the electronic order sets.

A combination of epidural analgesia administered and intravenous opioids and NSAIDs is an alternative that should be considered in chronic opioids users. Epidurals analgesia may be limited to the administration of a local anesthetic or to a combination of a local anesthetic and opioids. Although there is extensive data regarding the use of thoracic epidural analgesia documenting its safety, it is an invasive procedure with associated complications such as pruritus, urinary retention, and postoperative hypotension. Postoperative hypotension secondary to an inhibition of the sympathetic tone is of particular importance when using an epidural catheter. In these cases, patients may benefit from

a decrease in the amount of medication being delivered rather than from the administration of intravenous fluids boluses [115, 116].

A one-time intrathecal administration of an opioid and local anesthetic (0.5% bupivacaine) followed by a combination of a narcotics PCA and NSAIDs appears to be superior than both of the abovementioned options; however, it is an invasive procedure, and further data is required to determine its real impact on LOS [116]. It is not currently part of our standard ERP.

### Venous Thromboembolism Prophylaxis (VTE)

Venous thromboembolism prophylaxis is currently part of the SCIP guidelines and commonly built in as part of the mandatory electronic admission order sets. SCIP guidelines require starting of prophylaxis within 24 h of surgery. This allows for variability in the usage of the medication, as surgeons may opt to administer it prior to the surgical procedure itself or within the 24 h period. Data supporting the use of either unfractionated heparin versus low molecular weight heparin shows very little difference between these prophylactic agents. However, data regarding the length of prophylaxis after surgery is still controversial [60, 117]. A Cochrane meta-analysis that included four randomized trials demonstrated a reduction in VTE from 1.7 to 0.2% when prophylaxis was maintained for 4 weeks [118]. However, a database review of more than 52,000 patients found that the prevalence of postoperative symptomatic VTE after only inpatient prophylaxis was 0.67% [119, 120]. A recently published randomized controlled trial of 1 versus 4 weeks of pharmacological VTE prophylaxis specifically after colorectal laparoscopic surgery showed that VTE occurred in 9.7% versus 0.9%, respectively [121]. Symptoms of VTE were present in only two and one patient respectively. No episodes of pulmonary embolism occurred in either group. Guidelines indicated that prophylaxis should be continued for 4 weeks, especially in oncologic patients [60].

In our practice, patients with limited mobility, being discharged to a skill nursing facility, morbid obese, with advanced malignancies, with coagulation disorders, or with prior history of VTE or PE, are usually discharged on a 4-week course.

## Postoperative Recovery

### Analgesia

Pain control should continue during the inpatient stay as well as after discharge. Pain management strategies have been described earlier in the chapter. From an outpatient pain management standpoint, a gradual decrease in medication usage is expected. Medication (both opioids and NSAIDs) should be prescribed, keeping this in mind and considering the potential for abuse associated with narcotics usage. The amount of narcotics usage in the United States is significantly higher when compared to the rest of the world, and efforts are being implemented at a government level to monitor opioids usage. A fine line is required to maintain adequate pain control and patients' satisfaction while preventing abuse.

It is our practice to start a combination of acetaminophen and NSAIDs the day after surgery unless a specific contraindication exists. These medications are scheduled, while opioids are used for breakthrough pain control. Opioid PCA is usually discontinued in postoperative day 1 after a laparoscopic resection.

### Intravenous Fluid Management

ERP have demonstrated the safety of initiating early oral intake, thus being able to decrease intravenous fluid requirements. At the same time, published data indicated that restricting intravenous fluids to less than <2 l/day versus >3 l/day are associated with increase gastric emptying, faster recovery of gastrointestinal function, and overall decrease morbidity and LOS [55]. It is our practice to limit or stop intravenous fluids within 24–48 h of surgery.

### Early Oral Feeding, Ambulation, and Role of Nasogastric Tube

A large body of literature has shown that early introduction of oral intake within 24 h of surgery is safely tolerated in 70–90% of patients. Even though a Cochrane review and a meta-analysis fail to show a reduction in LOS when early feeding is introduced, numerous single institution reports over the last 10 years or more have reported average LOS of just over 2 days, and restarting oral intake within the first day of surgery has been an integral part of their ERPs [122]. Although early feeding increases the risk of vomiting [123], the risk of aspiration pneumonia remains the same whether feeding is started early on or after return of bowel function (absolute risk of 0–6.3% vs. 0–7.1%, respectively) [122–126]. Early feeding has also been associated with a decrease in insulin resistance, hyperglycemia, and wound infection.

Encouraging and facilitating early ambulation through the aid of ancillary staff while the patient is still in the hospital is key to achieve the goal of a short LOS. Early ambulation helps decrease muscle waste and helps prevent a reduction in gastrointestinal motility associated with an increased time in bed [125, 126].

### Prevention of Postoperative Nausea and Vomiting (PONV) and Postoperative Ileus (POI): Role of Nasogastric Tube and Motility Agents

ERP routinely includes medications that try to decrease PONV and prevent the development of POI. Several classes of antiemetics are available, and each class has been shown to be superior to placebo in the management of PONV. A combination of two or more drugs decreases even further the incidence of PONV [127–133].

A single dose of intravenous dexamethasone during surgery combined with ondansetron (serotonergic 5-HT3 receptor antagonists) appears to be the most adequate strategy to prevent PONV. Ondansetron is continued during the postoperative period at a dose of 4 mg every 6–8 h as needed. Studies have demonstrated a decreased incidence in PONV with ondansetron compared to metoclopramide. For patients at increased risk of developing PONV, a combination of a transdermal scopolamine patch and ondansetron can be used with studies suggesting increased efficacy when compared to ondansetron alone [131, 132].

Postoperative ileus (POI) refers to a transient impairment in gastrointestinal motility that prevents oral intake. Various definitions of POI have been proposed. Classically, it has been described as a delay to restart oral intake for more than 3 days after laparoscopic surgery or to more than 5 days after open procedures. Senagore et al. proposed an alternative classification by describing POI as any situation that requires a return to "nil per os" or the insertion of a nasogastric tube (NG). He further defines ileus as primary or secondary based on whether it is associated (secondary) or not to any other complication (i.e., anastomotic leakage) [9, 128, 129].

Primary POI causes not only patient discomfort and delays hospital discharge; it is a significant cause of healthcare expenditure, accounting for approximately $750 million per year [55, 132].

Alvimopan, a peripheral-acting mu-opioid receptor antagonist, has been shown to decrease the time required for return of gastrointestinal function and decrease POI and LOS after open and laparoscopic colorectal surgery. However, its role after laparoscopic colorectal surgery and an established ERP is less clear; Delaney et al. described a reduction in POI from 4 to 12% when comparing two matched laparoscopic colectomy groups when alvimopan was used. However, LOS (3.6 vs. 3.7 days) and hospital readmission rates (4% vs. 4.2%) were the same in both groups [134–141].

Oral magnesium oxide was described to facilitate return of bowel function after colonic surgery and as part of an ERP protocol. However, the data available is small and have not been validated in further studies.

Bisacodyl, either orally or as a suppository, facilitates return of bowel function; however, LOS is unchanged, and the amount of data available is limited [142, 143].

Chewing sugarless gum postoperatively has also been associated with a decreased time to return of bowel function and decreased LOS. The level of evidence is very robust, and its associated cost and reported adverse effects (i.e., bloating) are minimal [144–147].

Nasogastric tube decompression has been shown to have no role as a preemptive measure to prevent PONV or POI. Furthermore, it delays return of bowel function and hospital discharge. Therapeutic NG decompression still has a role in the treatment of POI; however, its usage is required in less than 10% of patients [148–150].

### Venous Thromboembolism Prophylaxis (VTE)

VTE prophylaxis should be initiated within 24 h per SCIP guidelines. This topic has been addressed earlier on the chapter while discussing intraoperative management; however, addressing VTE prophylaxis is mandatory during the postoperative period under current practice parameters.

### Discharge Planning, Follow-Up, and Coordination of Care

Discharge planning, follow-up, and coordination of care with other healthcare teams (i.e., predischarge appointments coordination with the different healthcare provider such as oncology, as needed) should be initiated early on during hospital stay. This process is facilitated by the electronic medical records system and electronic orders/appointments scheduling. Incorporation of ancillary support staff such as nurse practitioners, stoma therapists, social workers, and physical therapists as members of the ERP team allows for active education, planning, early identification of patients that may need home care or to be discharged to physical rehabilitation or extended care facilities, and decreased unnecessary hospital stay secondary to poor planning or administrative delays such as insurance approval [2, 9, 15, 21, 29, 31, 151, 152].

## Quality Pathway Evaluation Measures

### Electronic Order Set Creation and Updates to Comply with Best Practice Parameters Guidelines and Evidence-Based Literature

Creation of specialty-specific order sets requires the participation of the various members that contribute on a daily basis to patient care and application of the ERP. This includes surgeons, anesthesiologists, information technology personnel, nurses, ostomy/wound care team members, physical therapist, residents, and social workers to name a few. Data

have shown that the initial cost of implementing an ERP is offset by the reduction in morbidity and LOS achieved with the subsequent pathway implementation. Regular meetings are required to ensure that the ERP and the associated order sets remain in compliance with changes in practice parameters, evidence-based guidelines, and government and insurance policies [1, 43, 60].

### Implementation and Monitoring of Pathway Application

Compliance and application of the numerous components of an ERP have been shown to vary within members of any given colorectal group. Changes in members of the ERP can impact the way ERPs are implemented, and morbidity and LOS may change accordingly. Mobile Internet-based applications currently exist and are being used in high-volume centers to monitor in real-time ERP compliance and to identify variables that can affect its application, such as individual surgeon's preferences or a lack of support personnel. As information technology progresses and variables that affect patient care are identified, an opportunity for further improvement of ERP may occur. There is no data at the present time to evaluate its effect in overall patients' experience, quality of care, and healthcare cost [153–156].

### Quality Improvement Measures

Since the beginning of the century and secondary to high morbidity and mortality rates and a constant increase in healthcare cost, numerous programs have been developed to try to standardize care. With the objective of improving quality by decreasing variability among healthcare providers and contain cost, programs such as SCIP and National Surgical Quality Improvement Program (NSQIP) were developed. Over time, regional initiatives supported by private funding also developed as the opportunity to change individuals' practice styles toward an evidence-based, and best practice guidance model was seen as a way to achieve those goals.

Compliance with SCIP measures is becoming part of everyday practice. However, some of the standardized measures have failed to significantly improve quality. Internal practice monitoring and benchmarking them to national standards, as long as confounding variables can be included (i.e., tertiary center patients' complexity and postoperative morbidity), may allow physicians and hospitals to modify practice parameters and improve outcomes [1, 36–38, 45, 48, 64]. An easy-to-apply metric to evaluate for quality in colorectal surgery was described by the senior author of this chapter. The HARM score takes into consideration hospital stay, readmission, and mortality rates. The score is calculated by giving each patient discharge a value from 1 to 10. As the hospital mean HARM score increases from <2, to 2–3, to 3–4 and more than 4, an increase in complication rates after elective colorectal surgery is seen, changing from 15.2% to 18.2%, to 24.0%, and to 35.6%, respectively. This metric provides surgeons a low-cost tool to compare quality and may allow for identification of true outlier performers [152].

## Conclusion

The combination of ERPs and minimally invasive colorectal techniques has demonstrated a reduction in morbidity and mortality and overall length of hospital stay and is associated with a low readmission rate. This multimodal approach, based on interdisciplinary work, contributes to the standardization of patients' care and, as a result, contributes to increase quality of care. Its implementation through specialty-specific order sets covers the whole episode of care, from preoperative management until completion of care is achieved. Continuous pathway monitoring allows for updates in the order sets to be made to adjust to changes in best practice parameters and pathway compliance. Overall, the decrease in complications associated with the implementation of an ERP and minimally invasive colorectal surgery achieves the goals of improving quality of patients' care while simultaneously reducing healthcare-related cost when compared to patients managed outside a specific pathway [1–3, 6–9, 13–16, 18, 21, 35–38, 45, 47, 48, 62, 64, 84, 86].

## References


1. Adamina M, Kehlet H, Tomlinson GA, Senagore AJ, Delaney CP. Enhanced recovery pathways optimize health outcomes and resource utilization: a meta-analysis of randomized controlled trials in colorectal surgery. Surgery. 2011;149(6):830–40.
2. Asgeirsson T, Jrebi N, Feo L, Kerwel T, Luchtefeld M, Senagore AJ. Incremental cost of complications in colectomy: a warranty guided approach to surgical quality improvement. Am J Surg. 2014;207(3):422–6. discussion 5–6.
3. Chestovich PJ, Lin AY, Yoo J. Fast-track pathways in colorectal surgery. Surg Clin North Am. 2013;93(1):21–32.
4. Senagore AJ, Delaney CP. A critical analysis of laparoscopic colectomy at a single institution: lessons learned after 1000 cases. Am J Surg. 2006;191(3):377–80.
5. Senagore AJ, Stulberg JJ, Byrnes J, Delaney CP. A national comparison of laparoscopic vs. open colectomy using the National Surgical Quality Improvement Project data. Dis Colon Rectum. 2009;52(2):183–6.
6. Bosio RM, Smith BM, Aybar PS, Senagore AJ. Implementation of laparoscopic colectomy with fast-track care in an academic medical center: benefits of a fully ascended learning curve and specialty expertise. Am J Surg. 2007;193(3):413–5. discussion 5–6.
7. Delaney CP, Chang E, Senagore AJ, Broder M. Clinical outcomes and resource utilization associated with laparoscopic and open colectomy using a large national database. Ann Surg. 2008;247(5):819–24.
8. Delaney CP, Kiran RP, Senagore AJ, Brady K, Fazio VW. Case-matched comparison of clinical and financial outcome after

laparoscopic or open colorectal surgery. Ann Surg. 2003; 238(1):67–72.
9. Delaney CP, Senagore AJ, Gerkin TM, Beard TL, Zingaro WM, Tomaszewski KJ, et al. Association of surgical care practices with length of stay and use of clinical protocols after elective bowel resection: results of a national survey. Am J Surg. 2010;199(3):299–304. discussion 304.
10. Keller DS, Lawrence JK, Nobel T, Delaney CP. Optimizing cost and short-term outcomes for elderly patients in laparoscopic colonic surgery. Surg Endosc. 2013;27(12):4463–8.
11. Lawrence JK, Keller DS, Samia H, Ermlich B, Brady KM, Nobel T, et al. Discharge within 24 to 72 hours of colorectal surgery is associated with low readmission rates when using enhanced recovery pathways. J Am Coll Surg. 2013;216(3): 390–4.
12. Rossi G, Vaccarezza H, Vaccaro CA, Mentz RE, Im V, Alvarez A, et al. Two-day hospital stay after laparoscopic colorectal surgery under an enhanced recovery after surgery (ERAS) pathway. World J Surg. 2013;37(10):2483–9.
13. Bloomstone JA, Loftus T, Hutchison R. ERAS: enhancing recovery one evidence-based step at a time. Anesth Analg. 2015;120(1):256.
14. Bona S, Molteni M, Rosati R, Elmore U, Bagnoli P, Monzani R, et al. Introducing an enhanced recovery after surgery program in colorectal surgery: a single center experience. World J Gastroenterol. 2014;20(46):17578–87.
15. Delaney CP, Zutshi M, Senagore AJ, Remzi FH, Hammel J, Fazio VW. Prospective, randomized, controlled trial between a pathway of controlled rehabilitation with early ambulation and diet and traditional postoperative care after laparotomy and intestinal resection. Dis Colon Rectum. 2003;46(7):851–9.
16. Eglinton TW. The era of ERAS: a new standard of perioperative care. N Z Med J. 2013;126(1369):6–7.
17. Feldman LS, Delaney CP. Laparoscopy plus enhanced recovery: optimizing the benefits of MIS through SAGES 'SMART' program. Surg Endosc. 2014;28(5):1403–6.
18. Gignoux B, Pasquer A, Vulliez A, Lanz T. Outpatient colectomy within an enhanced recovery program. J Visc Surg. 2015;152(1):11–5.
19. ERAS Compliance Group. The impact of enhanced recovery protocol compliance on elective colorectal cancer resection: results from an international registry. Ann Surg. 2015;261(6): 1153–9.
20. Kariv Y, Delaney CP, Casillas S, Hammel J, Nocero J, Bast J, et al. Long-term outcome after laparoscopic and open surgery for rectal prolapse: a case-control study. Surg Endosc. 2006; 20(1):35–42.
21. Kariv Y, Delaney CP, Senagore AJ, Manilich EA, Hammel JP, Church JM, et al. Clinical outcomes and cost analysis of a "fast track" postoperative care pathway for ileal pouch-anal anastomosis: a case control study. Dis Colon Rectum. 2007;50(2):137–46.
22. Ljungqvist O. ERAS—enhanced recovery after surgery: moving evidence-based perioperative care to practice. JPEN J Parenter Enteral Nutr. 2014;38(5):559–66.
23. Lohsiriwat V. Enhanced recovery after surgery vs conventional care in emergency colorectal surgery. World J Gastroenterol. 2014;20(38):13950–5.
24. Noel JK, Fahrbach K, Estok R, Cella C, Frame D, Linz H, et al. Minimally invasive colorectal resection outcomes: short-term comparison with open procedures. J Am Coll Surg. 2007; 204(2):291–307.
25. Oda Y, Kakinohana M. Introduction of ERAS((R)) program into clinical practice: from preoperative management to postoperative evaluation: opening remarks. J Anesth. 2014;28(1): 141–2.
26. Patel SS, Patel MS, Mahanti S, Ortega A, Ault GT, Kaiser AM, et al. Laparoscopic versus open colon resections in California: a cross-sectional analysis. Am Surg. 2012;78(10):1063–5.
27. Pokala N, Delaney CP, Senagore AJ, Brady KM, Fazio VW. Laparoscopic vs open total colectomy: a case-matched comparative study. Surg Endosc. 2005;19(4):531–5.
28. Rona K, Choi J, Sigle G, Kidd S, Ault G, Senagore AJ. Enhanced recovery protocol: implementation at a county institution with limited resources. Am Surg. 2012;78(10): 1041–4.
29. Senagore AJ, Madbouly KM, Fazio VW, Duepree HJ, Brady KM, Delaney CP. Advantages of laparoscopic colectomy in older patients. Arch Surg. 2003;138(3):252–6.
30. Spanjersberg WR, van Sambeeck JD, Bremers A, Rosman C, van Laarhoven CJ. Systematic review and meta-analysis for laparoscopic versus open colon surgery with or without an ERAS programme. Surg Endosc. 2015;29:3443–53.
31. Steele SR, Bleier J, Champagne B, Hassan I, Russ A, Senagore AJ, et al. Improving outcomes and cost-effectiveness of colorectal surgery. J Gastrointest Surg. 2014;18(11):1944–56.
32. Zutshi M, Delaney CP, Senagore AJ, Fazio VW. Shorter hospital stay associated with fastrack postoperative care pathways and laparoscopic intestinal resection are not associated with increased physical activity. Colorectal Dis. 2004;6(6):477–80.
33. Zutshi M, Delaney CP, Senagore AJ, Mekhail N, Lewis B, Connor JT, et al. Randomized controlled trial comparing the controlled rehabilitation with early ambulation and diet pathway versus the controlled rehabilitation with early ambulation and diet with preemptive epidural anesthesia/analgesia after laparotomy and intestinal resection. Am J Surg. 2005;189(3):268–72.
34. Delaney CP, Fazio VW, Remzi FH, Hammel J, Church JM, Hull TL, et al. Prospective, age-related analysis of surgical results, functional outcome, and quality of life after ileal pouch-anal anastomosis. Ann Surg. 2003;238(2):221–8.
35. Gillissen F, Ament SM, Maessen JM, Dejong CH, Dirksen CD, van der Weijden T, et al. Sustainability of an enhanced recovery after surgery program (ERAS) in colonic surgery. World J Surg. 2015;39(2):526–33.
36. Hoffman RL, Bartlett EK, Ko C, Mahmoud N, Karakousis GC, Kelz RR. Early discharge and readmission after colorectal resection. J Surg Res. 2014;190(2):579–86.
37. Kehlet H. Enhanced Recovery After Surgery (ERAS): good for now, but what about the future? Can J Anaesth. 2015; 62(2):99–104.
38. Keller DS, Bankwitz B, Woconish D, Champagne BJ, Reynolds Jr HL, Stein SL, et al. Predicting who will fail early discharge after laparoscopic colorectal surgery with an established enhanced recovery pathway. Surg Endosc. 2014;28(1):74–9.
39. Keller DS, Delaney CP. Current evidence in gastrointestinal surgery: natural orifice translumenal endoscopic surgery (NOTES). J Gastrointest Surg. 2013;17(10):1857–62.
40. Keller DS, Khorgami Z, Swendseid B, Khan S, Delaney CP. Identifying causes for high readmission rates after stoma reversal. Surg Endosc. 2014;28(4):1263–8.

41. Kiran RP, Delaney CP, Senagore AJ, Steel M, Garafalo T, Fazio VW. Outcomes and prediction of hospital readmission after intestinal surgery. J Am Coll Surg. 2004;198(6):877–83.
42. Zhuang CL, Ye XZ, Zhang XD, Chen BC, Yu Z. Enhanced recovery after surgery programs versus traditional care for colorectal surgery: a meta-analysis of randomized controlled trials. Dis Colon Rectum. 2013;56(5):667–78.
43. Thiele RH, Rea KM, Turrentine FE, Friel CM, Hassinger TE, Goudreau BJ, et al. Standardization of care: impact of an enhanced recovery protocol on length of stay, complications, and direct costs after colorectal surgery. J Am Coll Surg. 2015;220(4):430–43.
44. Fearon KC, Ljungqvist O, Von Meyenfeldt M, Revhaug A, Dejong CH, Lassen K, et al. Enhanced recovery after surgery: a consensus review of clinical care for patients undergoing colonic resection. Clin Nutr. 2005;24(3):466–77.
45. Kehlet H, Buchler MW, Beart Jr RW, Billingham RP, Williamson R. Care after colonic operation—is it evidence-based? Results from a multinational survey in Europe and the United States. J Am Coll Surg. 2006;202(1):45–54.
46. Lassen K, Hannemann P, Ljungqvist O, Fearon K, Dejong CH, von Meyenfeldt MF, et al. Patterns in current perioperative practice: survey of colorectal surgeons in five northern European countries. BMJ. 2005;330(7505):1420–1.
47. Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud PA, et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. JAMA. 1999;282(15):1458–65.
48. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. Ann Surg. 2008;248(2):189–98.
49. Kahokehr A, Sammour T, Zargar-Shoshtari K, Thompson L, Hill AG. Implementation of ERAS and how to overcome the barriers. Int J Surg. 2009;7(1):16–9.
50. Sammour T, Zargar-Shoshtari K, Bhat A, Kahokehr A, Hill AG. A programme of Enhanced Recovery After Surgery (ERAS) is a cost-effective intervention in elective colonic surgery. N Z Med J. 2010;123(1319):61–70.
51. Srinivasa S, Sammour T, Kahokehr A, Hill AG. Enhanced Recovery After Surgery (ERAS) protocols must be considered when determining optimal perioperative care in colorectal surgery. Ann Surg. 2010;252(2):409. author reply 409–10.
52. Henry A, Stopfkuchen-Evans M, Wolf L, Bader A, Goldberg J, Kelley R, et al. Implementation of an Eras pathway in an Academic Medical Center: measurement of compliance and results. Dis Colon Rectum. 2015;58(5), E220.
53. Miller T, Ernst FR, Krukas MR, Gan T. Level of compliance with the Enhanced Recovery after Surgery (Eras) protocol and postoperative outcomes. Anesth Analg. 2013;116:100.
54. Patel A, Marimuthu K, Mathew G. Enhanced recovery after surgery (ERAS) card: a simple intervention to improve junior doctor compliance. Br J Surg. 2011;98:131–2.
55. Stein SL. Perioperative management. Clin Colon Rectal Surg. 2013;26(3):137–8.
56. Eriksson LI, Sandin R. Fasting guidelines in different countries. Acta Anaesthesiol Scand. 1996;40(8 Pt 2):971–4.
57. Smith I, Kranke P, Murat I, Smith A, O'Sullivan G, Soreide E, et al. Perioperative fasting in adults and children: guidelines from the European Society of Anaesthesiology. Eur J Anaesthesiol. 2011;28(8):556–69.
58. Soreide E, Eriksson LI, Hirlekar G, Eriksson H, Henneberg SW, Sandin R, et al. Pre-operative fasting guidelines: an update. Acta Anaesthesiol Scand. 2005;49(8):1041–7.
59. Khoo CK, Vickery CJ, Forsyth N, Vinall NS, Eyre-Brook IA. A prospective randomized controlled trial of multimodal perioperative management protocol in patients undergoing elective colorectal resection for cancer. Ann Surg. 2007; 245(6):867–72.
60. Gustafsson UO, Scott MJ, Schwenk W, Demartines N, Roulin D, Francis N, et al. Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS((R))) Society recommendations. World J Surg. 2013;37(2):259–84.
61. Lohsiriwat V. The influence of preoperative nutritional status on the outcomes of an enhanced recovery after surgery (ERAS) programme for colorectal cancer surgery. Tech Coloproctol. 2014;18(11):1075–80.
62. Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. Br J Anaesth. 1997;78(5):606–17.
63. Waitzberg DL, Saito H, Plank LD, Jamieson GG, Jagannath P, Hwang TL, et al. Postsurgical infections are reduced with specialized nutrition support. World J Surg. 2006;30(8):1592–604.
64. Keller DS, Bankwitz B, Nobel T, Delaney CP. Using frailty to predict who will fail early discharge after laparoscopic colorectal surgery with an established recovery pathway. Dis Colon Rectum. 2014;57(3):337–42.
65. Kulminski AM, Ukraintseva SV, Culminskaya IV, Arbeev KG, Land KC, Akushevich L, et al. Cumulative deficits and physiological indices as predictors of mortality and long life. J Gerontol A Biol Sci Med Sci. 2008;63(10):1053–9.
66. Farhat JS, Velanovich V, Falvo AJ, Horst HM, Swartz A, Patton Jr JH, et al. Are the frail destined to fail? Frailty index as predictor of surgical morbidity and mortality in the elderly. J Trauma Acute Care Surg. 2012;72(6):1526–30. discussion 30–1.
67. Hausel J, Nygren J, Lagerkranser M, Hellstrom PM, Hammarqvist F, Almstrom C, et al. A carbohydrate-rich drink reduces preoperative discomfort in elective surgery patients. Anesth Analg. 2001;93(5):1344–50.
68. Svanfeldt M, Thorell A, Hausel J, Soop M, Nygren J, Ljungqvist O. Effect of "preoperative" oral carbohydrate treatment on insulin action—a randomised cross-over unblinded study in healthy subjects. Clin Nutr. 2005;24(5):815–21.
69. Svanfeldt M, Thorell A, Hausel J, Soop M, Rooyackers O, Nygren J, et al. Randomized clinical trial of the effect of preoperative oral carbohydrate treatment on postoperative whole-body protein and glucose kinetics. Br J Surg. 2007;94(11): 1342–50.
70. Noblett SE, Watson DS, Huong H, Davison B, Hainsworth PJ, Horgan AF. Pre-operative oral carbohydrate loading in colorectal surgery: a randomized controlled trial. Colorectal Dis. 2006;8(7):563–9.
71. Contant CM, Hop WC, van't Sant HP, Oostvogel HJ, Smeets HJ, Stassen LP, et al. Mechanical bowel preparation for elective colorectal surgery: a multicentre randomised trial. Lancet. 2007;370(9605):2112–7.
72. Slim K, Vicaut E, Launay-Savary MV, Contant C, Chipponi J. Updated systematic review and meta-analysis of randomized clinical trials on the role of mechanical bowel preparation before colorectal surgery. Ann Surg. 2009;249(2):203–9.

73. van't Sant HP, Weidema WF, Hop WC, Lange JF, Contant CM. Evaluation of morbidity and mortality after anastomotic leakage following elective colorectal surgery in patients treated with or without mechanical bowel preparation. Am J Surg. 2011;202(3):321–4.
74. Van't Sant HP, Weidema WF, Hop WC, Oostvogel HJ, Contant CM. The influence of mechanical bowel preparation in elective lower colorectal surgery. Ann Surg. 2010;251(1):59–63.
75. Guenaga KF, Matos D, Wille-Jorgensen P. Mechanical bowel preparation for elective colorectal surgery. Cochrane Database Syst Rev. 2011;9, CD001544.
76. Jung B, Pahlman L, Nystrom PO, Nilsson E, Mechanical Bowel Preparation Study Group. Multicentre randomized clinical trial of mechanical bowel preparation in elective colonic resection. Br J Surg. 2007;94(6):689–95.
77. Collin A, Jung B, Nilsson E, Pahlman L, Folkesson J. Impact of mechanical bowel preparation on survival after colonic cancer resection. Br J Surg. 2014;101(12):1594–600.
78. Van't Sant HP, Kamman A, Hop WC, van der Heijden M, Lange JF, Contant CM. The influence of mechanical bowel preparation on long-term survival in patients surgically treated for colorectal cancer. Am J Surg. 2015;210(1):106–10.
79. Morris MS, Graham LA, Chu DI, Cannon JA, Hawn MT. Oral antibiotic bowel preparation significantly reduces surgical site infection rates and readmission rates in elective colorectal surgery. Ann Surg. 2015;261(6):1034–40.
80. Nelson RL, Gladman E, Barbateskovic M. Antimicrobial prophylaxis for colorectal surgery. Cochrane Database Syst Rev. 2014;5, CD001181.
81. Nelson RL, Glenny AM, Song F. Antimicrobial prophylaxis for colorectal surgery. Cochrane Database Syst Rev. 2009;1, CD001181.
82. Roos D, Dijksman LM, Tijssen JG, Gouma DJ, Gerhards MF, Oudemans-van Straaten HM. Systematic review of perioperative selective decontamination of the digestive tract in elective gastrointestinal surgery. Br J Surg. 2013;100(12):1579–88.
83. Song F, Glenny AM. Antimicrobial prophylaxis in colorectal surgery: a systematic review of randomized controlled trials. Br J Surg. 1998;85(9):1232–41.
84. Bakker N, Cakir H, Doodeman HJ, Houdijk AP. Eight years of experience with Enhanced Recovery After Surgery in patients with colon cancer: impact of measures to improve adherence. Surgery. 2015;157(6):1130–6.
85. Senagore AJ, Brannigan A, Kiran RP, Brady K, Delaney CP. Diagnosis-related group assignment in laparoscopic and open colectomy: financial implications for payer and provider. Dis Colon Rectum. 2005;48(5):1016–20.
86. Delaney CP, Fazio VW, Senagore AJ, Robinson B, Halverson AL, Remzi FH. 'Fast track' postoperative management protocol for patients with high co-morbidity undergoing complex abdominal and pelvic colorectal surgery. Br J Surg. 2001;88(11):1533–8.
87. Tekkis PP, Senagore AJ, Delaney CP. Conversion rates in laparoscopic colorectal surgery: a predictive model with, 1253 patients. Surg Endosc. 2005;19(1):47–54.
88. Bleier JI, Aarons CB. Perioperative fluid restriction. Clin Colon Rectal Surg. 2013;26(3):197–202.
89. Abraham-Nordling M, Hjern F, Pollack J, Prytz M, Borg T, Kressner U. Randomized clinical trial of fluid restriction in colorectal surgery. Br J Surg. 2012;99(2):186–91.
90. Boersema GS, van der Laan L, Wijsman JH. A close look at postoperative fluid management and electrolyte disorders after gastrointestinal surgery in a teaching hospital where patients are treated according to the ERAS protocol. Surg Today. 2014;44(11):2052–7.
91. Boland MR, Noorani A, Varty K, Coffey JC, Agha R, Walsh SR. Perioperative fluid restriction in major abdominal surgery: systematic review and meta-analysis of randomized, clinical trials. World J Surg. 2013;37(6):1193–202.
92. MacKay G. Randomized clinical trial of the effect of postoperative intravenous fluid restriction on recovery after elective colorectal surgery (Br J Surg 2006;93:1469–1474). Br J Surg. 2007;94(3):383.
93. MacKay G, Ihedioha U, McConnachie A, Serpell M, Molloy RG, Fearon KC, et al. Intravenous fluid and sodium restriction has no effect on recovery from colorectal surgery: an observer blinded randomized clinical trial. Br J Surg. 2006;93(7):901–2.
94. Miller TE, Roche AM, Mythen M. Fluid management and goal-directed therapy as an adjunct to Enhanced Recovery After Surgery (ERAS). Can J Anaesth. 2015;62(2):158–68.
95. Morera FJ. Randomized clinical trial of the effect of postoperative intravenous fluid restriction on recovery after elective colorectal surgery (Br J Surg 2006;93:1469–1474). Br J Surg. 2007;94(3):382–3.
96. Phan TD, An V, D'Souza B, Rattray MJ, Johnston MJ, Cowie BS. A randomised controlled trial of fluid restriction compared to oesophageal Doppler-guided goal-directed fluid therapy in elective major colorectal surgery within an Enhanced Recovery After Surgery program. Anaesth Intensive Care. 2014;42(6):752–60.
97. Tornero-Campello G. Randomized clinical trial of the effect of postoperative intravenous fluid restriction on recovery after elective colorectal surgery (Br J Surg 2006;93:1469–1474). Br J Surg. 2007;94(3):382.
98. Senagore AJ, Emery T, Luchtefeld M, Kim D, Dujovny N, Hoedema R. Fluid management for laparoscopic colectomy: a prospective, randomized assessment of goal-directed administration of balanced salt solution or hetastarch coupled with an enhanced recovery program. Dis Colon Rectum. 2009;52(12):1935–40.
99. American Society of Anesthesiologists Task Force on Acute Pain Management. Practice guidelines for acute pain management in the perioperative setting: an updated report by the American Society of Anesthesiologists Task Force on Acute Pain Management. Anesthesiology. 2012;116(2):248–73.
100. Garimella V, Cellini C. Postoperative pain control. Clin Colon Rectal Surg. 2013;26(3):191–6.
101. Ong CK, Lirk P, Seymour RA, Jenkins BJ. The efficacy of preemptive analgesia for acute postoperative pain management: a meta-analysis. Anesth Analg. 2005;100(3):757–73. table of contents.
102. Parikh HG, Dash SK, Upasani CB. Study of the effect of oral gabapentin used as preemptive analgesia to attenuate postoperative pain in patients undergoing abdominal surgery under general anesthesia. Saudi J Anaesth. 2010;4(3):137–41.
103. Siddiqui NT, Fischer H, Guerina L, Friedman Z. Effect of a preoperative gabapentin on postoperative analgesia in patients with inflammatory bowel disease following major bowel surgery: a randomized, placebo-controlled trial. Pain Pract. 2014;14(2):132–9.

104. Tirault M, Foucan L, Debaene B, Frasca D, Lebrun T, Bernard JC, et al. Gabapentin premedication: assessment of preoperative anxiolysis and postoperative patient satisfaction. Acta Anaesthesiol Belg. 2010;61(4):203–9.
105. Adachi YU, Nishino J, Suzuki K, Obata Y, Doi M, Sato S. Preemptive analgesia by preoperative administration of nonsteroidal anti-inflammatory drugs. J Anesth. 2007;21(2):294.
106. Mezei M, Hahn O, Penzes I. Preemptive analgesia—preoperative diclofenac sodium for postoperative analgesia in general surgery. Magy Seb. 2002;55(5):313–7.
107. Favuzza J, Brady K, Delaney CP. Transversus abdominis plane blocks and enhanced recovery pathways: making the 23-h hospital stay a realistic goal after laparoscopic colorectal surgery. Surg Endosc. 2013;27(7):2481–6.
108. Keller DS, Ermlich BO, Delaney CP. Demonstrating the benefits of transversus abdominis plane blocks on patient outcomes in laparoscopic colorectal surgery: review of 200 consecutive cases. J Am Coll Surg. 2014;219(6):1143–8.
109. Keller DS, Ermlich BO, Schiltz N, Champagne BJ, Reynolds Jr HL, Stein SL, et al. The effect of transversus abdominis plane blocks on postoperative pain in laparoscopic colorectal surgery: a prospective, randomized, double-blind trial. Dis Colon Rectum. 2014;57(11):1290–7.
110. Hubner M, Blanc C, Roulin D, Winiker M, Gander S, Demartines N. Randomized clinical trial on epidural versus patient-controlled analgesia for laparoscopic colorectal surgery within an enhanced recovery pathway. Ann Surg. 2015;261(4):648–53.
111. Hubner M, Schafer M, Demartines N, Muller S, Maurer K, Baulig W, et al. Impact of restrictive intravenous fluid replacement and combined epidural analgesia on perioperative volume balance and renal function within a Fast Track program. J Surg Res. 2012;173(1):68–74.
112. Kaminski JP, Pai A, Ailabouni L, Park JJ, Marecik SJ, Prasad LM, et al. Role of epidural and patient-controlled analgesia in site-specific laparoscopic colorectal surgery. JSLS. 2014;18(4).
113. Khan SA, Khokhar HA, Nasr AR, Carton E, El-Masry S. Effect of epidural analgesia on bowel function in laparoscopic colorectal surgery: a systematic review and meta-analysis. Surg Endosc. 2013;27(7):2581–91.
114. Marret E, Remy C, Bonnet F, Postoperative Pain Forum Group. Meta-analysis of epidural analgesia versus parenteral opioid analgesia after colorectal surgery. Br J Surg. 2007; 94(6):665–73.
115. Zingg U, Miskovic D, Hamel CT, Erni L, Oertli D, Metzger U. Influence of thoracic epidural analgesia on postoperative pain relief and ileus after laparoscopic colorectal resection: benefit with epidural analgesia. Surg Endosc. 2009;23(2): 276–82.
116. Levy BF, Scott MJ, Fawcett W, Fry C, Rockall TA. Randomized clinical trial of epidural, spinal or patient-controlled analgesia for patients undergoing laparoscopic colorectal surgery. Br J Surg. 2011;98(8):1068–78.
117. Douketis JD. Perioperative management of antithrombotic therapy: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest. 2012;141, e326S. Erratum in Chest. 2012;141(4):1129.
118. Rasmussen MS, Jorgensen LN, Wille-Jorgensen P. Prolonged thromboprophylaxis with low molecular weight heparin for abdominal or pelvic surgery. Cochrane Database Syst Rev. 2009;1, CD004318.
119. Fleming FJ. Operative approach and venous thromboembolism in colorectal surgery: casual or causal association? Dis Colon Rectum. 2011;54(12):1463–4.
120. Fleming FJ, Kim MJ, Salloum RM, Young KC, Monson JR. How much do we need to worry about venous thromboembolism after hospital discharge? A study of colorectal surgery patients using the National Surgical Quality Improvement Program database. Dis Colon Rectum. 2010;53(10):1355–60.
121. Pai A, Hurtuk MG, Park JJ, Marecik SJ, Prasad LM. A randomized study on 1-week versus 4-week prophylaxis for venous thromboembolism after laparoscopic surgery for colorectal cancer. Ann Surg. 2014 Sep 10. [Epub ahead of print].
122. Ng WQ, Neill J. Evidence for early oral feeding of patients after elective open colorectal surgery: a literature review. J Clin Nurs. 2006;15(6):696–709.
123. Lewis SJ, Andersen HK, Thomas S. Early enteral nutrition within 24 h of intestinal surgery versus later commencement of feeding: a systematic review and meta-analysis. J Gastrointest Surg. 2009;13(3):569–75.
124. Henriksen MG, Hansen HV, Hessov I. Early oral nutrition after elective colorectal surgery: influence of balanced analgesia and enforced mobilization. Nutrition. 2002;18(3):263–7.
125. Henriksen MG, Jensen MB, Hansen HV, Jespersen TW, Hessov I. Enforced mobilization, early oral feeding, and balanced analgesia improve convalescence after colorectal surgery. Nutrition. 2002;18(2):147–52.
126. Zhuang CL, Ye XZ, Zhang CJ, Dong QT, Chen BC, Yu Z. Early versus traditional postoperative oral feeding in patients undergoing elective colorectal surgery: a meta-analysis of randomized clinical trials. Digest Surg. 2013;30(3):225–32.
127. Asgeirsson T, El-Badawi KI, Mahmood A, Barletta J, Luchtefeld M, Senagore AJ. Postoperative ileus: it costs more than you expect. J Am Coll Surg. 2010;210(2):228–31.
128. Barletta JF, Asgeirsson T, Senagore AJ. Influence of intravenous opioid dose on postoperative ileus. Ann Pharmacother. 2011;45(7–8):916–23.
129. Barletta JF, Senagore AJ. Reducing the burden of postoperative ileus: evaluating and implementing an evidence-based strategy. World J Surg. 2014;38(8):1966–77.
130. Bungard TJ, Kale-Pradhan PB. Prokinetic agents for the treatment of postoperative ileus in adults: a review of the literature. Pharmacotherapy. 1999;19(4):416–23.
131. Harms BA, Heise CP. Pharmacologic management of postoperative ileus: the next chapter in GI surgery. Ann Surg. 2007;245(3):364–5.
132. Person B, Wexner SD. The management of postoperative ileus. Curr Probl Surg. 2006;43(1):6–65.
133. Stewart D, Waxman K. Management of postoperative ileus. Am J Ther. 2007;14(6):561–6.
134. Barletta JF, Asgeirsson T, El-Badawi KI, Senagore AJ. Introduction of alvimopan into an enhanced recovery protocol for colectomy offers benefit in open but not laparoscopic colectomy. J Laparoendosc Adv Surg Tech A. 2011;21(10): 887–91.
135. Bell TJ, Poston SA, Kraft MD, Senagore AJ, Delaney CP, Techner L. Economic analysis of alvimopan in North American phase III efficacy trials. Am J Health Syst Pharm. 2009; 66(15):1362–8.

136. Bell TJ, Poston SA, Kraft MD, Senagore AJ, Techner L. Economic analysis of alvimopan—a clarification and commentary. Pharmacotherapy. 2013;33(5):e81–2.
137. Delaney CP, Wolff BG, Viscusi ER, Senagore AJ, Fort JG, Du W, et al. Alvimopan, for postoperative ileus following bowel resection: a pooled analysis of phase III studies. Ann Surg. 2007;245(3):355–63.
138. Leslie JB. Alvimopan for the management of postoperative ileus. Ann Pharmacother. 2005;39(9):1502–10.
139. Ludwig K, Viscusi ER, Wolff BG, Delaney CP, Senagore A, Techner L. Alvimopan for the management of postoperative ileus after bowel resection: characterization of clinical benefit by pooled responder analysis. World J Surg. 2010;34(9):2185–90.
140. Senagore AJ, Bauer JJ, Du W, Techner L. Alvimopan accelerates gastrointestinal recovery after bowel resection regardless of age, gender, race, or concomitant medication use. Surgery. 2007;142(4):478–86.
141. Simorov A, Thompson J, Oleynikov D. Alvimopan reduces length of stay and costs in patients undergoing segmental colonic resections: results from multicenter national administrative database. Am J Surg. 2014;208(6):919–25.
142. Wiriyakosol S, Kongdan Y, Euanorasetr C, Wacharachaisurapol N, Lertsithichai P. Randomized controlled trial of bisacodyl suppository versus placebo for postoperative ileus after elective colectomy for colon cancer. Asian J Surg. 2007;30(3):167–72.
143. Zingg U, Miskovic D, Pasternak I, Meyer P, Hamel CT, Metzger U. Effect of bisacodyl on postoperative bowel motility in elective colorectal surgery: a prospective, randomized trial. Int J Colorectal Dis. 2008;23(12):1175–83.
144. Keller D, Stein SL. Facilitating return of bowel function after colorectal surgery: alvimopan and gum chewing. Clin Colon Rectal Surg. 2013;26(3):186–90.
145. Purkayastha S, Tilney HS, Darzi AW, Tekkis PP. Meta-analysis of randomized studies evaluating chewing gum to enhance postoperative recovery following colectomy. Arch Surg. 2008;143(8):788–93.
146. Hocevar BJ, Robinson B, Gray M. Does chewing gum shorten the duration of postoperative ileus in patients undergoing abdominal surgery and creation of a stoma? J Wound Ostomy Continence Nurs. 2010;37(2):140–6.
147. Chan MK, Law WL. Use of chewing gum in reducing postoperative ileus after elective colorectal resection: a systematic review. Dis Colon Rectum. 2007;50(12):2149–57.
148. Nelson RL. A systematic review of prophylactic nasogastric suction after abdominal surgery. Dis Colon Rectum. 2004;47(4):640.
149. Nelson R, Tse B, Edwards S. Systematic review of prophylactic nasogastric decompression after abdominal operations. Br J Surg. 2005;92(6):673–80.
150. Rao W, Zhang X, Zhang J, Yan R, Hu Z, Wang Q. The role of nasogastric tube in decompression after elective colon and rectum surgery: a meta-analysis. Int J Colorectal Dis. 2011;26(4):423–9.
151. O'Brien DP, Senagore A, Merlino J, Brady K, Delaney C. Predictors and outcome of readmission after laparoscopic intestinal surgery. World J Surg. 2007;31(12):2430–5.
152. Keller DS, Chien HL, Hashemi L, Senagore AJ, Delaney CP. The HARM score: a novel, easy measure to evaluate quality and outcomes in colorectal surgery. Ann Surg. 2014;259(6):1119–25.
153. Wind J, Polle SW, Fung Kon Jin PH, Dejong CH, von Meyenfeldt MF, Ubbink DT, Gouma DJ, Bemelman WA, Laparoscopy and/or Fast Track Multimodal Management Versus Standard Care (LAFA) Study Group; Enhanced Recovery after Surgery (ERAS) Group. Systematic review of enhanced recovery programmes in colonic surgery. Br J Surg. 2006;93(7):800–9.
154. Vlug MS, Wind J, van der Zaag E, Ubbink DT, Cense HA, Bemelman WA. Systematic review of laparoscopic vs open colonic surgery within an enhanced recovery programme. Colorectal Dis. 2009;11(4):335–43.
155. Bradshaw BG, Liu SS, Thirlby RC. Standardized perioperative care protocols and reduced length of stay after colon surgery. J Am Coll Surg. 1998;186(5):501–6.
156. Raue W, Haase O, Junghans T, et al. 'Fast-track' multimodal rehabilitation program improves outcome after laparoscopic sigmoidectomy: a controlled prospective evaluation. Surg Endosc. 2004;18(10):1463–8.
157. Basse L, Raskov HH, Hjort Jakobsen D, Sonne E, Billesbolle P, Hendel HW, et al. Accelerated postoperative recovery programme after colonic resection improves physical performance, pulmonary function and body composition. Br J Surg. 2002;89:446–53.
158. Anderson AD, McNaught CE, MacFie J, Tring I, Barker P, Mitchell CJ. Randomized clinical trial of multimodal optimization and standard perioperative surgical care. Br J Surg. 2003;90:1497–504.
159. Gatt M, Anderson AD, Reddy BS, Hayward-Sampson P, Tring IC, MacFie J. Randomized clinical trial of multimodal optimization of surgical care in patients undergoing major colonic resection. Br J Surg. 2005;92:1354–62.
160. Serclová Z, Dytrych P, Marvan J, Nová K, Hankeová Z, Ryska O, Slégrová Z, Buresová L, Trávníková L, Antos F. Fast-track in open intestinal surgery: prospective randomized study (Clinical Trials Gov Identifier no. NCT00123456). Clin Nutr. 2009;28(6):618–24.
161. Muller S, Zalunardo MP, et al. A fast-track program reduces complications and length of hospital stay after open colonic surgery. Gastroenterology. 2009;136:842–7.