

# Enhanced Recovery after Surgery Protocols for Amelioration of Surgical Outcomes

Satyam Krishan<sup>1</sup>, Abhimanyu Rakesh<sup>2</sup>, Aishwaryaa Joshi<sup>3</sup>, Sachreet Kaur<sup>4</sup>, Veena Chatrath<sup>5</sup>

<sup>1</sup>Intern, Department of Anaesthesia, Punjab Institute of Medical Sciences, Jalandhar, Punjab, India, <sup>2</sup>Intern, Department of Anaesthesia, Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab, India, <sup>3</sup>Junior Resident, Department of Anaesthesia, Government Medical College, Amritsar, Punjab, India, <sup>4</sup>Senior Resident, Department of Anaesthesia, Government Medical College, Amritsar, Punjab, India, <sup>5</sup>Professor and Head, Department of Anaesthesia, Government Medical College, Amritsar, Punjab, India

## Abstract

Enhanced recovery after surgery (ERAS) protocols termed as “fast track surgery” have now become an essential component in the perioperative period to improve post-operative outcomes. It is both the patient and the health services who receive the benefits of ERAS. It is a new and different approach when compared to traditional practices which aims at enhanced care of surgical patients. It includes pre-operative, intraoperative, and post-operative components which when applied altogether give best possible results. Effective implementation of ERAS protocols is associated with fast recovery of gut function and reduced rate of complications. All these factors further lead to decreased post-operative hospital stay, thereby decreasing hospital cost and increasing patient satisfaction.

**Key words:** Carbohydrate loading, Enhanced recovery, Goal-directed fluid therapy, Multimodal analgesia, Post-operative nausea and vomiting prophylaxis

## INTRODUCTION

The concept of enhanced recovery after surgery (ERAS) was given by Prof. Kehlet and Wilmore somewhere around the past decade of the 20<sup>th</sup> century.<sup>[1]</sup> His area of work was in colorectal surgeries where multiple factors were considered to be the reason for lengthened hospital stay and delayed recovery. One important factor being delayed return of bowel function.<sup>[2]</sup> ERAS is a multimodal, multidisciplinary approach which involves application of perioperative care protocols to reduce length of hospital stay, and post-operative complications. Both the patient and the health services as a whole receive the benefits of ERAS. The major focus of these protocols is on:<sup>[3]</sup>

1. Pre-operative evaluation and optimization
2. Use of cost-effective medications

3. Goal-directed fluid therapy (GDT) in perioperative period
4. Avoidance of perioperative fasting and carbohydrate loading up to 2 h preoperatively
5. Multimodal pain management
6. Standardized anesthetic and analgesic regimens (epidural and non-opioid analgesia)
7. Early mobilization in the post-operative period.

Successful implementation of these ERAS protocols requires proper coordination between the surgeon, the anesthesiologist, the nursing staff, and the patient as well the people taking care of the patient in the post-operative period. The patient outcome depends on the type and extent of surgical insults, susceptibility of the patient to these insults and perioperative stress, and the quality of perioperative care received by the patient. An ERAS Society was formed in 2010. It is a multidisciplinary society which has played an important role in providing guidelines, educational meetings, and other support.<sup>[4,5]</sup> The main aim of this society is the development of a good perioperative care and improvement of recovery through research, education, and implementation of evidence-based practice.

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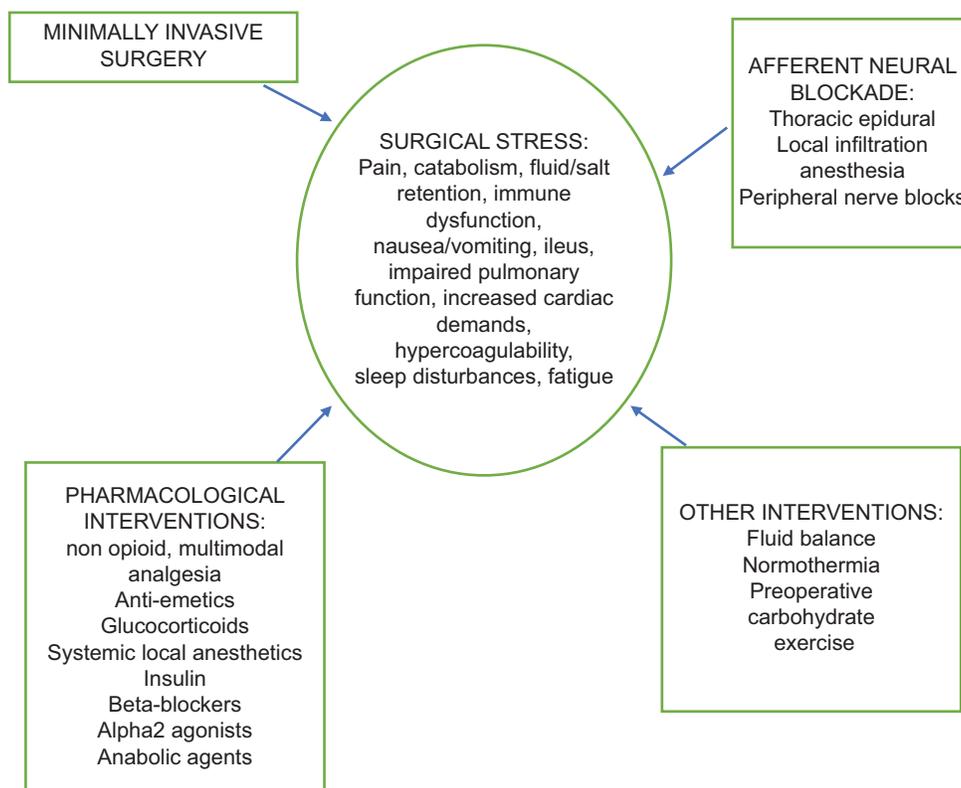


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**Corresponding Author:** Dr. Aishwaryaa Joshi, 298, Bhawani Nagar, Ghala Mala Chowk, Majitha Road, Amritsar, Punjab, India.

## APPROACHES TO REDUCE SURGICAL STRESS AND IMPROVING OUTCOMES



### GENERAL PRINCIPLES OF ERAS

- Decrease stress response to surgery: Metabolic, endocrine, and inflammatory response as well as reduce protein catabolism
- Standardization and optimization of perioperative medical care
- Decrease in the duration of stay in the hospital and return to normal life at the earliest
- Promotion of improved pain control
- Promotion of early mobility with adequate analgesia and decrease immobility related complications
- Improvement of gastrointestinal (GI) function recovery.

Traditional care in the perioperative period involves pre-operative overnight fasting (8h or more) and practice of routine mechanical bowel preparation (MBP). Routine usage of nasogastric (NG) tubes, abdominal drains and urinary catheters is recommended in the intraoperative period along with empirical hydration in the perioperative period. Traditional practices include post-operative removal of tubes on return of bowel motility, delayed enteral nutrition once bowel motility is restored and delayed mobilization of patient. All these factors are associated with prolonged hospital stay and an increase in morbidity and mortality in the post-operative period.

Certain changes which have been made in ERAS care protocols when compared with traditional care practices include minimum starvation (stop solids 6 h and liquids 2 h before surgery), no routine MBP, intake of drinks rich in carbohydrate 2 h before surgery, smoking cessation and abstinence from alcohol consumption, pre-operative exercises, use of NG tubes, abdominal drains, urinary catheters only when necessary, GDT, multimodal analgesic techniques, post-operative nausea and vomiting (PONV) prophylaxis and its management, early removal of drains, tubes and catheters, early enteral nutrition, and early post-operative mobilization.

Until now, ERAS protocols have been implemented in high-income countries. Efforts should be made for their utilization in middle- and low-income countries where they would prove to be beneficial.<sup>[6]</sup> It has the potential to improve outcome for all patients by improving the surgical pathway processes, planning and standardization of pre-operative and post-operative scenarios, and limitation of cost.<sup>[3]</sup>

Specific recommendations for specific procedures have been given by ERAS society for major elective surgeries such as colonic resection, rectal resection, gastric resection, major gynecology, bariatric surgery, breast reconstruction,

pancreaticoduodenectomy, cystectomy liver resection, head and neck cancer surgery, hip and knee replacement, thoracic surgery, and esophageal resection.<sup>[7]</sup> At present, ERAS protocols are used mainly for adult patients undergoing elective procedures. Whether similar advantages can be achieved in cases of geriatric and pediatric populations and in situations of trauma and emergency are yet to be explored.<sup>[8]</sup>

Based on scientific knowledge, there are 24 core elements of ERAS care and no single element alone can improve the outcome after surgery. It is only by the cumulative effect of these elements that the patient outcome can be improved.

## PERIOPERATIVE INTERVENTIONS IN ERAS TO EXPEDITE RECOVERY AFTER MAJOR OPERATIONS

### Pre-operative Components in Eras

#### *Patient and family education and counseling*

Preadmission education and counseling of the patient, as well as the family members who take care of the patient postoperatively, are essential components of ERAS. The provision of information by the surgeon to the patient in a tactful manner is the main purpose of the counseling session.<sup>[9]</sup> Pre-operative information and instructions about surgery to be undertaken and possible complications lead to reduction in emotional and psychological distress and thus improve post-operative recovery and discharge. It is especially found to be beneficial for patients who have depression, unrealistic expectations, and those who have limited support. Various methods which can be used for the disclosure of information include preadmission group teaching classes, video recordings, booklets, post-admission teaching sessions, and pre-operative visits from nurse/anesthesiologist.<sup>[10]</sup>

#### *Nutrition*

The term “prehabilitation” refers to the process of optimizing the functional and nutritional capacity and preparation of the patient to cope with the surgical stress.<sup>[11]</sup> Nutritional status of the patient should be properly assessed while doing a pre-operative assessment. The European Society for Clinical Nutrition and Metabolism (ESPEN) states that malnutrition can be taken as an independent risk factor for an increased rate of mortality, infection, and increased cost.<sup>[12]</sup> It is associated with delayed wound healing, wound infection, and sepsis. Pre-operative oral nutritional support for 7–14 days for severely malnourished patients is suggested under ESPEN guidelines. However, specific nutrition support goals still need to be further delineated.<sup>[12]</sup> Immunonutrition, which is enteral nutrition fortified with arginine, glutamine, and omega 3 fatty acids,

reduces the complications and length of hospital stay in patients undergoing GI surgeries.

#### *Pre-operative cessation of smoking, drinking, and recreational drugs*

An increased risk of delayed healing of wounds and severe cardiovascular and pulmonary complications postoperatively has been observed in patients with history of cigarette smoking.<sup>[13]</sup> Decreased incidence of post-operative pulmonary complications is associated with increased duration of abstinence from smoking in pre-operative period.<sup>[14]</sup> Studies have shown that intensive smoking and alcohol cessation intervention 6–8 weeks before surgery could reduce post-operative morbidity by about 50%. A careful pre-operative evaluation by the anesthesiologist is pivotal.

#### *Pre-operative exercise*

Exercise promotes an improvement in inspiratory muscle endurance, functional mobility, reduces anxiety, reduces incidence of post-operative pain, and improves the quality of life. A recent meta-analysis has concluded that inspiratory muscle training and aerobic activities are associated with reduced post-operative complications after abdominal surgeries.<sup>[15]</sup>

#### *Pre-operative fasting*

Based on various studies, it has been found that it is perfectly safe to allow patients to drink clear fluids up until 2 h before elective surgery. Overnight fasting increases the stress response and contributes to the ongoing catabolic state of the body. Minimum fasting for different ingested materials that have been recommended by the American Society of Anesthesiologists (ASA) is as follows:

- (a) Clear liquid – 2 h
- (b) Breast milk – 4 h
- (c) Infant formula – 6 h
- (d) Non-human milk – 6 h
- (e) Light meal – 6 h
- (f) Fried, fatty food – 8 h or more.

#### *Carbohydrate loading*

Surgical outcomes can be improved by optimization of metabolic state of the patient before major surgery. These perioperative metabolic strategies aim at reducing the activation of inflammatory reactions by corticosteroids, nonsteroidal anti-inflammatory drugs (NSAIDs), and minimally invasive surgery. Besides reducing insulin resistance, carbohydrate loading also leads to reduction in nitrogen and protein loss and thus improves muscle function. It is also found to be beneficial in reducing pre-operative hunger, thirst, and anxiety.<sup>[16,17]</sup> Allowing solid food up to 6 h preoperatively and a carbohydrate-rich drink (12.5%), preferably containing complex carbohydrates,

800 ml at bedtime, and 400 ml 2 h before surgery is the recommended protocol.<sup>[18]</sup> At the time of preanesthetic checkup, the patients are counseled about benefits of taking carbohydrates before surgery and accordingly strict orders are advised regarding carbohydrate loading and its timings. Regular monitoring of the blood glucose levels in the perioperative period is essential.<sup>[19]</sup> Carbohydrate loading reduces the metabolic stress of surgery, effectively reduces insulin resistance, improves pre/post-operative well-being, improves post-operative muscle function, reduces lean body mass losses, and results in faster recovery.

### ***Pre-operative bowel preparation***

MBP was used before in colorectal surgeries to reduce the fecal content in the gut, but it has been found that routine MBP leads to dehydration in the pre-operative period and is unpleasant for the patients.<sup>[20]</sup>

Disadvantages of MBP include an increase in expenses, requirement of admission to hospital before surgery, abdominal pain and bloating, fluid and electrolyte imbalance, histological changes in the colorectal mucosa, and potential bacterial translocation and disruption of anastomosis.<sup>[21,22]</sup>

Oral antibiotics may be administered for the improvement of these disadvantages caused by MBP.<sup>[23]</sup> In addition, drinking of clear fluids by the patient is encouraged up to 2 h before the induction of anesthesia.<sup>[24]</sup>

A meta-analysis of seven randomized controlled trials performed on patients who underwent elective colorectal surgery, it was found that the incidence of infection (total and surgical site infection) was less in patients who were given systemic antibiotics and MBP both in pre-operative period compared with those who were given either of the two alone.<sup>[25]</sup> Thus, ERAS guidelines with regard to the use of MBP may need to be revisited in the future.

### ***Prophylaxis of infections***

Most common nosocomial infections in surgical patients are surgical site infections, which account for approximately 500,000 infections annually and lead to an increased hospital stay, higher costs, and an increase in mortality and morbidity. Thus, prophylactic use of antibiotic regimes must be encouraged to improve surgical outcomes. It is recommended that a single dose of a broad-spectrum antibiotic, which covers both aerobic and anaerobic organisms be administered just before the administration of an incision.<sup>[26]</sup> A second dose is given if the surgical procedure lasts for more than 4 h or there is a blood loss of more than 1500 ml. Longer courses of antibiotics are no longer recommended as they are associated with risk of clostridium difficile infection.

### ***Prophylaxis of thromboembolic events***

The annual incidence of venous thromboembolism (VTE) is estimated to be 1–2/1000/year among the general population. It includes both deep vein thrombosis and pulmonary embolism.<sup>[27]</sup> Previous VTE, immobility, age >70 years, history of thromboembolic condition, heart or respiratory failure, obesity, and acute infarction or stroke are certain risk factors which are associated with an increased incidence of VTE. There are various mechanical and pharmacological measures which can be used for decreasing the incidence of thromboembolism.<sup>[28,29]</sup> The mechanical measures include use of graduated compression stockings or intermittent pneumatic compression devices. Pharmacological measures include use of low-molecular-weight heparin of which 5000 units are given subcutaneously every 8–12 h. A pre-operative assessment of the patient for the identification of the presence of any of the risk factors for thromboembolism is essential for management of anticoagulation therapy in the perioperative period >7 days before surgery to improve post-operative outcome.<sup>[30]</sup>

Other pre-operative considerations include mild perioperative hypothermia, prevention of aspiration, optimization of pre-operative hemoglobin levels, mental/psychological preparedness, fluid management, prevention of PONV, and post-operative ileus.

## **INTRAOPERATIVE COMPONENTS IN ERAS**

### ***Anesthesia Techniques***

Use of short-acting anesthetic agents, avoidance of salt and water overload, and maintenance of normothermia using a body warmer and a fluid warmer have all been shown to decrease patient complications when incorporated into an intraoperative ERAS protocol. Heat loss which occurs intraoperatively is a major risk factor that leads to increased stress response. Thus, maintenance of normothermia intraoperatively is an important component of ERAS protocols.

### ***Opioid Sparing and Multimodal Analgesia***

Perioperative multimodal analgesia uses a combination of analgesic medications that act on different sites and pathways in an additive or synergistic manner to achieve pain relief with minimal or no opiate consumption.<sup>[31]</sup> Although all medications have certain side effects, opioids, in particular, are associated with multisystem, short- and long-term effects. The strategy of post-operative minimization of opioid use reduces nausea and vomiting, impairment of bowel function, delayed mobilization, and pulmonary morbidity. Thus, ERAS protocols aim at opioid-sparing analgesia to decrease morbidity and mortality

associated with the same. Nonopioids that are commonly used in ERAS protocols include NSAIDs, gabapentin, glucocorticoids, acetaminophen, ketamine, and tramadol.<sup>[32]</sup> The regional anesthetic techniques commonly used in ERAS pathways include neuraxial techniques (epidural and spinal) and peripheral nerve blocks (transversus abdominal plane, paravertebral, brachial plexus, sciatic, and femoral nerve blocks). A regional anesthesia block used in addition to genetic algorithm is useful as it leads to:

- Reduced post-operative use of opiates
- Rapid awakening from anesthesia
- Early enteral intake and mobilization.

One of the essential missions for treating pain is the identification of high-risk patients for intractable post-operative pain, patients with history of hyperalgesia, substance abuse, and opioid dependence.

### **Surgical Approach**

Use of laparoscopic and minimally invasive techniques is preferred. For open procedures, either a transverse or a smaller vertical incision is recommended. High inspired oxygen improves blood flow at the anastomotic site and reduces risk of wound infections. It also helps in enhancing defense against microbes and improves wound healing.<sup>[33]</sup>

### **GDT**

Perioperative fluid management is a key element for the success of ERAS protocols. GDT related to ERAS protocols will minimize the complications associated with perioperative fluid imbalance. As such, there are no specified goals mentioned anywhere in GDT. The basic principle of the practice is to maximize tissue oxygenation by achieving maximum hemodynamic status with the required amount of fluid therapy. It is associated with decreased incidence of post-operative infections and organ dysfunction.<sup>[34]</sup> The parameters that matter in GDT are: Cardiac index, stroke volume, stroke volume variation, mixed venous oxygen saturation, systemic vascular resistance, and plethysmography variability index. Commonly used techniques in GDT are transesophageal echocardiography,<sup>[35]</sup> pulmonary artery catheterization,<sup>[35]</sup> arterial waveform analysis-based techniques,<sup>[36]</sup> Esophageal Doppler, and Bioimpedance based technologies.<sup>[37]</sup>

If a patient is undergoing low-risk surgery, then a “zero balance” technique should be encouraged. It has been well established that both hypervolemia and hypovolemia are associated with increased incidence of post-operative morbidity and mortality. Thus, maintenance of intravascular euolemia throughout the perioperative period is ideal. Hypotension associated with general anesthesia or epidural should be treated with vasoconstrictors rather than fluids.

### **Avoidance of Drains and NG Tubes**

Prophylactic NG tubes are not inserted routinely after bowel surgery. Meta-analyses of trials performed in GI surgery (mainly lower GI surgeries) found that avoidance of use of NG tubes was associated with acceleration of bowel functions and reduced pulmonary complications.<sup>[38]</sup> NG tube insertion postoperatively may be required in up to 15% of patients. In a meta-analysis which compared routine use of NG tube versus no use of NG tube after gastrectomy, it was found that the time to start of oral diet was short in group with no NG tube. However, no difference was observed in other complications.<sup>[39]</sup> A disadvantage of using drains is that they pose problem in early mobilization of the patient, which is further detrimental for the health of the patient. Thus avoidance/early removal of drains and NG tubes is an essential component of ERAS protocols.

### **PONV Prophylaxis**

PONV still poses an important problem in anesthesia. A simple scoring system for the identification of risk factors for PONV may be used in patients who are undergoing surgery who may benefit from prophylactic antiemetic medication. The simplified Apfel score includes four factors: Female gender, non-smoking status, post-operative use of opioids, and previous history of PONV or motion sickness.<sup>[40]</sup> Multimodal approaches involving the use of two or more prophylactic antiemetic drugs, avoiding highly emetogenic anesthetics and analgesics, and ensuring adequate hydration are strongly recommended for all patients at increased risk of developing PONV.<sup>[41,42]</sup> The ASA guidelines of 2014 suggest use of a multimodal approach with different strategies, which include reduction of baseline risks (e.g, adequate hydration, intraoperative use of propofol, dexmedetomidine, etc.), combination therapy of antiemetics using a 5HT<sub>3</sub> antagonist with droperidol or dexamethasone to effectively reduce incidence of PONV.<sup>[43]</sup> The choice of drug basically depends on patient factors, cost effectiveness, and practical considerations.

## **POST-OPERATIVE COMPONENTS IN ERAS**

### **Early Nutrition**

Starting early feed in the post-operative period decreases the need for intravenous fluid therapy as well as decreases the incidence of ileus. It reduces insulin resistance, improves muscle function, and prevents breakdown of proteins. Adequate nutrition leads to a significant decrease in mortality and morbidity, probably due to reduction in conditions which lead to death such as sepsis, pneumonia, cardiac dysfunction, and anastomotic dehiscence as well a reduction in length of hospital stay.

### **Early Mobilization**

Immobilization has deleterious effects on patients, especially on the musculoskeletal, cardiovascular, and respiratory

systems. Thus, early mobilization is an essential component of ERAS protocols to reduce post-operative complications. Reduction in skeletal muscle loss and improvement of respiratory function and delivery of oxygen to tissues is observed with early mobilization.<sup>[44]</sup> Physical activity is associated with improvement in cardiopulmonary functions, decreased fatigue symptoms, and improved muscular strength and quality of life. It is recommended that on the day of surgery, the patients should sit out of bed for 2 h and at least 6 h a day until discharge.<sup>[45]</sup> The involvement of physiotherapy and rehabilitation departments is essential. Adequate analgesia with multimodal approach is vital to ensure successful and less distressing early ambulation.

### Multimodal Analgesia

Post-operative pain relief promotes early mobilization, early feeding, and reduces stress-related complications.<sup>[46]</sup> It consists of the use of a combination of regular acetaminophen, NSAIDs, local infiltration techniques, regional blocks, epidural techniques, patient-controlled analgesia, and patient-controlled epidural analgesia. Epidural when used in major surgeries are known to be associated with decreased incidence of bowel ileus and respiratory complications.<sup>[47]</sup> ERAS protocols promote the use of opioid sparing analgesia because excessive use of opioids is associated with an increase in risk of sedation, PONV, ileus, and respiratory complications.<sup>[48]</sup>

### Post-operative Glycemic Control

Target blood sugar should be between 180 mg/dl and 200 mg/dl and patients having blood glucose higher than this range should be treated with insulin therapy. It is recommended to do regular blood glucose monitoring to prevent iatrogenic hypoglycemia.

### Maintenance of Hydration

ERAS promotes abstinence from intravenous fluid therapy as soon as the patient can take fluids orally. Early starting of oral fluids including carbohydrate drinks should be encouraged as it improves healing conditions and promotes early discharge without an increase in morbidity. There are several benefits of improved perioperative management of fluids. These benefits range from improved pulmonary functions, GI motility, tissue oxygenation, and wound healing. One important aspect that needs to be kept in mind is prevention of fluid overload. Wound healing is delayed in case of tissue hypoxia, which results from fluid overload.<sup>[49]</sup> In the post-operative period, in response to stress of surgery, some extent of oliguria appears to be a normal physiological response. Although traditionally oliguria is considered a sign of hypovolemia, perioperative oliguria is not considered to be abnormal always if it is not associated with other signs of hypovolemia.<sup>[50]</sup> Oliguria is considered to be an expected occurrence due to judicious

fluid management in the perioperative period. However, if a patient presents with anuria, it should be taken seriously.

### Patient and Family Education

Post-operative care of the patient by the family members creates a positive environment and promotes early recovery of the patient. The patient as well as the family members should be informed about the possible complications in the post-operative period to reduce emotional and psychological stress.

## CONCLUSION

ERAS protocols aim at blunting of the catabolic response of the body towards the stress of surgery. They require proper implementation in the pre-operative, intraoperative, and post-operative periods for the achievement of better results; in terms of early post-operative recovery. Although a protocolized approach is recommended by the ERAS guidelines for a good outcome, it has been observed that even the individual elements of ERAS protocols when applied, have been found to be beneficial.

ERAS is patient centered and includes evidence-based protocols that have a significant effect on early post-operative recovery and reduced length of hospital stay. However, in spite of the significant progress in its implementation in recent years, still its widespread adoption is limited and there is significant work and research to be done in near future.

## REFERENCES

1. Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. *Am J Surg* 2002;183:630-41.
2. Eskicioglu C, Forbes SS, Aarts MA, Okrainec A, McLeod RS. Enhanced recovery after surgery (ERAS) programs for patients having colorectal surgery: A meta-analysis of randomized trials. *J Gastrointest Surg* 2009;13:2321-9.
3. Cannesson M, Kain Z. Enhanced recovery after surgery versus perioperative surgical home: Is it all in the name? *Anesth Analg* 2014;118:901-2.
4. Lassen K, Coolsen M, Slim K, Carli F, de Aguiar-Nascimento JE, Schäfer M, *et al.* Guidelines for perioperative care for pancreaticoduodenectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Clin Nutr* 2012;31:817-30.
5. Steenhagen E. Enhanced recovery after surgery: It's time to change practice! *Nutr Clin Pract* 2016;31:18-29.
6. McQueen K, Oodit R, Derbew M, Banguti P, Ljungqvist O. Enhanced recovery after surgery for low-and middle-income countries. *World J Surg* 2018;42:950-2.
7. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: A review. *JAMA Surg* 2017;152:292-8.
8. Singh M, Askari R, Stopfkuchen-Evans M. Enhanced recovery after surgery: Are the principles applicable to adult and geriatric acute care and trauma surgery? *Anesthesiol Clin* 2019;37:67-77.
9. Shenson JA, Craig JN, Rohde SL. Effect of preoperative counseling on hospital length of stay and readmissions after total laryngectomy. *Otolaryngol Head Neck Surg* 2017;156:289-98.
10. Lepczyk M, Raleigh EH, Rowley C. Timing of preoperative patient teaching. *J Adv Nurs* 1990;15:300-6.

11. Leissner KB, Shanahan JL, Bekker PL, Amirfarzan H. Enhanced recovery after surgery in laparoscopic surgery. *J Laparoendosc Adv Surg Tech A* 2017;27:883-91.
12. Braga M, Ljungqvist O, Soeters P, Fearon K, Weimann A, Bozzetti F, *et al.* ESPEN guidelines on parenteral nutrition: Surgery. *Clin Nutr* 2009;28:378-86.
13. Turan A, Mascha EJ, Roberman D, Turner PL, You J, Kurz A, *et al.* Smoking and perioperative outcomes. *Anesthesiology* 2011;114:837-46.
14. Theadom A, Cropley M. Effects of preoperative smoking cessation on the incidence and risk of intraoperative and postoperative complications in adult smokers: A systematic review. *Tob Control* 2006;15:352-8.
15. Moran J, Guinan E, McCormick P, Larkin J, Mockler D, Hussey J, *et al.* The ability of prehabilitation to influence postoperative outcome after intra-abdominal operation: A systematic review and meta-analysis. *Surgery* 2016;160:1189-201.
16. Soop M, Nygren J, Thorell A, Weidenhielm L, Lundberg M, Hammarqvist F, *et al.* Preoperative oral carbohydrate treatment attenuates endogenous glucose release 3 days after surgery. *Clin Nutr* 2004;23:733-41.
17. Hausel J, Nygren J, Lagerkranser M, Hellström PM, Hammarqvist F, Almström C, *et al.* A carbohydrate-rich drink reduces preoperative discomfort in elective surgery patients. *Anesth Analg* 2001;93:1344-50.
18. Nygren J, Thorell A, Ljungqvist O. Preoperative oral carbohydrate nutrition: An update. *Curr Opin Clin Nutr Metab Care* 2001;4:255-9.
19. Gustafsson UO, Nygren J, Thorell A, Soop M, Hellström PM, Ljungqvist O, *et al.* Pre-operative carbohydrate loading may be used in Type 2 diabetes patients. *Acta Anaesthesiol Scand* 2008;52:946-51.
20. Jung B, Pählman L, Nyström PO, Nilsson E, Mechanical Bowel Preparation Study Group. Multicentre randomized clinical trial of mechanical bowel preparation in elective colonic resection. *Br J Surg* 2007;94:689-95.
21. Saha AK, Chowdhury F, Jha AK, Chatterjee S, Das A, Banu P. Mechanical bowel preparation versus no preparation before colorectal surgery: A randomized prospective trial in a tertiary care institute. *J Nat Sci Biol Med* 2014;5:421-4.
22. Ballantyne GH. The experimental basis of intestinal suturing. Effect of surgical technique, inflammation, and infection on enteric wound healing. *Dis Colon Rectum* 1984;27:61-71.
23. Gupta R, Gan TJ. Peri-operative fluid management to enhance recovery. *Anaesthesia* 2016;71 Suppl 1:40-5.
24. Carmichael JC, Keller DS, Baldini G, Bordeianou L, Weiss E, Lee L, *et al.* Clinical practice guidelines for enhanced recovery after colon and rectal surgery from the American society of colon and rectal surgeons and society of American gastrointestinal and endoscopic surgeons. *Dis Colon Rectum* 2017;60:761-84.
25. Chen M, Song X, Chen LZ, Lin ZD, Zhang XL. Comparing mechanical bowel preparation with both oral and systemic antibiotics versus mechanical bowel preparation and systemic antibiotics alone for the prevention of surgical site infection after elective colorectal surgery: A meta-analysis of randomized controlled clinical trials. *Dis Colon Rectum* 2016;59:70-8.
26. Alfonsi P, Slim K, Chauvin M, Mariani P, Faucheron JL, Fletcher D, *et al.* Guidelines for enhanced recovery after elective colorectal surgery. *Ann Fr Anesth Reanim* 2014;33:370-84.
27. Goldhaber SZ. Venous thromboembolism: Epidemiology and magnitude of the problem. *Best Pract Res Clin Haematol* 2012;25:235-42.
28. Laryea J, Champagne B. Venous thromboembolism prophylaxis. *Clin Colon Rectal Surg* 2013;26:153-9.
29. Chen AH, Frangos SG, Kilaru S, Sumpio BE. Intermittent pneumatic compression devices-physiological mechanisms of action. *Eur J Vasc Endovasc Surg* 2001;21:383-92.
30. Douketis JD, Spyropoulos AC, Spencer FA, Mayr M, Jaffer AK, Eckman MH, *et al.* Perioperative management of antithrombotic therapy: Antithrombotic therapy and prevention of thrombosis, 9<sup>th</sup> ed: American college of chest physicians evidence-based clinical practice guidelines. *Chest* 2012;141:e326S-50.
31. Brown AK, Christo PJ, Wu CL. Strategies for postoperative pain management. *Best Pract Res Clin Anaesthesiol* 2004;18:703-17.
32. Beverly A, Kaye AD, Ljungqvist O, Urman RD. Essential elements of multimodal analgesia in enhanced recovery after surgery (ERAS) guidelines. *Anesthesiol Clin* 2017;35:e115-43.
33. Kabon B, Kurz A. Optimal perioperative oxygen administration. *Curr Opin Anaesthesiol* 2006;19:11-8.
34. 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;62:158-68.
35. Sangkum L, Liu GL, Yu L, Yan H, Kaye AD, Liu H. Minimally invasive or noninvasive cardiac output measurement: An update. *J Anesth* 2016;30:461-80.
36. Li MQ, Yang LQ, Zhou L, Liu J, Liu H. Non-invasive cardiac output measurement: Where are we now? *J Anesth Perioper Med* 2018;5:221-7.
37. Jordan HS, Ioannidis JP, Goudas LC, Chung M, Kupelnick B, Miller K, *et al.* Thoracic Electrical Bioimpedance. Rockville (MD): Agency for Healthcare Research and Quality (US); 2002.
38. Nelson R, Edwards S, Tse B. Prophylactic nasogastric decompression after abdominal surgery. *Cochrane Database Syst Rev* 2007;3:CD004929.
39. Yang Z, Zheng Q, Wang Z. Meta-analysis of the need for nasogastric or nasojejunal decompression after gastrectomy for gastric cancer. *Br J Surg* 2008;95:809-16.
40. Apfel CC, Korttila K, Abdalla M, Kerger H, Turan A, Vedder I, *et al.* A factorial trial of six interventions for the prevention of postoperative nausea and vomiting. *N Engl J Med* 2004;350:2441-51.
41. Habib AS, White WD, Eubanks S, Pappas TN, Gan TJ. A randomized comparison of a multimodal management strategy versus combination antiemetics for the prevention of postoperative nausea and vomiting. *Anesth Analg* 2004;99:77-81.
42. White PF. Prevention of postoperative nausea and vomiting--a multimodal solution to a persistent problem. *N Engl J Med* 2004;350:2511-2.
43. Gan TJ, Meyer TA, Apfel CC, Chung F, Davis PJ, Habib AS, *et al.* Society for ambulatory anesthesia guidelines for the management of postoperative nausea and vomiting. *Anesth Analg* 2007;105:1615-28.
44. Papaspyros S, Uppal S, Khan SA, Paul S, O'Regan DJ. Analysis of bedside entertainment services' effect on post cardiac surgery physical activity: A prospective, randomised clinical trial. *Eur J Cardiothorac Surg* 2008;34:1022-6.
45. Massey RL. A randomized trial of rocking-chair motion on the effect of postoperative ileus duration in patients with cancer recovering from abdominal surgery. *Appl Nurs Res* 2010;23:59-64.
46. Liu SS, Wu CL. Effect of postoperative analgesia on major postoperative complications: A systematic update of the evidence. *Anesth Analg* 2007;104:689-702.
47. 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;98:1068-78.
48. Kamdar NV, Hoftman N, Rahman S, Cannesson M. Opioid-free analgesia in the era of enhanced recovery after surgery and the surgical home: Implications for postoperative outcomes and population health. *Anesth Analg* 2017;125:1089-91.
49. Voldby AW, Brandstrup B. Fluid therapy in the perioperative setting-a clinical review. *J Intensive Care* 2016;4:27.
50. Johnson BL 3<sup>rd</sup>, Davis BR, Rafferty JF, Paquette IM. Postoperative predictors of early discharge following laparoscopic segmental colectomy. *Int J Colorectal Dis* 2015;30:703-6.

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