ISSN: 1607-8322, e-ISSN: 2220-5799 Anaesthesia, Pain & Intensive Care
Vol 24(3); June 2020 DOI: 10.35975/apic.v24i3.1287

REVIEW ARTICLE OPEN ACCESS

Enhanced recovery after surgery (ERAS) in clinical practice

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Abstract

'Enhanced Recovery After Surgery' (ERAS) protocols are an evidence-based, multidisciplinary system for patient care that— since its emergence in 2001— has shown remarkable efficacy in reducing surgical complications, shortening length of stay (LoS), and the incidence of hospital re-admission. Unfortunately, wide spread acceptance of ERAS has been slow, as it conflicts with some traditional perioperative care practices. However, with protocol compliance >70%, studies have shown significant reduction in mortality and postsurgical complications, with 30-50% reduction in LoS and approximately a 50% reduction in complications. A primary objective of ERAS protocols is to maintain anabolic homeostasis, preventing protein breakdown, muscle loss, and insulin resistance. One key element of the ERAS protocol is the implementation of an auditing system to ensure compliance with the elements of the guidelines published by the international ERAS Society. This component of ERAS is essential for not only optimizing adherence, but also for the continuous updating of protocols to meet current evidence-based best practices. Through the implementation of the ERAS program, it is possible to facilitate the highest possible quality of patient outcomes and provide informed, modernized care. The content of this review will focus on the key elements of the ERAS protocol and institutional acceptance and implementation.

Key words: Enhanced Recovery After Surgery; ERAS; Enhanced Recovery Program; ERP; Fast track recovery; Surgical quality improvement; Hospital stay; Traditional care methods

Citation: Leger R, Livelsberger J, Sinha A. Enhanced recovery after surgery (ERAS) in clinical practice. Anaesth. pain intensive care 2020;24(3):335-345.

Received: 23 March 2020; **Reviewed:** 7 May 2020; **Accepted:** 14 May 2020

1. Introduction

An extensive body of evidence-based research exists investigating the treatment and care surrounding surgical patients. Over the past two decades a transformational change has taken place.

Internationally, beginning with the landmark work of Danish surgeon Henrik Kehlet to implement modernized, fact-based changes in perioperative patient care. Kehlet and colleagues, over a series of articles demonstrated a truly revolutionary improvement in the reduction of patients' length of stay (LoS) and postoperative surgical complications following gastrointestinal surgeries via the implementation of evidence-based care protocols versus more traditional methods.[1-3] These recovery protocols became known as "fast-track" recovery procedures, which have since been re-termed as enhanced recovery after surgery (ERAS) pathways— to place emphasis on the improvement of patient outcomes and not just on hospital LoS.[4] Since its emergence in 2001, ERAS's multidisciplinary, evidence-based approach to improving patient care has proven tremendously efficacious. Most notable amongst these outcomes is the marked reduction in postoperative complications by approximately 50%[4-7]

and reduction in the LoS, in some surgeries by greater than 2 days.[2,3,7]

Adoption and implementation of these proven and effective recovery pathways, however, has been slow and met with opposition.[7-9] The international ERAS society has in response released a comprehensive series of guidelines for the implementation of evidence-based ERAS protocols catered to a growing array of surgical specialties and procedures: gastrectomy, bariatric surgery, pancreaticoduodenectomy, radical cystectomy, hepatic surgery, colonic surgery, rectal/pelvic surgery, breast reconstruction, and head and neck cancer surgery with free flap reconstruction.[10-19] A unifying goal of these procedures is the drive to quickly return patients to normal daily function and mitigate the surgical stress and accompanied catabolic state, that have been attributed to cause a number of postoperative complications while delaying patient recovery.[1,3,7,11,20-23] The contents of this review will focus on examining current evidence for ERAS pathways and discuss the implementation and associated obstacles to this much needed quality improvement.

2. ERAS Protocols & Recommendations

The ERAS pathways have since the ERAS Society's formation in 2010 diversified and expanded to include a progressively increasing number of surgeries across a growing number of surgical specialties.23 As such, these multidisciplinary guidelines disseminated by the society, include recommendations specific to the given type of surgery. However, the ERAS protocols are all linked by a set of unifying objectives— the reduction in the stress response of patients to surgery and the speedy resumption of normal daily function.[1,3,7,11,20-23] The attenuation of patient stress via ERAS is aimed at minimizing the postoperative catabolic state experienced by the patient, which can lead to the detrimental outcomes of insulin resistance, muscle loss, infection, and delays in wound and anastamotic healing,[20-22] inevitably leading to prolonged recovery and extended hospital stays and costs. ERAS protocols can be divided into three time points— preoperative, intraoperative, and postoperative; the key elements which unify the different ERAS guidelines will be discussed here.

2.1. Preoperative Interventions & Recommendations

2.1.1. Patient Counselling

One of the hallmark aspects of ERAS is the emphasis placed on preoperative patient counselling. It is believed that informing, educating, and discussing the procedure with the patient has beneficial effects on attenuating anxiety and fears of patients going into surgery.[24-26] Stergiopolou et al. displayed that patients scheduled for laparoscopic cholecystectomy displayed lower levels of anxiety with higher level of knowledge about their procedure.[26] Given the lack of associated risk and the known effects of stress on promoting catabolism,[22] the benefits of this counselling are clear.

2.1.2. Alcohol & Tobacco Cessation

Cessation of alcohol consumption and smoking prior to surgery has also been shown to be important for the reduction of postoperative complications.[27,28] Depending on the amount of consumption, excessive alcoholism can increase the risk of postoperative complications from 50-200%— with infection, wound breakdown, cardiac ischemia, and/or arrhythmias, being the most recognized complications.[29] Alcoholism can also increase the intraoperative risk of cardiomyopathy— especially during the induction of anesthesia.[29] Smoking is associated with complications such as pneumonia, hypertension, atelectasis, bronchospasm, delayed wound healing, thromboembolic events, and respiratory failure.[28,29] In a randomized controlled trial Sorensen and colleagues demonstrated the efficacy of presurgical smoking cessation programs, by showing that smokers who abstained for one month prior to surgery displayed significantly reduced wound infections compared to patients who continued to smoke up to the time of surgery.[30] Current ERAS guidelines suggest to counsel the patients for complete abstinence from alcohol and tobacco use for one month prior to surgery,[10-19] though of course counselling for long-term cessation in patients who abuse alcohol and tobacco is always advisable.

2.1.3. Prehabilitation

Prehabilitation is the term for a series of efforts aimed at increasing functional capacity prior to surgery for

the purposes of reducing the impact of surgical stress.[31] Prehabilitation programs routinely consist of exercise and dietary regimens, as well as cognitive stress reduction techniques such as meditation.[31] The benefits of exercise prior to surgery include its proven ability to reduce anxiety,[32] as well as improved cardiopulmonary function.[31] With regards to improving patients' nutritional status, it has been shown that poor nutrition is a predictor for postsurgical complications and increased LoS.[31,33,34] Inadequate nutrition is an especially pervasive problem within elderly patients,[33] which make up a significant segment of the surgical patient population.

2.1.4. Anti-microbial & Thromboembolic Prophylaxis

Prophylactic treatments for infections and thromboembolic events are other key elements of the preoperative care recommended by the ERAS guidelines.[10-19] For the prevention of venous thromboembolism (VTE), ERAS pathways recommend the use of low-molecular-weight heparin (LMWH) as compared to traditional unfractionated heparin, unless otherwise indicated, because of its need to only be administered once daily and a lower risk of heparin-induced thrombocytopenia.[16,22] Unsurprisingly, the administration of prophylactic antibiotics has been shown to decrease the risk of surgical site infection in patients postoperatively.[35] The current consensus for the administration for antimicrobial prophylaxis, is that it should occur approximately 60 min prior to surgical incision and be discontinued within 24 hours after surgery.[36] In a meta-analysis of randomized controlled trials Mittendorf et al. determined that patients undergoing abdominal hysterectomies not receiving antibiotic prophylaxis developed infections in 21% of cases, compared to 9% for women who did receive prophylactic antimicrobial treatments— a clinically and statistically significant difference.[37]

2.1.5. Preoperative Fasting & Carbohydrate Loading

Traditional care methods typically recommend fasting after midnight on the night prior to surgery for the purported purpose of preventing pulmonary aspiration; however, this practice has not been validated by evidence-based investigations.[38-40] Evidence suggests that patients being "nil by mouth" for prolonged periods prior to surgery may not only impose additional stress due to hunger and excessive dry mouth, but also contribute to the increased endocrine-induced catabolism and insulin resistance experienced by many patients postoperatively.[38,41] It is additionally true, that giving patients a carbohydrate-rich drink prior to surgery, as recommended by ERAS, has an additional benefit of reducing anxiety.[38] ERAS protocols recommend that patients, in most cases, refrain from excessive fasting, allowing for the safe consumption of solids up to 6 hours and clear liquids up to 2 hours prior to the time of surgery.[10-19]

A summary of the key preoperative elements of the ERAS protocol are listed in Table 1.

Table 1: Preoperative ERAS recommendations

Intervention	Purpose
Preoperative Patient Counselling	To reduce patient stress and anxiety prior to surgery
Improving Nutritional Status	To prevent excessive protein breakdown and catabolism
Reduction of Fasting Period	To prevent detrimental catabolism and insulin resistance following surgery
Carbohydrate Loading	To prevent insulin resistance
Smoking/Alcohol Cessation	To avoid potential pulmonary and thromboembolic events and reduce the risks of wound infection, sepsis, and pneumonia
Prehabilitation	To reduce the impact of surgical stress and increase functional capacity
Thromboembolic Prophylaxis	To reduce the risk of venous thromboembolisms during and after surgery
Anti-microbial Prophylaxis	To reduce the risk of postoperative infections

2.2. Intraoperative Interventions & Recommendations

2.2.1. Minimally Invasive Approaches

Minimally invasive surgical approaches are, understandably, the preferred by the patients.[42] The use of minimally invasive procedures was among the first investigated elements of ERAS, with studies showing that enhanced recovery methods combined with laparoscopy lead to shorter LoS and fewer complications,[2,3] as well as decreases in postoperative inflammatory response.[41] Vlug et al. in the first large-scale multicenter study on the topic, observed that the use of laparoscopy with enhanced recovery methods resulted in reductions in LoS greater than 2 days.[43] More recent investigations have shown that laparoscopy is not only associated with shorter LoS, but also reduced pain postoperatively, and is associated with a lower risk for wound infection.[44]

2.2.2. Preservation of Normothermia

The operating room setting poses an additional stressor to patients— with standard temperatures between 20º and 25ºC and anesthetic alteration of the homeostatic setpoint— semi-clad patients are subjected to cold stress and are often at risk of intraoperative hypothermia.[41] Hypothermia may also adversely affect patients via its ability to impair immune function,[45] leaving patients susceptible to postoperative infections. Evidence-based studies have shown warming patients intraoperatively both decreases the rate of surgical wound infections and reduces the total LoS.[45,46] It has also been proposed that prophylactic warming of patients prior to surgery may have beneficial effects at mitigating postoperative infections. In a randomized controlled trial Melling and colleagues investigated a sample of 421 patients. Out of whom half were artificially warmed for 30 min prior to surgery, while the other half were not, concluding that significantly fewer surgical site infections occurred in patients who received prophylactic warming compared to those who did not.[47]

2.2.3. Management of Fluid Balance & Hemostasis

An extremely important aspect of the ERAS protocols is the careful and appropriate management of patients' fluid balance and hemostasis, ensuring that patients are not transfused or administered excess of fluids intraoperatively.[10-19] Adequate fluid administration is vital for preserving cardiac output, perfusion and tissue oxygenation,5 while administration of fluids in excess of losses can lead to complications such as pulmonary and bowel edema[48,49] and delays in wound and anastomotic healing.[22] Surprisingly, perioperative fluid administration has often exceeded losses occurring during surgery.[22] Decreases in fluid administration below that typical of traditional care has also been associated with significantly faster returns to normal gastrointestinal function and shorter LoS in patients undergoing colonic resection.[50] It has been identified that careful attention to fluid balance is an especially important consideration during procedures such as cardiac surgery with cardiopulmonary bypass, where up to 2 L of priming fluid are routinely used, putting patients at an elevated risk for developing complications.[20] Current ERAS guidelines have even outlined the use of transesophageal doppler for the monitoring of patient fluids, in high-risk cases.[12,20]

2.2.4. Nausea & Vomiting Prophylaxis

Postoperative nausea and vomiting (PONV) is a relatively common anesthetic complication that occurs in 20-30% of patients following general anesthesia.51 In rare cases it has been associated with aspiration, dehydration, electrolyte imbalances, bleeding, and wound dehiscence.[51] In some patients it has been identified as potentially more stressful than postoperative pain.[22] The use of volatile anesthetics and the administration of opioids have both been identified as risk factors for PONV.[51] Accordingly, the intraoperative use of pharmacological prophylactic agents— ondansetron, dexamethasone or droperidol— has also been outline in ERAS protocols.[19] ERAS also recommends the minimization of opioids and avoiding general anesthesia, if possible, in part to reduce the risk of PONV.[11]

2.3. Anesthetic Recommendations

Anesthetic recommendations for ERAS typically focus on techniques that minimize the use of opioids— especially long-acting ones— and promote early mobilization and pain management.[10-19] This typically includes the preferential use of neuraxial anesthesia if not contraindicated and the avoidance of long-acting opioids and sedative/hypnotics in patients over 70.[20,22] The opioid abuse is the leading cause of overdose and death from prescription drugs, with concomitant

benzodiazepine use acting as a prevalent contributor to opioid-related morbidity and mortality.[52] Moreover, the use of both benzodiazepines and opioids is associated with prolonged postoperative delirium in elderly patient populations.[53]

Preferential use of neuraxial anesthesia over general anesthesia has also been shown to improve postoperative outcomes.[54,55] In a meta-analysis, that included 16,555 patients, Liu et al. demonstrated that patients undergoing knee arthroplasty had a significantly lower incidence of both pneumonia and surgical site infection within a 30 day period, when receiving neuraxial anesthesia compared to general anesthesia.[54] This is believed to be due to the lesser impact that neuraxial anesthesia has on immune function and the comparatively lower degree of surgical stress.[54]

A summary of the key intraoperative elements of the ERAS protocol are listed in Table 2.

increasing the risk of VTE,[41,57] whereas restricted oral intake following surgery has been associated with contributing to catabolism and the loss of weight and skeletal muscle.[41]

2.4.2. Avoidance/Early Removal of Nasogastric Tubes, Catheters, & Drains

ERAS pathways also emphasize the avoidance or early removal of nasogastric (NG) tubes, urinary catheters, and drains in surgical patients.[10-19] The traditional view of NG tubes was that they decreased the incidence of PONV, aspiration, anastomotic leak, and wound dehiscence.[58] Whereas, NG tubes are often reported by patients as one of the most painful aspects of their care,[59] further complicating postoperative care.

Although avoidance of NG tubes may somewhat increase the risk of vomiting postoperatively, their avoidance is associated with shorter LoS and a decreased incidence of fever, atelectasis, and pneumonia.[58] Similarly, evidence has shown little or

Table 2: Intraoperative ERAS recommendations and their purpose.

Intervention	Purpose
Minimally Invasive Approach	To reduce the risk of complications and postoperative pain
Minimization of Opioids Administration	To promote early mobilization and reduce the risk of PONV
Preservation of Normothermia	To lower the risk of wound infection
Preservation of Fluid Balance & Hemostasis	To reduce the risk of postoperative complications
Nausea & Vomiting Prophylaxis	To prevent postoperative vomiting
Neuraxial Anesthesia for Open Procedures	To reduce the risk of insulin resistance and minimize the stress response

2.4. Postoperative Interventions & Recommendations

2.4.1. Early Mobilization & Oral Feeding

Surgical patients typically qualify to leave the hospital when they can resume eating and drinking normally, have controlled their pain through oral analgesics, and have sufficient mobility to care for themselves and accomplish the normal activities of daily living.[5] As such, it is unsurprising that ERAS protocols call for the early mobilization and resumption of oral feeding by patients as soon as possible following surgery.[10-19] Prolonged bed rest has been associated with adverse effects such as increased catecholamine secretion and reduced maximal oxygen uptake[56] as well as

no efficacy in the use of drainage systems for a myriad of surgical procedures.[60-62] In a recent meta-analysis of randomized controlled trials, Picchio et al. examined a sample of 1,939 patients undergoing laparoscopic cholecystectomy, either with or without the use of a drain.[60] They observed significantly lower morbidity in the no drain group, with a lower incidence of wound infection and less reported postoperative pain 24 h after surgery compared to patients with a drainage system.[60] In contrast, the use of urinary catheterization is necessary following certain procedures associated with voiding dysfunction.[63] However, urinary tract infections secondary to prolonged catheterization is the leading cause of nosocomial infections, accounting for 40% of infections in the hospital setting.[64] Early

removal of urinary catheters, within one day postoperatively, is recommended.[63]

2.4.3. Analgesic Recommendations

ERAS makes a number of recommendations for optimizing postoperative analgesia to maximize patients' return of function. Neuraxial analgesia, multimodal analgesia, and local anesthetic infiltration are the most recommended.[10-19] In a meta-analysis of randomized controlled trials, Block et al. showed that epidural analgesia was superior to parenteral opioid analgesia at any postoperative timepoint, regardless of the analgesic agent used.[65] Interestingly, epidural analgesia may also hasten lung recovery following laparoscopic surgery.[11] The usage of local anesthetic infiltration and peripheral nerve blocks for the control of postoperative pain have also been shown to have favorable outcomes for patients compared to standard methods, with patients displaying less postoperative pain, less opioid use, and less need for rescue analgesia.[66,67] Local anesthetic infiltration has even shown an association with decreased postoperative cortisol and glucose responses, indicating an attenuation in patients' stress responses to surgery.[66] With the use of these local anesthetics, ERAS guidelines have suggested the longer-acting local anesthetics such as ropivacaine and levobupivacaine as opposed to lidocaine,[11] to maximize analgesic efficacy. In cases where neuraxial blocks and local anesthetics are not indicated, ERAS pathways recommend the use of multimodal analgesia— combining opioids with non-steroidal anti-inflammatory drugs (NSAID), acetaminophen, and gabapentin— to limit the opioid administration to the patient.[16,20] Preemptive administration of multimodal analgesia preoperatively may also contribute to lowering postoperative pain,[20] improving patients' postoperative experience.

A summary of the key postoperative elements of the ERAS protocol are listed in Table 3.

Table 3: Postoperative ERAS recommendations and purpose.

Intervention	Purpose
Early Resumption of Oral Feeding	To reduce the risk of insulin resistance
Early Mobilization	To support the quick return to normal function and reduce the risk of pneumonia & VTE
Avoidance of NG tubes, catheters, & drains	To reduce pain, discomfort, and the risk of pneumonia, while promoting the resumption of oral feeding
Multimodal Analgesia	To control pain while sparing excessive opioid usage
Local anesthetic infiltration & nerve blocks	To control pain while sparing excessive opioid usage

3. Audit

The ERAS pathways recommend the implementation of a structured, institutional system of auditing, to ensure that the various aspects of the ERAS protocols are adhered to and kept up to date.[10-19] The effectiveness of such audits in the implementation of quality improvement initiatives has been somewhat controversial. In a meta-analysis Jamtvedt et al. found that audits were able to improve professional practice; however, the researchers found the magnitudes of improvement to be only small to moderate.[68] Nonetheless, given the lack of any associated risks, these audits have still been routinely recommended for institutions adopting ERAS programs.

3.1. Adoption & Implementation of ERAS

Despite its clear and proven benefits, the international adoption of ERAS has been slow.[8,22] Past analyses of this issue have revealed key barriers to the adoption of ERAS protocols in clinical practice. The most frequently cited is a resistance to change from traditional practices,[8,22,69] even those practices which have been found unnecessary and even harmful such

as mechanical bowel preparation.[10-15,17] In a qualitative study to determine which factors were impeding the adoption of ERAS protocols, Pearsall and colleagues identified resistance to change, poor communication/collaboration, and patient factors as the largest obstacles to implementation.[69] Respondents to this investigation also frequently agreed that a standardized guideline for ERAS protocols would be essential;[69] fortunately, the ERAS society has published just such guidelines for patients receiving a number of surgeries— which are continuously updated with new evidence.[23] Regrettably, within the culture of medicine it has been shown that empirical research findings are neither rapidly nor routinely translated into changes in clinical care.[70] Within the United States, McGlynn et al. showed that the patients received only 55% of the recommended care, ranging from 79% to 11% depending on the type of surgery.[71] This gap between evidence-based care and standard care in the practice of medicine is irreconcilable with the ethical ideals of medicine, which promote the best interest of patients. Furthermore, studies have shown that apart from not receiving recommended care, 20-30% of patients may be receiving care that is either unnecessary or even harmful.[70]

Previous investigations— fortunately— have made determinations on which practices are successful and important for the implementation of quality improvement (QI) programs such as ERAS. The spread of practices between departments has been identified as an important factor in the successful implementation and continued, long-term compliance with QI programs.[8] De Groot et al. conducted a multicenter examination of the spread of ERAS protocols from the gastrointestinal surgical teams to the gynecological surgical teams at a number of Dutch hospitals where ERAS pathways were in practice.[8] They concluded that almost no spread of ERAS protocols took place between the related departments, even in hospitals with mixed wards for gastrointestinal and gynecological patients.8 This presents a clear avenue for future efforts at ERAS implementation to focus on. Other identified factors associated with successful QI implementation are engaged clinicians, an important problem, an understanding of the QI's processes, a method to improve them, face-to-face communication, institutional structure, patient participation, and a sustainable system for measurement, audit, and feedback.[6,9,72] Many of these components— such as patient involvement, an important problem, and a system for audits— are built into the ERAS pathway.[10-19] However, it remains clear that increased efforts are needed to make ERAS implementation universal.

Even within centers where ERAS has been adopted, varying degrees of successful implementation and compliance have been reported.[73] Improved compliance rates have been shown to be important for eliciting the reported beneficial aspects of ERAS. Different levels of compliance with ERAS protocols have been cited as being necessary for observing effects on patient outcomes— from 50-90%[23] to more recently 70-80%.[5] In one study, compliance greater than 70% was associated with a 42% decline in mortality for patients with colorectal cancer.[5] In a recent prospective study Pisarska et al. stratified patients in high (> 90%), moderate (70-90%), and low (< 70%) compliance with ERAS guidelines and investigated differences in patient outcomes. Even between the moderate and high compliance groups significantly better outcomes were observed— with respective complication rates of 16.4%, 36.4%, and 35.7%.[73] Improvement was also observed on secondary measures of recovery: LoS and the rates of oral feeding and mobilization that occurred on postoperative day 1.[73] It is, however, worth noting that compliance may decline in circumstances where ERAS protocols are contraindicated by the patient's conditions and/or co-morbidities. Selective non-compliance with aspects of ERAS protocols were found by one study to be medically justifiable in as many as 80% of cases in centers where ERAS was in place.[22] Maximizing implementation in all cases where ERAS protocols are indicated is, however, of the utmost importance for improving and modernizing the standard of care and providing patients with the healthcare they deserve.

4. Conclusions

There is a strong consensus that ERAS is not only safe and feasible, but also represents the best available standard of perioperative care for surgical patients based on existing evidence. The application of ERAS recommended guidelines has been proven to reduce complications, shorten the length of hospital stay, and

reduce postoperative pain— while simultaneously diminishing economic costs for hospitals and patients. The primary barriers to successful implementation of ERAS internationally is an ingrained resistance to change and the systemic failure of communication both within and between different specialties. Although these obstacles are not insurmountable, drastic changes are needed to close the gap between evidence-based care and outdated traditional practices.

5. Authors' Contribution

RL: collection and review of literature, drafting and review of manuscript, production of tables

JL, AS: concept, review of literature, design of the manuscript, final editing and critical review

6. Conflicts of Interest

The authors of this article have no conflicts of interest of any kind with the topics discussed in this article, nor was there any receipt of funds from any institution with regards to this research.

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