Vascular Surgery and ERAS

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Introduction

As there are multiple different types of vascular operations, with open, endovascular, or hybrid approaches, there are varying complications that can affect the patient's post-procedural course. As operative type and location of incisions vary, so do the specific complications associated with these procedures. Unlike other surgical specialties that tend to perform operations in one area of the body, vascular surgeons perform cervical, upper and lower extremity, transabdominal and retroperitoneal operations. The common thread is the vascular disease with its risk for cerebrovascular and cardiovascular complications. But, in addition, some patients will experience ileus and other commonalities addressed in the hepatobiliary and colorectal guidelines, whereas others will experience difficulty with mobility and have needs similar to patients following orthopedic guidelines. Ideally, vascular teams including surgeons, anesthesiologists, nurses, and therapists have the experience and flexibility to address these challenges with guidance from clinical pathways or protocols. Further engaging patients to participate in preoperative nutrition, tobacco cessation, and exercise programs to help mitigate known risks is also ideal. Unfortunately, the advanced age, frequent comorbidities, decreased mobility, and access to resources of the general vascular patient population can be problematic without clear direction and support from the vascular team. Enhanced recovery after surgery (ERAS), with its emphasis on coordinating and improving perioperative care, may significantly benefit patients undergoing vascular surgery as it has for the patients in many other surgical specialties.

In 2018, the ERAS® Society, ERAS® USA Society, and the Society for Vascular Surgery (SVS) developed a multidisciplinary, multi-society committee to develop ERAS protocols for vascular surgery. The guidelines are being developed in accordance with ECRI Institute regulations. Multiple systematic reviews are being performed by third-party methodologists acting as an honest broker. Through an iterative process, the committee will critically appraise the literature and develop guidelines based on the grading of recommendation assessment, development, and evaluation (GRADE) system [1]. The strength of the recommendations in the GRADE system is based on the quality of the evidence and the risk/benefit ratio of the therapy. In areas where evidence is lacking, no grade will be assigned, but suggested practice based on expert opinion will be provided in order to provide a comprehensive clinical guideline.

Vascular surgery patients have not had the benefit of formalized perioperative care pathways. There is current work being done to synthesize the existing literature describing best practices in the preoperative, intraoperative, and postoperative care of patients undergoing vascular operations. Similar to existing ERAS protocols, the joint guidelines committee from the ERAS societies and SVS will be publishing clinical practice guidelines. Below, the unique challenges and considerations for vascular surgery patients are described.

Aorta

Patients with supra-inguinal atherosclerosis often have many high-risk chronic health problems, such as coronary artery disease, heart failure, diabetes, chronic kidney disease, and cerebrovascular disease, and must often recover from a high-risk, high-stress operation if endovascular options are not

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available. Major complications have been reported to be as high as 20% and 30-day mortality approximately 3.5% [2]. Although the pathophysiology is different from aortoiliac occlusive disease, abdominal aorta aneurysms (AAA) are commonly found in male smokers over the age of 65 years, which is another high-risk surgical population. Treatment options for Abdominal Aortic Aneurysm (AAA) include both open and endovascular approaches, but all are at risk for postoperative complications and hospital readmissions [3, 4].

Although there are no formal guidelines, there are published reports of various ERAS-like clinical care pathways for open abdominal aortic surgery. Based on an exhaustive literature review, 12 articles were identified providing information on ERAS-like clinical care pathways in aortic surgery [5–16]. All of the studies were conducted on patients with either infrarenal AAA disease or aortoiliac occlusive disease. All pathways had similar protocols, including the use of epidural analgesia, oral intake on the day of surgery or postoperative day (POD) 1, and ambulation on postoperative day 1 (Table 52.1 and Fig. 52.1). The studies are limited by study design, heterogeneity, possible confounding, and high risk of bias. However with that caveat, the 12 studies uniformly demonstrated clinically and statistically significant improved outcomes, with patients tolerating regular diets within a median of 3 days of surgery, decreased length of stay to as little as 3 days, and no increase in morbidity and mortality.

The largest reported experience is from the University Hospital of Novara in Novara, Italy [14]. From 2000 to 2014, 1014 patients underwent open aortic surgery as part of a "fast-track protocol." In this case series, 97% of patients tolerated a semisolid diet and 97% walked on the day of surgery. Median inpatient length of stay was only 3 days, and 80% were discharged to their homes by postoperative day 5. Hospitals such as the University Hospital of Novara have shown that it is possible to have dramatically improved results with coordinated clinical care pathways, but their protocol and results may not be generalizable to all aortic surgery populations. More research and clinical quality improvement programs are needed. Special considerations for open aortic surgery patients are discussed as follows.

Preoperative Counseling, Risk Assessment, and Optimization

Discussing the intent to use an ERAS pathway in the perioperative period serves as a platform for setting timelines and goals and can be used to set expectations for postoperative mobilization, nutrition, and discharge. Importantly, in

Table 52.1 Sample open aortic operation pathway

	Preoperative	Day of surgery	POD 1	POD 2	POD 3 – discharge
Preoperative optimization	Discuss intent to use ERAS. Assess need for further preoperative workup based on symptoms, history, and exercise tolerance	N/A	N/A	N/A	N/A
Tobacco	Assess current tobacco use. In office tobacco cessation consult if appropriate	Provide supplemental nicotine therapy	Provide supplemental nicotine therapy	Provide supplemental nicotine therapy	Provide supplemental nicotine therapy. Develop discharge plan for continued abstinence from tobacco
Ambulation/ physical activity	Assess current level of activity. Discuss with patient possible effects of baseline activity on postoperative recovery	Physical therapy consult Out of bed to chair	Ambulate at least once	Ambulate at least 3 times daily	Ambulate at least 3 times daily
Pain control	Assess current sources of pain and medications used. Discuss plan to use regional/local analgesia (i.e., epidural catheter)	Epidural placement preoperatively for use intraoperatively and postoperatively. Management per acute pain team	Continue epidural and multimodal pain medications	Continue epidural and multimodal pain medications	Remove epidural. Continue multimodal pain medications. Wean IV breakthrough pain medications as early as possible
Nutrition	Discuss plan for reduced preoperative fasting and early postoperative enteral nutrition	Clear liquid diet until 2 hours before surgery. Resume clear liquid diet postoperatively	Advance to regular diet. Bowel regimen	Continue regular diet, bowel regimen	Continue regular diet, bowel regimen
Early line and drain removal	N/A	NG tube out postoperatively if placed	Foley out	Daily discussion of need for existing lines and drains	Daily discussion of need for existing lines and drains

POD postoperative day, *ERAS* enhanced recovery after surgery, *N/A* not applicable, *IV* intravenous, *NG* nasogastric

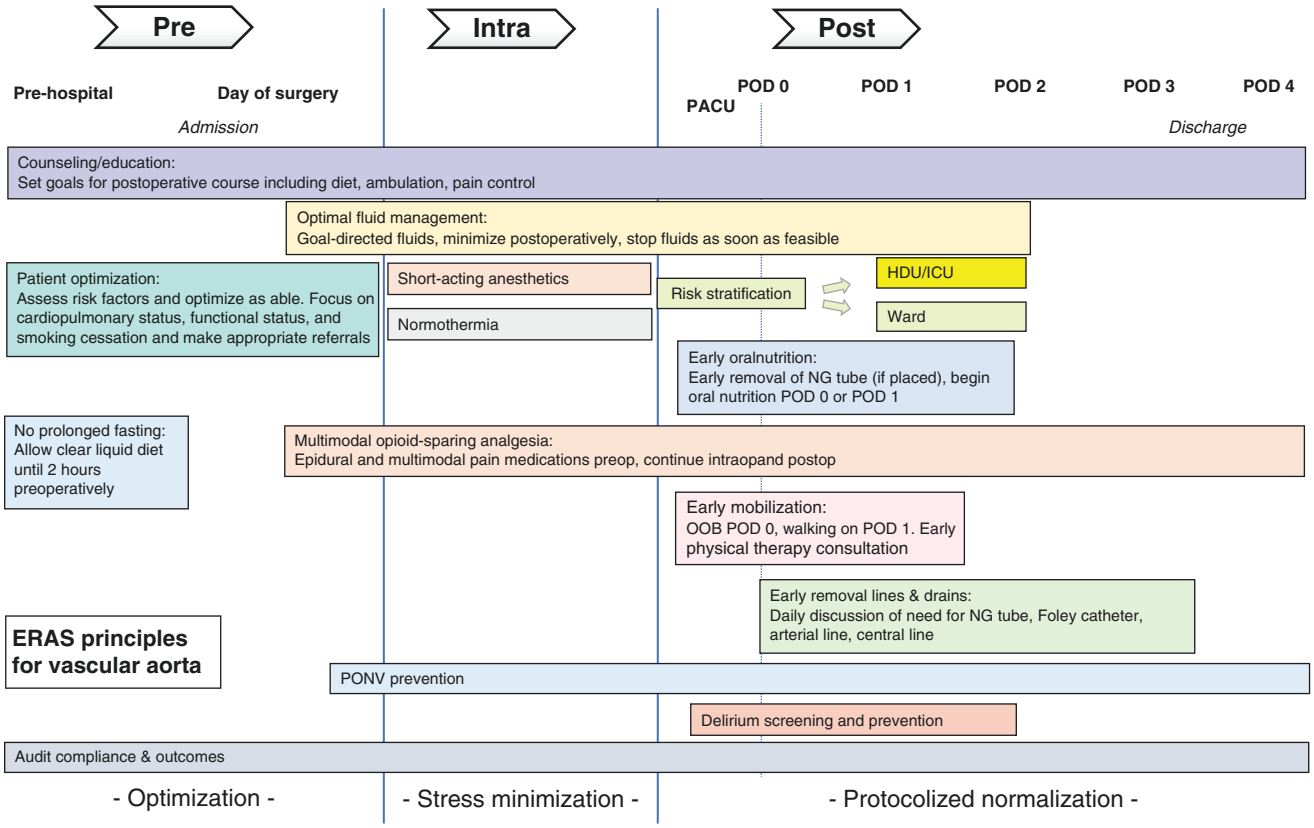

Fig. 52.1 ERAS principles for vascular aorta: Epidural anesthesia, postoperative intake on postoperative day (POD) 0 or POD 1, ambulation POD 1, CLD up to 2 hours before surgery, limited fluids postop (ex, 1 L/day). Preoperative counseling, setting expectations, daily goals, early removal of lines and drains, discharge planning. Medical screening and optimization. Abbreviations: PACU postoperative anesthesia care unit, HDU high-dependency unit, ICU intensive care unit, OOB out of bed, POD postoperative day, NG nasogastric, PONV postoperative nausea and vomiting

vascular surgery, it can also be used to implement a plan for preoperative optimization of chronic medical conditions and lifestyle considerations.

Cardiac Risk Assessment and Optimization

Cardiac disease is one of the most common comorbidities among vascular patients and contributes to increased morbidity and mortality throughout the perioperative period [17]. An ERAS pathway should reinforce the application of preexisting American Heart Association (AHA) guidelines for preoperative cardiovascular optimization. Based on the AHA guidelines, appropriate laboratory tests, electrocardiograms, echocardiograms, and stress testing should be ordered to assist with preoperative cardiovascular risk assessment and management. Beta-blockers, angiotensin-converting enzyme (ACE) inhibitors/angiotensin receptor blockers (ARBs), statins, and antiplatelet agents are part of optimal medical management of vascular disease and should be continued in the perioperative period. Where appropriate, cardiology referral should be placed for assistance with thorough preoperative optimization and also for postoperative management for inpatients at higher than average risk [17].

Anticoagulation

The frequent use of systemic anticoagulation may affect timing of surgery and limit options for regional anesthetic techniques in patients undergoing vascular surgery. Additionally, anticoagulation increases the risk of intraoperative and/or postoperative hemorrhage. This necessitates judicious anticoagulation management strategies. An ERAS pathway could establish a clear preoperative and postoperative plan for anticoagulation cessation and reimplementation. Ideally, this would include guidance regarding preoperative coagulation studies, timing of cessation, and postoperative resumption [18]. Reversal agents for anticoagulants are usually reserved for urgent or emergent indications.

Tobacco Cessation

Tobacco use significantly contributes to the development of vascular disease, increases the risk of perioperative complications, and impairs wound healing postoperatively [19]. The use of tobacco products among patients with vascular disease is estimated to be 70%; thus, incorporating standardized assessment of tobacco usage and providing assistance with tobacco cessation as part of an ERAS pathway would be

particularly beneficial for the vascular population [20]. Patients tend to be motivated to quit during the inpatient stay, and this is an opportune time to encourage efforts to do so. For the patients not ready to abstain from tobacco, pathways should also incorporate a supplemental nicotine treatment regimen (i.e., patches, gum) along with counseling efforts.

Physical Activity

Hayashi et al. found that patients who had regular physical activity prior to open AAA repair had earlier ambulation postoperatively [21]. As might be expected, the earlier ambulation postoperatively was associated with earlier hospital discharge. In this study, regular physical activity was defined as at least 30 minutes of exercise twice weekly for at least 1 year. The exact amount of weekly activity and duration of activity needed to achieve the benefit seen in this study is not known. However, patients can be counseled that beginning or continuing an exercise regimen preoperatively may contribute to a decreased length of stay and accelerated recovery. In addition, knowledge of a patient's baseline level of activity can be taken into account when discussing the expected postsurgical timeline.

Perioperative Pain Control

Regional Analgesia

In the 12 existing publications related to ERAS-like pathways in open aortic surgery, epidural analgesia is consistently incorporated. Studies that have used epidural anesthesia as a component of their ERAS pathway have had promising outcomes, including decreased complication rates, faster time to extubation postoperatively, shorter intensive care unit (ICU) stay, and shorter hospital stay [6, 9, 11–13, 15, 16]. Some of these studies have even reported adequate pain control without the use of any opioids [6, 14, 16]. Because epidural anesthesia is only a single component of ERAS pathways, the degree to which these outcomes can be attributed to the epidurals as opposed to other aspects of the pathway is unknown. However, mechanisms by which epidurals improve outcomes have been shown in studies of other surgical patients and have been speculated for vascular surgery patients. For example, in coronary artery bypass graft (CABG) patients, epidurals have been shown to decrease epinephrine release, possibly decreasing myocardial ischemia (MI) and thereby decreasing morbidity and mortality [12]. This decreased stress response can be presumed to be at least partially responsible for the decreased complication rates seen in vascular surgery patients who receive epidural anesthesia. In aortic surgery in particular, epidural anesthesia combined with general anesthesia has been shown to decrease the need for postoperative mechanical ventilation as compared to general anesthesia alone. Muehling et al. showed that only 5% of patients with an epidural needed mechanical ventilation postoperatively compared with 33% of those in the "traditional" group who received general anesthesia only [11]. This is hypothesized to be due to a decrease in the use of inhaled anesthetics intraoperatively in patients receiving epidural anesthesia.

Another study compared general anesthesia alone to general plus epidural anesthesia in open aortic surgery and showed no difference in length of ICU stay, length of hospital stay, time to oral intake, time to ambulation, morbidity, or mortality [22]. However, as in Muehling's study the patients in this study who received an epidural were extubated significantly faster than those who received general anesthesia alone [11, 22]. A limitation to the generalizability of this study is the now outdated practice of leaving the operating room and transferring the patient to the intensive care unit still sedated and intubated. Additionally, all of these patients had a nasogastric (NG) tube in place until they had a return of bowel sounds. It is possible that lack of aggressive feeding and ambulation protocols inhibited the possible beneficial effects of the epidural. It may be that the effect of the individual components of an ERAS pathways is synergistic and most beneficial when implemented in their entirety. Further research may shed light on this important question.

Delirium Screening

Delirium is a common comorbidity of vascular patients [23]. Delirium is also an underreported complication that results in decreased functional status [24]. Avoidance of the ICU, minimizing opioid use, early ambulation, facilitating physiologic sleep, optimizing day/night cycles, and visual and verbal orientation reminders may reduce the risk of delirium, but similar to the cardiac surgery ERAS guidelines, routine delirium screening and aggressive use of preventive measures are important.

Nutrition Management

Reduced Preoperative Fasting

Many ERAS pathways in other surgical specialties allow patients to have clear liquids, specifically a high-glucose carbohydrate drink, up to 2 hours prior to surgery. There is no demonstrable benefit to this particular intervention on outcomes after aortic surgery. However, reduced preoperative fasting in animal and human studies has been shown to improve patient well-being, decrease the stress response from surgery, decrease insulin resistance postoperatively, and decrease length of stay [25]. With regard to insulin resistance, this phenomenon is seen postoperatively following abdominal operations and leads to decreased uptake of exogenous glucose and increased endogenous glucose pro-

duction (catabolic state). Insulin resistance postoperatively has been independently linked to length of stay [25].

Early Removal of Nasogastric Tubes and Resumption of Postoperative Nutrition

Traditionally, open aortic surgery has been associated with the expectation that patients will develop a postoperative ileus due to the visceral rotation and mobilization of the duodenum required to expose the aorta. Traditional practice is to place a nasogastric tube in the operating room and leave it in place until the patient had return of bowel sounds or flatus. Shifting this perspective has been a central component of the available studies of ERAS protocols in open aortic surgery [5, 7, 10, 13, 15].

The management of nasogastric tubes in ERAS protocols varies. Some centers do not place NG tubes at all, some place them selectively, and some place them routinely and remove them at the end of the case or on the first postoperative day. These studies suggest that postoperative ileus is less common than previously thought. The likelihood of developing an ileus may depend on the surgical approach and whether the bowel is eviscerated. Studies comparing surgical approaches directly have not been performed. Early nutrition has been tolerated in patients undergoing both transperitoneal and retroperitoneal aortic operations. Results have suggested that it is safe to give patients enteral nutrition as early as postoperative day 0 and that early nutrition may improve outcomes.

Promotility Agents

Some studies of ERAS in aortic surgery specifically commented on the use of bowel regimens postoperatively to aid in return bowel function. The most commonly used agent was scheduled metoclopramide. Other agents included misoprostol, vegetable fibers, and senna. There is no clear evidence to recommend for or against the routine use of these medications, but it is reasonable to recommend a bowel regimen as deemed necessary given the bowel manipulation as well as the routine use of opioids. One study implemented a postoperative chewing gum protocol and found that chewing gum 3 times daily was associated with a shorter time to bowel sounds, food intake, and mobilization, though length of stay was not significantly different [26].

Nutrition

Most studies of ERAS protocols in open aortic surgery have offered patients clear liquids about 2 hours postoperatively and a regular diet by late POD 0 or on POD 1, which is considerably sooner than traditional practice. A change in expectation of surgeons of how open aortic surgery patients will progress postoperatively is important. The available literature suggests that patients tolerate an early nutrition regimen and combined with an ERAS protocol, they have better outcomes and earlier discharge without an increase in complications.

Early Postoperative Mobilization

The 12 identified ERAS studies in aortic surgery patients uniformly include early mobilization. Generally this was defined as out of bed to chair on POD 0 and walking on POD 1. Early mobilization is felt to contribute to reduced rates of complications (such as deep vein thrombosis [DVT] and pulmonary complications) and to earlier return of bowel function and possibly earlier discharge. As this is a patient- and nursing-driven effort, implementation of an ERAS protocol should include both patient and nursing education. Other components of the protocol, such as improved pain control with epidural catheters and earlier removal of lines and drains, may help promote early mobilization. As discussed in the preoperative section, patients' baseline physical activity may predict their postoperative mobility, and counseling about activity should begin as early before surgery as possible. This is of particular importance to the vascular surgical population that tends to be older, frailer, and more likely to have preexisting mobility limitations.

Intravenous Fluid Management

Intravenous (IV) fluid management can be a particular challenge in this group of patients, who may have congestive heart failure, chronic kidney disease, or other conditions that mandate precise and goal-directed fluid management. An additional consideration that requires expert management is physiologic changes in cardiac preload and afterload due to aortic cross clamping. Suprarenal clamping also impacts renal perfusion and must be accounted for with the fluid management.

Multiple studies have shown the benefits of goal-directed fluid therapy in many types of operations including vascular procedures. A meta-analysis of 41 randomized controlled trials (RCTs) evaluating perioperative fluid management for different operations found that patients who received goal-directed fluid therapy as opposed to traditional management had significantly lower complication rates and lower postoperative lactate levels. However, the meta-analysis failed to show a significant difference in length of stay or mortality [27].

Two of the RCTs in the meta-analysis evaluated fluid management in patients undergoing open aortic surgery. The first found that patients who were treated with goal-directed therapy had lower complication rates and lower postoperative C-reactive protein (CRP) levels with no difference in other inflammatory markers or length of stay [28]. The second failed to show a difference in complication rate or length of stay [29]. A third RCT not included in the meta-analysis randomized 22 patients undergoing elective open abdominal aneurysm repair to fluid restriction or standard management. The fluid-restricted group had lower complication rates and decreased length of stay [30]. A retrospective review by the

same author found that patients who developed major complications (such as MI, pneumonia, pulmonary edema, or acute renal failure) after open abdominal aortic aneurysm repair were more likely to have received higher volume of fluids and to have a net positive fluid balance compared to patients without complications [31].

Some of the available studies of ERAS in vascular surgery also include a component of postoperative fluid restriction in their protocols. Examples of postoperative fluid management plans include limiting IV fluids to 1 L per day or stopping fluids once the patient was tolerating a clear diet [12, 14]. As with other components of ERAS in vascular surgery, no definitive conclusions on the specific effects of fluid management on outcomes can be reached at this time.

Early Drain and Line Removal

Like other components of ERAS pathways, the effect of the early removal of lines and drains postoperatively has not been studied as a single intervention. Nonetheless, it is not unreasonable to assume that early removal of lines and drains has contributed to the overall benefits of ERAS pathways in open aortic surgery. Early Foley catheter removal should decrease the risk of urinary tract infection risk and increase mobility. In this more elderly population, special attention must be given to early recognition and treatment of urinary retention after Foley catheter removal. Other lines such as central venous catheters and arterial lines were not mentioned in the available literature but should be removed as soon as feasible. Several ERAS pathways transferred postoperative patients to the floor from the recovery unit as long as they were hemodynamically stable. Avoidance of routine ICU admission has many potential benefits including earlier removal of lines as well as potentially reduced delirium, earlier mobilization, shorter hospitalization, and reduced costs.

Lower Extremity

Peripheral arterial disease (PAD) is the most common indication for lower extremity vascular surgery [32, 33]. This patient population is also commonly found to have concurrent heart disease with a higher risk of cardiovascular mortality than those patients with primary coronary artery disease [34–36]. In addition to heart disease, there is a high prevalence of chronic health conditions such as diabetes, cerebrovascular disease, chronic obstructive pulmonary disease (COPD), and renal disease [37]. This patient population is also more likely to suffer from post-procedural delirium [38]. The presence of multiple comorbidities in patients with infrainguinal atherosclerosis leads to a high rate of perioperative morbidity, mortality, and hospital readmissions [38, 39].

There have not yet been studies of the use of ERAS protocols in patients undergoing lower extremity vascular surgery, and more information is needed (Table 52.2). However, pain control and mobility, two common aspects of ERAS pathways, have been studied (Fig. 52.2).

Pain Control

There is an increased prevalence of opioid use among vascular patients for the treatment of chronic pain [40]. Many patients requiring lower extremity vascular surgery have preexisting chronic pain often treated with opioids. The regular use of opioids can have a major impact on analgesic management of patients in the perioperative period.

ERAS pathways for patients undergoing lower extremity revascularization should accommodate the needs of both opioid-naive patients and chronic opioid users. The management pathway for chronic opioid users can be challenging. For these patients, an ERAS pathway should incorporate the degree of opioid usage, and also the reason for opioid use, as an operation may reduce or eliminate the patient's source of chronic pain. For patients who have a direct improvement in their chronic pain from revascularization, the prescribed regimen should include a tapered dosage. Patients with chronic pain unaffected by the operation will most likely require analgesics in addition to their baseline analgesic regimens to adequately control their postoperative pain.

Continuous peripheral nerve blocks (CPNBs) may be particularly useful for patients undergoing lower extremity vascular surgery [41]. In the opioid-naive patient, standardized, multimodal, and opioid-sparing analgesia including CPNB should hasten recovery and reduce the use of analgesics in the perioperative period. In the opioid-tolerant patient, CPNBs have the potential to reduce additional need for opioids in the perioperative period. Although their use has been referenced in the context of ERAS pathways for patients undergoing other lower limb procedures (i.e., knee replacement) [42], there are no reports of CPNB in lower extremity vascular surgery.

Available studies have shown that the use of local analgesia as a central component of pain control regimens in lower extremity vascular surgery is both feasible and beneficial. Licker et al. implemented a local analgesia and sedation protocol for 176 patients undergoing saphenous vein ligation and phlebectomy compared to 200 prior patients who received general anesthesia [43]. Postoperative nausea, dizziness, and headache were reduced to 4% versus 41% ($p < .001$). The mean time to discharge from the ambulatory surgical center was reduced by 364 minutes, allowing the

Table 52.2 Sample lower extremity operation pathway

	Preoperative	Day of surgery	POD 1	POD 2	POD 3 – discharge
Preoperative optimization	Discuss intent to use ERAS. For amputation patients, preoperative OT and PT consult	N/A	N/A	N/A	N/A
Ambulation/ physical activity	For amputation patients, preoperative OT and PT consults for planning of postoperative mobilization and DME	Out of bed to chair or up to side of bed for meals. Amputees to use limb guards for all transfers	Ambulate if possible, continue work with PT and OT. Begin disposition planning	Ambulate twice daily, continue to advance mobility with nurses and therapists. Inpatient rehabilitation assessment if appropriate	Ambulate twice daily, continue to advance mobility. Discharge safety teaching
Pain control	Assess current pain medications used and reasons for use. If chronic pain is expected to improve following revascularization or amputation, plan for postoperative taper of pain medications when appropriate	Multimodal analgesia preoperatively. CPNB catheter placement preoperatively OR liposomal bupivacaine at incisions intraoperatively. Begin IV and PO PRN narcotics	Continue CPNB. Continue multimodal therapy. Continue PRN oral narcotics. Discontinue IV narcotics	Continue CPNB. Continue multimodal therapy. Continue PRN oral narcotics	Remove CPNB. Continue multimodal pain medications. Finalize plan for chronic opioid taper if appropriate
Nursing	N/A	For amputees, assure rigid dressing in place or that soft dressing with limb guard fits properly	Remove Foley catheter	Premedicate by 6 AM for first post-op dressing change	Daily dressing change. Assist with discharge teaching: stump care for amputations, signs and symptoms of infection for all patients

POD postoperative day, *ERAS* enhanced recovery after surgery, *N/A* not applicable, *OT* occupational therapy, *PT* physical therapy, *DME* durable medical equipment, *CPNB* continuous peripheral nerve block, *IV* intravenous, *PRN* as needed

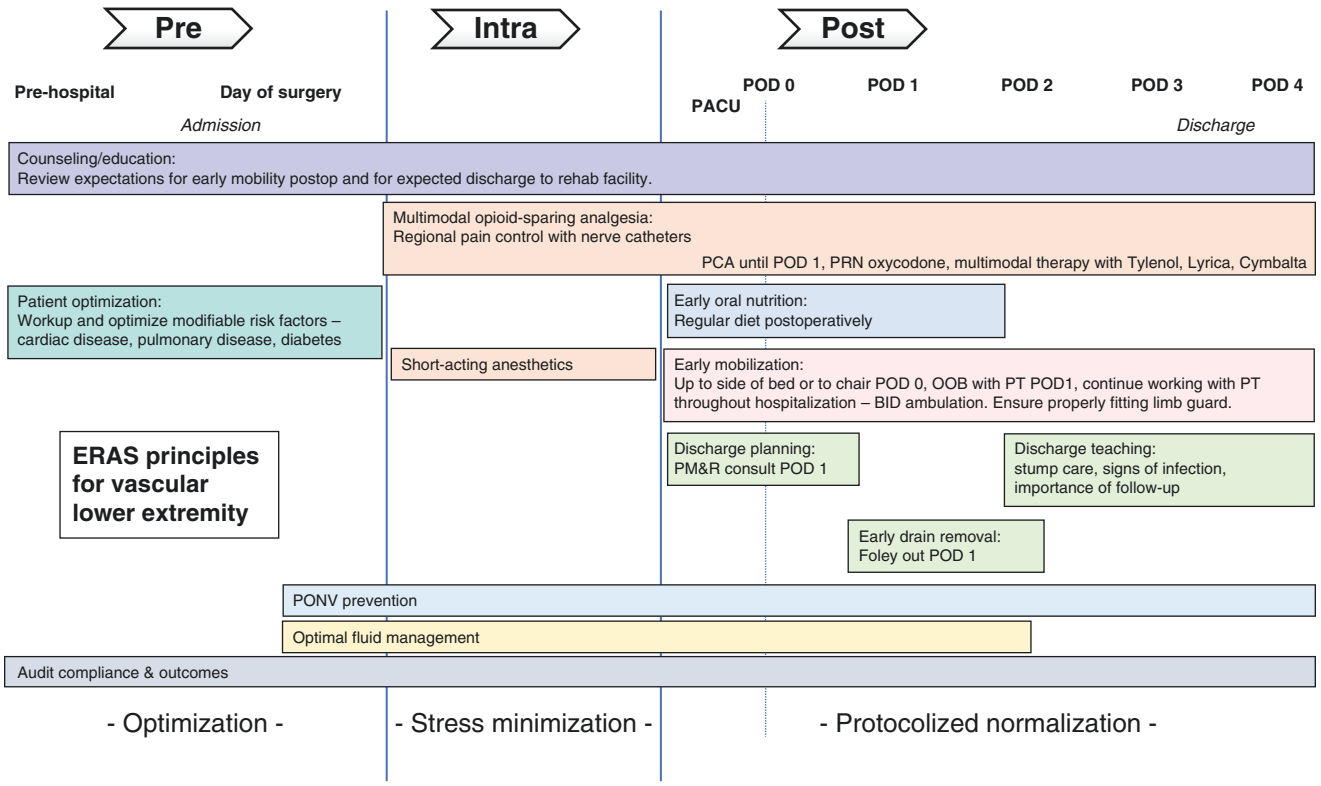

Fig. 52.2 ERAS principles for vascular lower extremity. Abbreviations: PACU postoperative anesthesia care unit, PCA patient-controlled anesthesia, POD postoperative day, OOB out of bed, PT physical therapy, BID twice a day, PM&R physical medicine and rehabilitation, PONV postoperative nausea and vomiting

schedule to accommodate one more case per day without an increase in the rate of complications. Another study showed that above-knee popliteal bypass can be done using local analgesia and sedation with good results [44]. The ten patients in the case series tolerated the procedure well and all ambulated within 8 hours postoperatively.

Mobilization and Prosthetics

Postoperative mobilization is a key component of ERAS pathways. Patients undergoing lower extremity vascular surgery often have preexisting mobility limitations and reduced functional status that may prevent preoperative conditioning. Postoperative mobilization presents unique challenges and may require specific experienced personnel, such as physical therapists. This is a departure from ERAS pathways utilized for other operations including open aortic surgery, where it is realistic to rely on the assistance of nurses or even family members to assist with postoperative ambulation.

For patients undergoing lower extremity amputation, education and expectation management regarding healing, physical therapy, prosthetic fitting, discharge, and rehabilitation is critical. ERAS pathways for amputation patients should incorporate preoperative education, physiatry consult, and ideally a peer visit as well as hands on education dedicated to postoperative limb care [45]. Marzen-Groller et al. created an inpatient protocol for ambulation after amputation [46]. The protocol included a preoperative physical therapy assessment for patients with planned above-knee amputation (AKA), below-knee amputation (BKA), and transmetatarsal amputation (TMA). Therapy plans were initiated preoperatively and continued postoperatively. Postoperative care was team based with both nurses and physical therapists playing key roles. The patients in the study either returned to their baseline mobility scores or even improved. The study also found a trend toward a lower rate of DVT, though this was not statistically significant.

Endovascular

Endovascular procedures are often overlooked when considering ERAS pathways since these minimally invasive procedures are often done on an outpatient basis or only require a short hospital stay. Endovascular interventions are not associated with the postoperative ileus common to intra-abdominal surgery or the pain associated with longer incisions. Although there is not a formal, society-endorsed guideline, the University of North Carolina has published their experience with an ERAS pathway for transcatheter aortic valve replacement [47], which has been shown to reduce the rate of postoperative delirium [48].

There is scant data to guide decisions for patients undergoing catheter-based interventions, but it is reasonable to conclude that ERAS concepts will also benefit these patients. For example, patients undergoing endovascular aneurysm repair are likely to be smokers greater than 65 years old. Preoperative expectation setting and education, smoking cessation counseling, consideration of regional instead of general anesthesia, opioid-sparing multimodal analgesia, goal-directed fluid therapy, and assistance with ambulation after 2–4 hours of postoperative bedrest required after percutaneous arterial access can reasonably be assumed to improve care.

Similar benefit may be anticipated for lower extremity endovascular revascularizations. Pre-procedure education and counseling on a supervised exercise program is beneficial. Additionally, the importance of understanding antiplatelet therapy, smoking cessation, diabetes management, and cardiovascular risk modification in the patients undergoing lower extremity endovascular cases cannot be overstated. With standardized sedation plans and post-procedure care, one could anticipate faster throughput, possibly allowing for increased efficiency and case volume. Reduction in postoperative recovery time and the associated increase in operating capacity has been demonstrated in patients undergoing a “fast-track” venous ligation and phlebectomy in an outpatient surgical center at the University of Geneva in Switzerland. It is reasonable to believe this success can be realized in other settings [43].

Conclusion

ERAS pathways have provided significant benefits to patients, providers, and hospitals when used for many different surgical operations. Although there is a paucity of data for ERAS in vascular surgical patients, we anticipate a similar improvement for our complex, aged, and frail vascular population. There is significant enthusiasm and effort for creating well-designed ERAS pathways for vascular operations. The majority of the existing evidence pertains to open aortic surgery, but there will be utility in ERAS pathways for lower extremity and endovascular surgery as well. Similar to other ERAS pathways, attention to preoperative education, expectation setting, along with modifications in nutrition, mobilization, analgesia, and IV fluid management should result in a better patient experience, improved outcomes, and reduced length of stay.

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