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REVIEW

Enhanced recovery after vascular surgery

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ABSTRACT

INTRODUCTION: A multimodal perioperative care measure, the enhanced recovery after surgery (ERAS) method, is intended to accomplish early recovery following surgical procedures. It aims to preserve preoperative organ function and mitigate the significant stress response that typically occurs during recovery.

EVIDENCE ACQUISITION: The goal of this systematic review and meta-analysis was to evaluate the advantages of enhanced recovery in the scope of vascular surgery. Following PRISMA Guidelines, a systematic search was conducted on various electronic reference databases (Web of Sciences, PubMed and Cochrane library). The keywords employed were ("Enhanced Recovery After Surgery" OR "ERAS") AND (vascular) AND ("surgery" OR "operation" OR "procedure"). Inclusion criteria are articles published in English, and full-text was available, published between 2013-2023. Data was obtained on hospitalization duration, in hospital mortality, and post-surgical morbidity.

EVIDENCE SYNTHESIS: Five hundred seventeen articles were identified and seven papers involving 1954 patients included for systematic review. The incidence of postoperative morbidity demonstrated a significant reduction when utilizing the ERAS approach in comparison to non-ERAS protocols (OR=0.21 [95%CI, 0.08 to 0.54], P=0.001). Additionally, the implementation of an ERAS protocol resulted in a notable reduction in hospitalization duration (MD=-0.59 [95%CI, -1.13 to -0.04], P=0.04). Furthermore, no significant difference was identified in hospital mortality rates.

CONCLUSIONS: The multimodal perioperative care approach known as Enhanced Recovery After Surgery (ERAS) method is intended to facilitate immediate postoperative recovery by safeguarding preoperative organ function and reducing the visceral stress response post-surgery. The utilization of ERAS, coupled with enhanced perioperative care, brings substantial advantages to patients undergoing vascular surgery as well as those undergoing a range of other surgical specialties.

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KEY WORDS: Enhanced recovery after surgery; Vascular surgical procedures.

Introduction

A multimodal perioperative care measure, the enhanced recovery after surgery (ERAS) method, is intended to accomplish early recovery following surgical procedures. It aims to preserve preoperative organ function and mitigate the significant stress response that typically occurs during recovery.[1]

The initial establishment and successful execution of ERAS method occurred in colorectal surgery. Subsequently, there have been reports of its implementation in orthopedic, cardiac, and vascular surgery as well.[2]

Due to the diverse range of vascular surgery types, such as endovascular, open, and hybrid procedures, patients may encounter various complications during their post-procedural recovery. As a result, each type of vascular surgery is associated with its own specific set of complications. Unlike other surgical specialties that typically concentrate on a specific body region, vascular surgeons undertake a wide array of surgeries, including cervical,

retroperitoneal, transabdominal, and upper and lower extremity procedures.[3]

The ideal approach to enforcing ERAS involves skilled and adaptable vascular team comprising surgeons, anesthesiologists, nurses, and therapists, who can follow a clinical pathway or protocol. Patient participation in smoking cessation, preoperative nutrition, and exercise programs would also be beneficial to reduce known risks. However, in the absence of clear guidance and assistance from the vascular team, geriatric patients often encounter comorbidities, decreased mobility, and access issues. The utilization of ERAS, coupled with enhanced perioperative care, brings substantial advantages to patients undergoing vascular surgery as well as those undergoing a range of other surgical specialties.[3]

Evidence acquisition

Research methodology

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines were adhered to in this systematic review. Relevant studies published until April 23, 2023 were identified through electronic data searches in Web of Science, Cochrane Library, and PubMed. The search terms utilized were as follows: ("Enhanced Recovery After Surgery" OR "ERAS") AND (vascular) AND ("surgery" OR "operation" OR "procedure"). In addition, manual searches were conducted to identify potentially pertinent articles from the source list of collected studies. The search was restricted to English-language articles, and all searches were restricted to publications between the years 2013 and 2023.

Selection of studies and eligibility criteria

The process of selecting studies involved multiple stages and specific criteria for eligibility. Initially, the remaining articles underwent filtering based on their titles, followed by screening the abstracts of potentially relevant articles. Subsequently, articles that satisfied the eligibility criteria and had complete full texts were retrieved and evaluated. The entire study selection procedure was carried out separately by two researchers, and any disputes that arose were settled through discussions with the other investigators until a consensus was reached.

We included any single arm or comparative observational studies or randomized clinical trials. The study participants were exclusively adults (over 18 years old) going through either endovascular or open procedures on the venous or arterial system. The focus of interest was on the implementation of a standard ERAS-like pathway or specific components of an ERAS pathway (including early mobility, multimodal analgesia, coordinated perioperative care, and patient education) during the prompt perioperative period. Exclusion criteria encompassed studies with inaccessible full texts, impertinent titles or abstracts, case series, review articles, letters to the editors, conference abstract, or case reports. Additionally, non-English studies, research involving children (<18 years old), postoperative or outpatient recovery pathway, and studies lacking adequate data to compute effect sizes for the outcomes were likewise excluded. The outcomes of interest were post-operative morbidity (involving any adverse events), duration of hospitalization, and in-hospital mortality.

Data retrieval

Two writers independently conducted the data extraction process, and the extracted data were subsequently cross-checked for accuracy. In the event of any discrepancies, a discussion was held to reach a consensus. Pertinent information from each included study was collected, including study-related details (such as first author, study design, study location, study period, and year of publication), demographic data (including age and sample size), as well as outcome data.

Statistical analysis

All analyses were performed using Review Manager version 5.4 (The Cochrane Collaboration, The Nordic Cochrane Centre, Copenhagen, Denmark). Odds Ratio (OR) and mean difference (MD) were utilized as the outcome measures for dichotomous data and continuous, respectively. The P value and 95% confidence interval (CI) were reported for the measures. Meta-analysis was performed for each outcome if at least two studies reported the same type of data. Heterogeneity among the studies was assessed using Cochran's Q and I^2 statistics. In cases where there was no significant heterogeneity (P value >0.1, I^2<50%), a fixed-effects model was utilized for meta-analysis. Alternatively, a random-effects model was employed when heterogeneity was present. Potential publication bias was examined visually using Begg's funnel plots. Significance in all analyses was indicated by a P value <0.05.

Evidence synthesis

Study selection

We retrieved 511 records from the initial database query and six more records via manual searching. After screen-

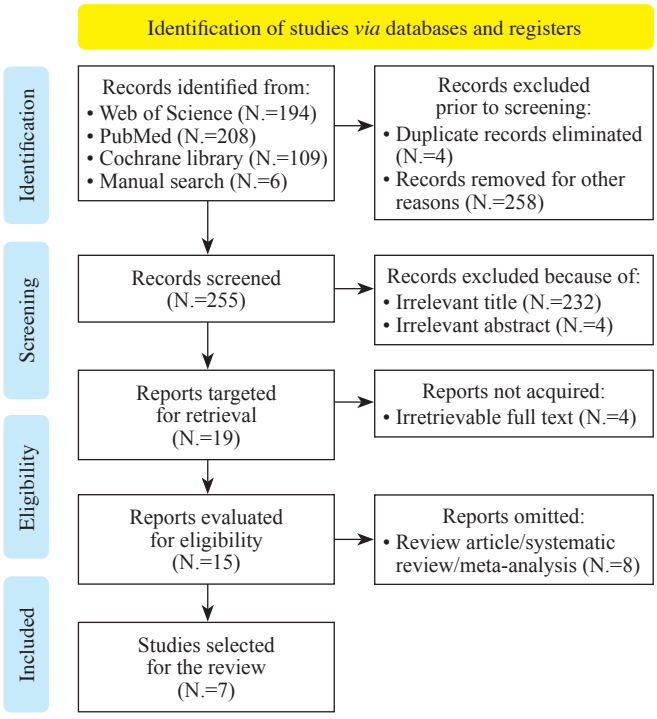

Figure 1.—Flow diagram illustrating the study selection process based in PRISMA guidelines (Adapted from Page *et al.*).[4]

ing the titles and abstracts, 19 articles were identified as potentially eligible for review. Following a thorough assessment of the full texts, seven studies met the criteria and were included. The PRISMA flow chart (Figure 1) provides a summary of the process of selecting studies.[4]

Study characteristics

The characteristics of the seven included studies, which are relevant to this analysis, are presented in Table I.[2, 5-10] It comprises one randomized controlled trial (RCT), five observational studies, and one descriptive study. These studies collectively involved a total of 1954 patients who underwent vascular surgery. Among the included studies, the majority (N.=6) were conducted in Europe, while one study was conducted in Asia. For detailed information on the outcomes of each individual study, please refer to Table II.[2, 5-10]

Patient's characteristics

In this systematic review, we only included adult patients who underwent ERAS elements included in vascular surgery. In terms of types of vascular surgery, five studies[2, 7-10] investigating the impact of ERAS on abdominal aortic aneurysm repair, one study[6] on varicose vein surgery and one study on coronary artery surgery.[5]

Postoperative morbidity

In the current study, post-operative morbidity was defined as any complications that occurred following vascular surgery. Out of the six studies available on post-operative morbidity, the meta-analysis included data from five studies, which involved 873 patients. A pooled estimate of five studies showed significant differences in the incidence of postoperative morbidity (OR=0.21 [95%CI, 0.08 to 0.54], P=0.001), in which individuals who underwent ERAS elements included in vascular procedure had lower odds in developing any complications following vascular surgery; thus, suggesting the benefit of ERAS protocol implementation (Figure 2).[2, 5, 6, 9, 10] In terms of potential publication bias, Begg's funnel plots analysis was performed qualitatively by visual inspections as documented in Figure 3.

In hospital mortality

Information regarding hospital mortality was obtained from a total of five studies involving 1511 patients.[5-10] A total of 23 mortality was reported among patients who underwent abdominal aortic aneurysm repair utilizing ERAS protocol, whereas no mortality reported among patients who underwent coronary artery surgery implementing ERAS protocol. Nevertheless, since the majority of the studies reported no mortality and lack of comparison group; thus, meta-analysis cannot be generated.

Duration of hospitalization

Information on the duration of hospitalization following vascular surgery was provided by a total of seven studies. However, the meta-analysis included only three studies involving 246 patients.[5-8] A pooled estimate of three studies showed significant differences in the mean hospital stay (MD=-0.59 [95%CI, -1.13 to -0.04], P=0.04), in which individuals who underwent ERAS elements included in vascular surgery had shorter period of hospitalization compared to control group; thus, suggesting the benefit of ERAS protocol implementation (Figure 4).[5, 8, 10]

Discussion

Counseling, risk assessment, and optimization in preoperative

The ERAS protocol guides postoperative mobilization, discharge planning, and nutrition in the perioperative pe-

TABLE I.—*Characteristics of the included studies.*[2, 5-10]

Authors	Country	Study Design	Study Period	Population	Age (mean±SD)/ median (IQR)	Intervention	Comparison	Outcome
Renghi *et al.*[10]	Italy	RCT	2005-2006	59 patients underwent mini-invasive abdominal aortic surgery in a fast-track	I=72.2±9.6 C=68.9±10	Thoracic epidural infusion	Local analgesia	Postoperative recovery, day of discharge, postoperative complication
Martelli *et al.*[9]	Italy	Retrospective cohort	2006-2010	97 patients with abdominal aortic aneurysms underwent EVAR *vs.* fast-track open protocol	I=83±2 C=82±1.5	Left subcostal incision, no opioids, epidural analgesia, early mobilization and feeding	Endovascular aneurysm repair (EVAR) group	Intraoperative outcome (length of surgery, infusion, blood and liquid loss), in hospital mortality, postoperative complication
Hayashi *et al.*[8]	Japan	Descriptive study	2012-2014	67 patients underwent open abdominal aortic aneurysm repair	I=68.7±6.1 C=69.0±7.6	Preoperative 6-minute walk test	Patients who achieved ambulation independence on/ after postoperative day 3	Pre, intra, and postoperative recovery outcome
Feo *et al.*[2]	Italy	Retrospective cohort	2005-2013	221 patients underwent abdominal aortic aneurysm repair	I=69.9±8.6 C=71.1±8.2	Preoperative consultation, Two-hour preoperative fasting, NG tube removed in PACU, epidural analgesia, early mobilization and feeding	Patients who had undergone conventional perioperative protocols	Postoperative morbidity and mortality, time to functional recovery, hospital length of stay, readmission rate
Brustia *et al.*[7]	Italy	Retrospective study	2000-2014	1,014 patients underwent abdominal aortic aneurysm repair	70.49±8.2	Left subcostal incision, epidural analgesia, early mobilization and feeding	N/A	The incidence and characteristics of postoperative complications, the mortality rate, and the time of discharge to home for patients
Licker *et al.*[6]	Switzerland	Prospective study	2009-2011	376 patients underwent varicose vein surgery	I=47±14 C=47±14	Local analgesia plus sedation *vs.* general anesthesia	Patients receiving general anesthesia or spinal anesthesia	Post-operative recovery time, length of stay, hospital costs, adverse events
Anastasiadis *et al.*[5]	Greece	Prospective study	2010-2011	120 patients underwent elective coronary artery surgery	I=64.4±9.9 C=65.1±7.8	Minimal extracorporeal circualtion (MECC)	Patients who underwent conventional cardiopulmonary bypass	Rate of fast-track recovery, overall morbidity and mortality, need for perioperative blood transfusion, chest tube drainage, and duration of hospitalization

TABLE II.—*Outcomes of individual studies.*[2, 5-10]

Authors	Post-operative morbidity, *n*	In hospital mortality, *n*	Hospital Length of Stay, days, mean±SD / median (range)
Renghi *et al.*[10]	I=15/29 C=24/30	I=0 C=0	I=3.2±1.4 C=3.4±1.7
Martelli *et al.*[9]	I=11/55 C=9/42	I=0 C=0	4 (mean of both groups); on the third day: I=64% of patients C=42.9% of patients
Hayashi *et al.*[8]	NR	N/A	I=9.8±2.1 C=11.1±2.8
Feo *et al.*[2]	I=24/130 C=62/91	I=3/130 C=3/91	I=5 (4-7) C=7 (6-9)
Brustia *et al.*[7]	104/1,014	17/1,014	3.97±2.7
Licker *et al.*[6]	I=8/176 C=82/200	NR	I=patients were eligible for discharge on the day of surgery; C=14 patients required overnight hospital admission
Anastasiadis *et al.*[5]	I=3/60 C=8/60	I=0 C=0	I=10.8±2.6 C=11.5±2.8

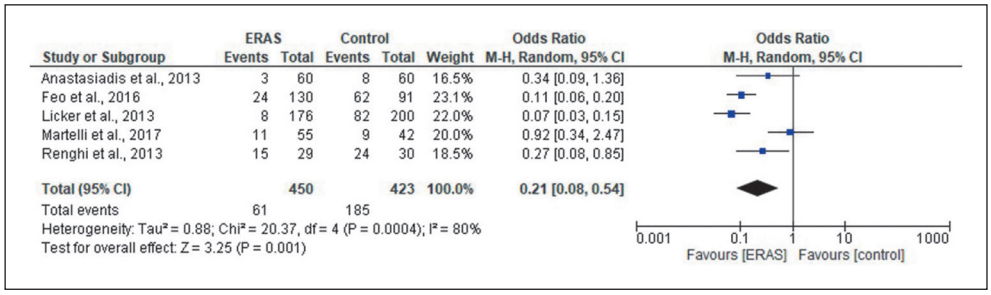

Figure 2.—Forest plot.[2, 5, 6, 9, 10]

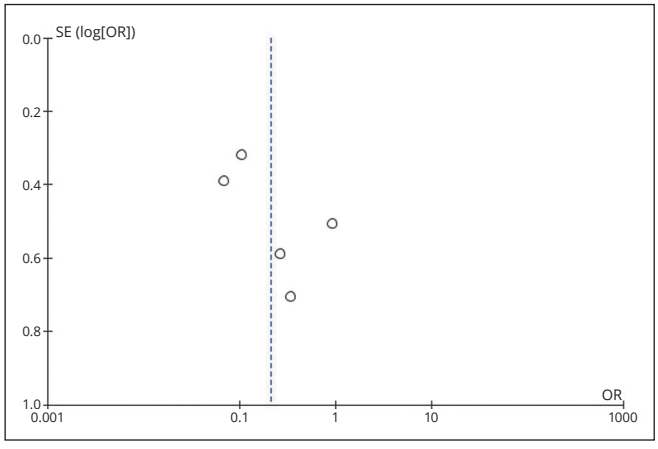

Figure 3.—Funnel plot.

riod. ERAS can also be used in vascular surgery to implement strategies to optimize preoperative chronic medical conditions and lifestyle factors as presented in Table III.[3]

The preoperative evaluation is of utmost importance as it allows the physician to assess risks, evaluate the patient's stability in relation to preexisting conditions, and maximize pre-operative organ function. This is particularly significant as postoperative dysfunction often correlates with preexisting comorbidities. When ERAS anxiety is present, it is projected that the duration of hospitalization and requirement for analgesics can be decreased. Table IV illustrates the suggested guidelines for ERAS implementation in vascular surgery (including preoperative, intraoperative, and postoperative periods).[2]

Patients should prioritize premedication to minimize

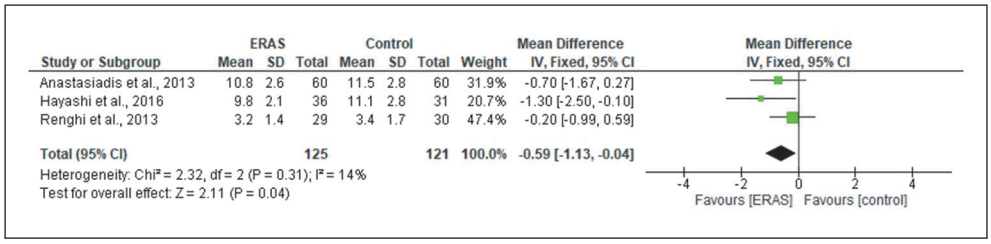

Figure 4.—Forest plot.[5, 8, 10]

TABLE III.—*ERAS in vascular surgery.*[2]

Respiratory
Preoperative antibiotics use
Early extubation
Protective modes of ventilation
Prevention of ventilator-associated pneumonia
High-flow oxygen therapy or intermittent nasal continuous positive airway pressure after extubation
Breathing exercises
Cardiovascular
Monitoring for signs of myocardial ischemia
Goal directed fluid therapy
Maintaining the MAP above 80–90 mmHg
Renal
Monitoring of the amount of urine and creatinine clearance
Maintaining the normovolemia and electrolyte balance
Use diuretics with caution
Avoid fluid overload and dopamine
Nutrition
Without preoperative mechanical bowel preparation
Maintenance the glucose level <215 mg/dL
Oral nutrition within the first 24-48 h after operation
Use prokinetics (metoclopramid and erithromycin)
Avoidance of nasogastric drainage or early removal
Monitoring of IAP
Pain management
PCEA 48 h before and 48 h after intervention
Avoid systemic opioid use
Other
Stabilize already existing disease and optimize organ dysfunction before surgery
Oral carbohydrate drinks before surgery
Minimize the time for surgical intervention
Patient education
Consider thromboprophylaxis
Avoid hypothermia
Early mobilization

TABLE IV.—*ERAS in vascular surgery.*[1]

Preoperative	Perioperative	Postoperative
Patient counseling/ education	Abdominal drains (none)	Regular diet
Fasting (reduced)	Nasogastric tube (none)	Early feeding
Use of non-steroidal anti-inflammatory drugs (NSAIDs)	Fluid restriction	Pain management
Carbohydrate enriched drinks	Analgesia – NSAIDS, narcotics, use of epidural analgesia	Chewing gum/ileus
Stress management	Fluid restriction	Early ambulation
Patient expectations (managing)		Exercise therapy
		Patient discharge planning
Accelerated rehabilitation	Urinary catheter (time of removal)	Removal of epidural catheter

the surgical stress response. Beta-blockers are effective in reducing catecholamine levels and cardiovascular complications both during and after surgery. Given that surgical procedures trigger sympathetic system activation and stress-induced catabolism, the use of anti-catabolic medications can positively impact the postoperative recovery. Alpha-2 adrenergic agonists like clonidine and dexmedetomidine are particularly beneficial, as they help reduce postoperative nausea and vomiting, intraoperative blood loss, and myocardial ischemia.[2]

Fasting overnight before surgery serves multiple purposes, including preventing dehydration and minimizing the likelihood of postoperative complications such as pain and nausea. Clear carbohydrate fluids may reduce postoperative anxiety and endocrine response if administered during this period.[2]

Cardiovascular risk evaluation and optimization

Optimal management of cardiovascular risk is crucial in vascular patients due to the high prevalence of cardiac comorbidities, which can significantly impact surgical outcomes. In alignment with the guidelines set forth by the American Heart Association (AHA), the implementation of ERAS method should adhere to the AHA's recommendations for preoperative cardiovascular evaluation and optimization. This may involve conducting diagnostic tests such as electrocardiograms, echocardiograms, and stress testing to assess and manage the cardiovascular risk in patients with preexisting heart conditions. Continuation of medications such as statins, angiotensin-converting enzyme inhibitors/angiotensin receptor blockers, beta-blockers, and antiplatelet agents during the surgical period is crucial as part of the comprehensive medical management of vascular disease. When appropriate, higher-risk inpatients should be referred to a cardiologist for overall preoperative assistance and optimization and postoperative care.[3]

Anticoagulants

Patients undertaking vascular rehabilitation may be limited in their selection of regional anesthetic techniques due to the routine use of systemic anticoagulants. Anticoagulants pose a risk of bleeding complications in vascular patients. ERAS facilitates the implementation of protocols for managing anticoagulation, including discontinuation and reintroduction, to ensure patient safety and optimize outcomes. The operation of the ERAS system will include instructions on preoperative anticoagulant use, the scheduling of anticoagulant discontinuation, and postoperative anticoag-

ulant resumption. Anticoagulant reversal agents are typically reserved for emergent or emergency situations.[3]

Tobacco cessation

Tobacco cessation is crucial in vascular patients due to its detrimental effects on vascular health, perioperative complications, and wound healing. With a high prevalence of tobacco use among vascular patients, incorporating tobacco cessation as part of the ERAS pathway would greatly benefit their outcomes. Hospitalization presents an opportune moment to motivate patients to quit smoking and promote tobacco cessation. Patients are often more receptive to quitting during this time of treatment, making it an ideal opportunity to provide support and encourage tobacco cessation efforts. For patients who are not ready to quit smoking, ERAS combines additional nicotine treatment regimens (*i.e.*, gum, patches) with counseling efforts.[3, 11]

Physical exertion

According to Hayashi.*et.al*., regular physical activity before surgery can improve the condition of AAA patients. Regular physical activity refers to exercising for at least 30 minutes, twice a week, over a duration of at least one year. The specific amount and duration of activity required for visible results remain uncertain. Nevertheless, patients should be notified that initiating or maintaining an exercise program before surgery may lead to a reduce duration of hospitalization and accelerated healing. The patient's preoperative activity level should also be considered when discussing expected postoperative recovery time.[8]

Perioperative pain control

Aortic surgery is one of the most important interventions in vascular surgery. Today, endovascular management and open surgery are the most common surgical techniques. According to Hertzer *et al.*, elective open infrarenal aortic surgery is associated with an average ICU stay of approximately three days and a mortality rate ranging from 1.2% to 10.5%.[12] Both endovascular and open surgery are prone to postoperative complications such as graft migration, thrombosis, and aneurysm rupture. However, endovascular management offers advantages in terms of shorter procedure duration, reduced blood loss risk, decreased risk of malnutrition, and shortened hospitalization.[11, 13, 14]

Regional anesthesia

Epidural anesthesia is found to be more commonly employed compared to regional anesthesia among the 12 studies investigating ERAS-like pathways in open aortic surgery. Studies that incorporate epidural anesthesia as part of the ERAS pathway have shown positive results, such as reduced complication rates, faster extubation after surgery, shorter ICU stays, and shorter length of stays. Multiple of these studies report effective pain management without the use of analgesics. Epidural anesthesia has been found to decrease the release of epinephrine in patients undergoing coronary artery bypass graft surgery, potentially lowering the occurrence of myocardial ischemia and consequently reducing mortality and morbidity rates. The observed decrease in complication rates among patients receiving epidural anesthesia during vascular surgery is thought to be attributed to the attenuated stress response. The combined use of epidural and general anesthesia in aortic surgery has been shown to reduce the requirement for mechanical ventilation compared to general anesthesia alone.[3]

According to Muehling *et.al.*, In patients who received epidural anesthesia, the incidence of postoperative mechanical ventilation was significantly lower (5%) compared to those who received only general anesthesia in the "traditional" group (33%). This is because patients receiving epidural anesthesia use less intraoperative inhalational anesthetics. In different study comparing general anesthesia combined with an epidural to general anesthesia alone in open aortic surgery, no significant differences were observed in ICU stay, hospital stay, time to oral intake, time to ambulation, mortality, or morbidity. However, similar to Muehling's investigation, patients who underwent epidural anesthesia were extubated considerably earlier compared to those who only received general anesthesia.[13]

In all cases, patients were provided with nasogastric tubes until bowel sounds resumed. However, the lack of a feeding protocol and active ambulation might have hindered the potential benefits of epidural anesthesia. The combination of various components in the ERAS pathway demonstrates synergistic and beneficial effects.[3]

Delirium screening

Delirium is a common coexisting condition in patients with vascular disease and is often overlooked, resulting in a decline in functional ability. To prevent delirium, it is crucial to minimize unnecessary stays in the intensive care unit, minimize opioid usage, promote early ambulation, establish a healthy sleep pattern, optimize the day/night cycle, and provide visual and verbal cues for orientation. Regular and thorough screening for delirium should be implemented as part of routine care.[3]

Postoperative period

The postoperative period is of utmost importance in the recovery of patients undergoing vascular surgery. Important to a successful recovery is the caliber of postoperative care. The optimization of microcirculation, inflammatory response management, fluid resuscitation, hemodynamic support, blood glucose levels, aerobic metabolism, oxygen delivery, and appropriate use of vasoconstrictors and vasodilators are key aspects in achieving successful outcomes in vascular surgical interventions.[3]

The occurrence of complications is affected by aspects such as the underlying disease, the specific surgical procedure, and the urgency of the intervention. Several complications may occur in the early postoperative period, while others may occur in the late phase.[3]

The study by Crimi and Hill demonstrated the significance of early management of hemodynamic, pulmonary, renal, neurological, hematologic, and gastrointestinal complications immediately after surgery. Ischemic-reperfusion injury results in dysfunctions of these organ systems. Treatment on the first postoperative day is primarily determined by the kind of surgical procedure, the operative time, and the patient's condition. Throughout this duration, it is crucial to be aware of complications, particularly hemodynamic ones.[15]

Intravenous fluid management

In aortic surgery, effective fluid management is crucial in the postsurgical period. It includes maintaining a balanced fluid status to prevent complications like acute kidney injury and issues associated with fluid overload, such as heart failure, impaired oxygenation, and delayed bowel function. Generally, patients are already in a euvolemic state after surgery, eliminating the need for additional fluid boluses or diuretics. With careful clinical assessment, the fluid balance of postoperative patients can be optimized.[16]

In cases where a euvolemic patient is capable of oral fluid intake, intravenous fluids may be unnecessary to maintain adequate fluid levels. Nonetheless, when fluid replacement is necessary, a restrictive fluid therapy approach tends to yield better outcomes compared to liberal fluid administration. Research has shown that patients receiving 1.5 L/day of fluids experienced lower risk of cardiopulmonary complications, fewer complications, and shorter lengths of stay in the ICU and overall duration of hospitalization compared to those in the free fluid therapy group. In abdominal aortic surgery, a Cochrane review found no evidence supporting the use of specific fluids, crystalloids, or colloids.[16]

Pain management

The utilization of analgesics for managing chronic pain in vascular patients has witnessed a notable rise. A considerable number of patients undergoing lower extremity vascular surgery experience chronic pain, which was traditionally addressed with analgesics. The regular administration of analgesics can significantly impact the perioperative pain management of these patients.[17]

The ERAS pathway for lower extremity revascularization patients needs to consider both opioid-naive individuals and those dependent on opioids. Managing chronic opioid users can pose a challenge. Since surgery can alleviate or remove the underlying cause of chronic pain, the ERAS pathway should take into account the patient's opioid usage level and reasons for opioid use. For patients whose chronic pain improves following revascularization, the prescribed regimen should involve dose reduction. Patients with chronic pain unimpacted by surgery may require additional analgesia for adequate postoperative pain control. Continuous peripheral nerve blocks (CPNB) provide significant benefits for lower extremity vascular surgery patients.[18]

Evidence supports the use of standard, multimodal, and opioid-sparing analgesia to reduce perioperative opioid consumption and expedite recovery in opioid-naive patients. Continuous peripheral nerve blocks (CPNB) hold the capacity to reduce additional opioid usage in opioid-tolerant patients during the perioperative period. The use of continuous peripheral nerve blocks in lower limb vascular surgery has not been reported, despite its mention in the context of the ERAS pathway for other lower limb procedures like knee replacement. However, research suggests that incorporating local analgesia as a key component of pain control in lower extremity vascular surgery is both feasible and beneficial. For instance, Licker.et.al. successfully implemented a local analgesia and sedation protocol in 176 patients undergoing saphenous vein ligation and phlebectomy, as an alternative to previous general anesthesia used in 200 patients.[19]

The occurrence of postoperative nausea, dizziness, and migraines was significantly lower at 4% compared to 41% (P=0.001). The average duration of discharge from the ambulatory surgical center was reduced by 364 minutes, enabling the scheduling of an additional case per day without a rise in complications. In another study, the utilization of local analgesia and sedation showed excellent outcomes in performing popliteal bypass sheath. All ten patients in the case series successfully underwent the procedure and were able to walk within eight hours without any complications (Figure 5, 6).[20-22]

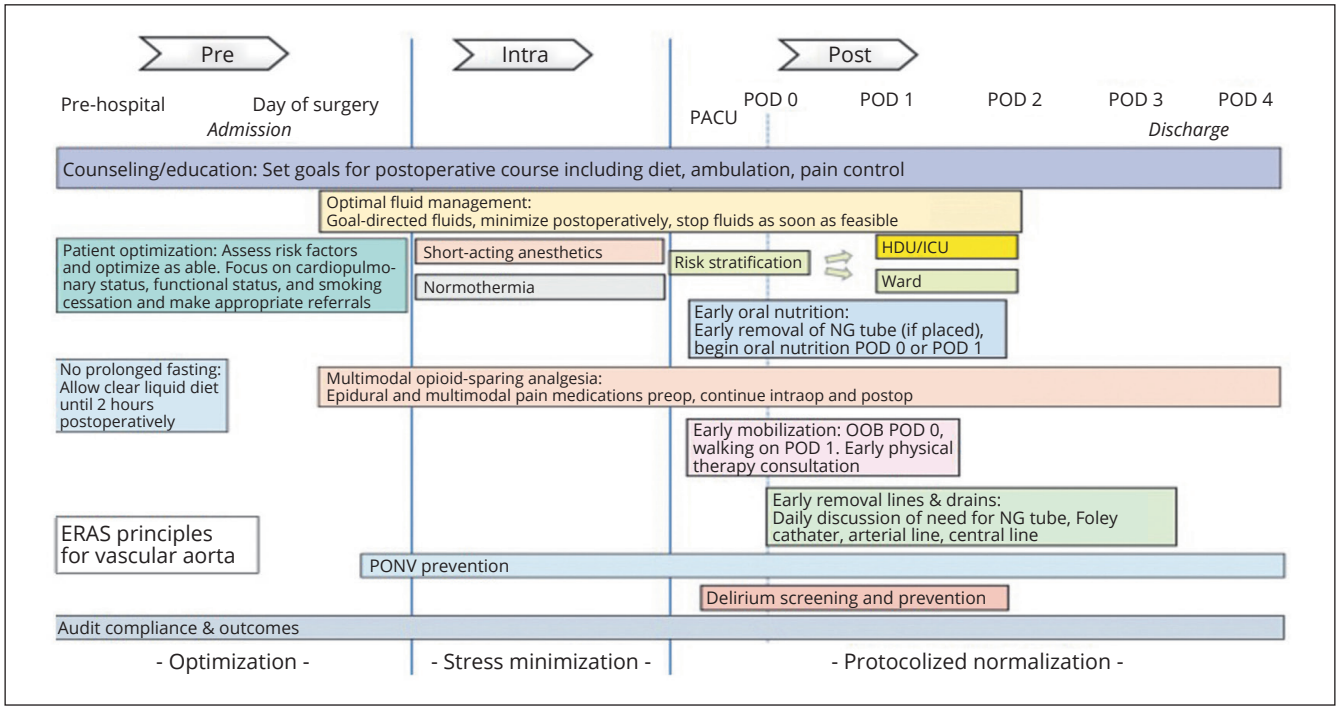

Figure 5.—ERAS in aorta vascular surgery.

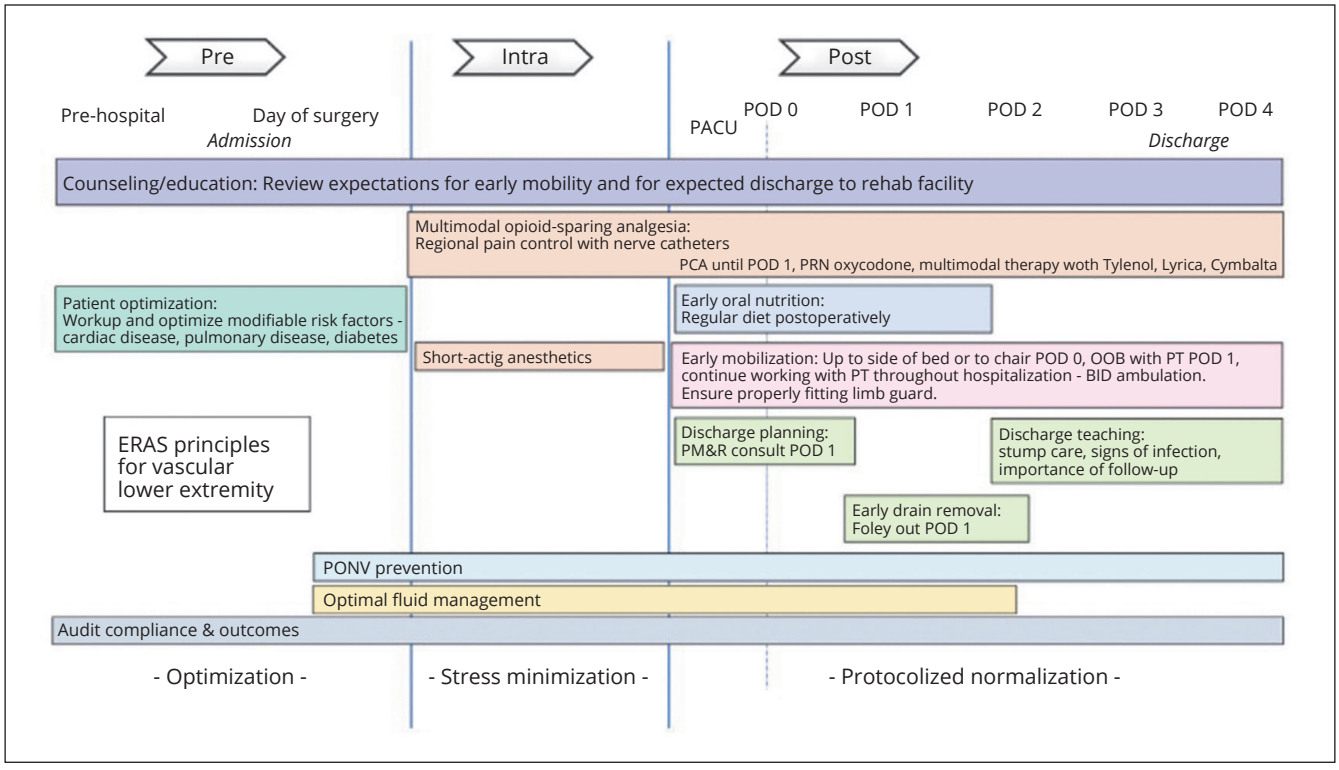

Figure 6.—ERAS principle in vascular surgery at lower extremity.

Mobilization and implants

Postoperative mobilization is a vital aspect of the ERAS pathway, particularly for patients undergoing lower extremity vascular surgery. These patients often have preexisting mobility limitations and reduced functional capacity, making preoperative conditioning challenging. Therefore, specialized personnel, such as physical therapists, may be required to facilitate postoperative mobilization due to the specific challenges involved. Mobilization is the initial (key) ERAS pathway used for other surgeries, including open aortic surgery, but in actuality, postoperative ambulation requires the assistance of a nurse or even a family member. Patient education and psychological support regarding recovery, physical therapy, prosthetics, discharge planning, and rehabilitation are essential for lower extremity amputees. The ERAS pathway for amputees should include preoperative education, physiotherapy consultations, and ideally medical rehabilitation peer visits and limb care education.[19] Marzen-Groller *et al.* establish protocols for hospitalization for ambulation after amputation. Patients undergoing below-knee amputation, above-knee amputation, or transmetatarsal amputation received preoperative physical therapy evaluations and continued with postoperative care. The study showed improved mobility scores and a potential decrease in DVT rates, although not statistically significant.[19]

Conclusions

The ERAS protocol aims to promote early recovery after surgical procedures by preserving preoperative organ function and minimizing the physiological stress response to surgery. It employs a multimodal perioperative care approach. Given the diverse range of vascular surgeries, such as open, endovascular, and hybrid procedures, there are specific complications associated with each. To address these challenges, the implementation of Enhanced Recovery After Surgery (ERAS) and comprehensive perioperative care can greatly benefit patients undergoing vascular surgery, as well as those undergoing various other surgical specialties.

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Conflicts of interest
The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions
Yeri Holo Saragi: conception and design, drafting of the article and collection and assembly of data; Yan E. Sembiring: critical revision of the article for important intellectual content and Final approval of the article; I. Putra: provision of study materials or patients; Heroe Subroto: critical revision of the article for important intellectual content and final approval of the article; Ketut P. Yasa: statistical expertise and critical revision of the article for important intellectual content; Cheong Lim: conception and design. All authors read and approved the final version of the manuscript.

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