SOCIETY FOR VASCULAR SURGERY DOCUMENT

A framework for perioperative care for lower extremity vascular bypasses: A Consensus Statement by the Enhanced Recovery after Surgery (ERAS®) Society and Society for Vascular Surgery

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ABSTRACT

The Society for Vascular Surgery and the Enhanced Recovery After Surgery (ERAS) Society formally collaborated and elected an international, multi-disciplinary panel of experts to review the literature and provide evidence-based suggestions for coordinated perioperative care for patients undergoing infrainguinal bypass surgery for peripheral artery disease. Structured around the ERAS core elements, 26 suggestions were made and organized into preadmission, preoperative, intraoperative, and postoperative sections. (J Vasc Surg 2023;77:1295-315.)

Keywords: Analgesia and anesthesia; Enhanced recovery after surgery; Evidence-based recommendations; Guidelines; Infrainguinal bypass surgery; Perioperative care; Peripheral artery disease

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Enhanced Recovery After Surgery (ERAS) pathways have been beneficial for many surgical specialties, and have recently been developed for open aortic surgery.[1,2] The concept of multi-disciplinary care to control perioperative physiology and maintain hemostasis to attenuate stress and accelerate convalescence was first described in 1997.[3] Since then ERAS has spread to six continents, and 20 surgical specialties have published formal ERAS Society consensus statements. Although each specialty and geographic region may be unique, the common foundational theme is to create a culture in which all perioperative physicians, surgeons, nurses, and therapists work together within a clinical pathway to apply evidence-based practice in unison.

Vascular surgery patients, specifically patients with peripheral artery disease (PAD), present unique challenges due to their advanced age, frailty, and multiple comorbidities compared with the general population. This combination of factors results in complex management strategies, increased utilization of health care resources, prolonged hospitalizations, and rehabilitation needs.[4] ERAS, with its aim of delivering high-quality perioperative care and accelerating recovery, appears well-suited to address the needs of patients undergoing infrainguinal bypass operations, but unfortunately, there is not enough published data to support formal ERAS guidelines. To reduce unwarranted clinical practice variation and to potentially enhance clinical care, this document is a synthesis of the existing literature for best practices and provides a framework for the perioperative care of patients undergoing open surgical infrainguinal bypass. The paper also shows the gaps in the literature and suggests areas where research is needed for more robust knowledge to improve the care for this patient group.

METHODS

Formation of the Guideline Development Group and selection of topics. In collaboration, the Society for Vascular Surgery and the ERAS Society initiated the formation of the multidisciplinary, international Guideline Development Group (GDG), which consisted of vascular surgeons, anesthesiologists, and advanced practice providers with expertise in ERAS and vascular pathophysiology. The GDG was consulted for advice on appropriate items to be included, with the final decision being made by the lead authors (KM and HDB). The selected topics for the consensus statement were allocated to authors for literature summary depending on each individual's expertise. The final content was agreed upon by all authors.

Literature search strategy. A third-party team of investigators and a reference librarian specializing in literature reviews assisted the GDG in identifying and categorizing the existing effectiveness and comparative effectiveness literature on ERAS protocols relevant to vascular surgery. The librarian executed and documented the search in July 2019 (Appendix 1). The databases queried included PubMed, CINAHL, and clinicaltrials.gov. Systematic reviews, randomized controlled trials (RCTs), and observational cohort studies reporting on adults (≥18 years) undergoing lower extremity vascular surgery and reporting on any one or combinations of the ERAS guideline items were included. GDG members then searched reference lists and repeated literature searches to include any new publications through December 2021. Many ERAS items had not been studied specifically in patients undergoing

infrainguinal bypass, so published data and ERAS guidelines from other surgical specialties were included for the elements that were generalizable. The included studies were carefully reviewed by the GDG, who unanimously agreed upon them.

Quality assessment, data analyses, and consensus generation. Suggestions for best perioperative practices were made based on the supporting literature specific to this patient population, and, at times, supporting literature extrapolated from other surgical populations. Assessment of the quality of evidence was judged to be high, moderate, or low. Where non-vascular literature was used as a primary basis for suggestions, the quality of evidence was extrapolated to this population and indicated in each section. Because of this, although some of the practice suggestions are based from a high-quality evidence base and are unlikely to change, other suggestions are merely from expert consensus or low-quality evidence and may change if more rigorous research is performed.

The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system was used to judge the literature, but formal recommendations using the GRADE system were not made across all elements due to lack of consistently high-quality data derived from this specific patient population.[5]

RESULTS

The literature search yielded 3460 citations. There were 109 studies addressing ERAS interventions, as either individual core elements or combinations of elements, in vascular surgery patients, and another 18 studies included mixed cohorts, including vascular surgery patients. Most of these studies involved vascular patients with abdominal aortic pathology, and only 45 involved patients undergoing lower extremity vascular operations. Structured around the 22 ERAS core elements, 26 suggestions for best perioperative practices were made and organized into preadmission, preoperative, intraoperative, and postoperative sections (Table).

PREADMISSION RECOMMENDATIONS

1. Patient information, education, and counseling

Preoperative education and counseling are cornerstones of ERAS pathways to engage patients and caregivers in all aspects of their perioperative care. It allows setting and managing expectations regarding early mobility, postoperative pain control, anticipated length of stay (LOS), and follow-up.[6,7] Although studies on lower extremity bypass-specific education strategies are lacking, there is literature, including an RCT, from other general surgical specialties on use of extended pre- and postoperative counseling, guidance by an ERAS nurse, and written information leads to less pain, less nausea, reduced time as an inpatient, and increased enhanced recovery pathway adherence.[8-10]

Suggestion: Patients should receive dedicated verbal and written preoperative education and counseling.

Quality of evidence: Low.

2. Assessment and optimization: (a) nutritional deficiency; (b) anemia screening; (c) frailty; (d) delirium risk; (e) psychosocial concerns, and (f) tobacco and alcohol overconsumption

2a. Nutritional deficiency. Poor nutrition in patients with PAD undergoing revascularization correlates with worse outcomes, including increased mortality and risk of major amputation.[11-14] Poor nutrition also significantly impacts wound healing in patients with chronic limb-threatening ischemia, a group that is particularly high-risk for baseline malnutrition.[13,15,16] Coupled to these issues, limited mobility due to rest pain, tissue loss, or prior contralateral amputation can induce a decline in basal energy expenditure, reduced insulin sensitivity, anabolic resistance to protein nutrition, and muscle strength.[17]

Preoperative nutritional deficiency can be established by screening.[18] There are many nutritional screening tools available, and only expert consensus regarding the best; however, the European Society for Clinical Nutrition and Metabolism (ESPEN) suggests the Malnutrition Universal Screening Tool (MUST) be used in the outpatient community setting, and Nutritional Risk Screening 2002 (NRS 2002) for inpatients.[18,19] These guidelines have suggested specific parameters for severe nutritional risk based on weight loss, body mass index, and preoperative serum albumin concentration.

If one of these criteria is present, formal nutritional assessment is needed, and targeted nutritional therapy should be initiated.[18,19] Oral nutritional supplements, including those containing immunonutrients,[20-22] are almost always preferred to enteral or parenteral nutrition regimens.[18] Regimens for treating malnutrition via oral nutritional supplementation have shown greatest effect if started at least 7 to 10 days preoperatively in non-vascular cohorts.[23-26]

Suggestion: Screen for malnutrition and treat nutritional deficiency preferably with oral regimens.

Quality of evidence: Moderate.

2b. Anemia screening. Preoperative anemia, is associated with poor outcomes after surgery and is common in patients undergoing lower extremity arterial bypass.[27-30] Although blood transfusion can quickly correct preoperative anemia, caution should be used, as transfusion is also associated with increased mortality and morbidity.[31,32] There are benefits to avoiding transfusion, and it is recommended that patients who are at risk for transfusion such as those with severe anemia or with moderate to large volume blood loss (>500 mL) undergo testing and treatment for anemia when possible.[33]

Table. Best practice suggestion and level of evidence for each Enhanced Recovery After Surgery (*ERAS*) element

ERAS element	Suggestion	Evidence level
Preadmission		
1. Patient information, education, counseling	Patients should receive dedicated verbal and written preoperative education and counseling.	Low[a]
2a. Screening, assessment, and optimization: nutritional deficiency	Screen for malnutrition and treat nutritional deficiency preferably with oral regimens.	Moderate[a]
2b. Screening, assessment, and optimization: anemia	Evaluate the cause of and treat chronic preoperative anemia.	Low
2c. Screening, assessment, and optimization: frailty	Screen for frailty as a routine part of preoperative patient assessment.	Moderate
2d. Screening, assessment, and optimization: delirium	Screen for delirium risk and implement preoperative practices to minimize onset of delirium as a routine part of practice.	Low
2e. Screening, assessment, and optimization: psycho-social	Routinely screen for depression.	Low
2f. Screening, assessment, and optimization: tobacco and alcohol	i. Prescribe smoking cessation therapy before surgery. ii. Recommend alcohol cessation prior to surgery.	High[a] Low[a]
2h. Screening, assessment, and optimization: medical risk	Evaluate and optimize comorbidities prior to elective surgery and consider medical risks before urgent surgery.	High
2i. Screening, assessment, and optimization: glycemic control	All patients should have a baseline HbA_{1c} level prior to revascularization. In patients with elevated HbA_{1c} levels, anti-hyperglycemic treatment should be initiated and/or titrated with the assistance of a specialist.	High
3. Preoperative anti-platelet, anticoagulation plan	Continue aspirin throughout the perioperative period.	High
Preoperative		
4. Fasting	Avoid overnight fasting; encourage clear fluids up to 2 hours and light foods up to 6 hours prior to the induction of general anesthesia.	High[a]
5. Carbohydrate loading	Patients without diabetes should receive a preoperative carbohydrate drink. Patients with stable diabetes should receive a preoperative carbohydrate drink alongside their anti-diabetic medication.	High[a] Low[a]
6. Venous thromboembolism prophylaxis	Routinely use either low-dose unfractionated heparin or low molecular weight heparin with calf-length intermittent compression devices, when possible, starting prior to surgery or within 24 hours of surgery end, and continuing throughout the hospitalization.	High[a]
7. Pre-anesthetic sedative and analgesia medication	i. Do not routinely use sedatives to reduce anxiety preoperatively. ii. Routinely use preoperative administration of acetaminophen, NSAIDs, and gabapentinoids as part of a multimodal opioid-sparing analgesia strategy. iii. For opioid-dependent patients, maintain outpatient pain regimen in the perioperative period.	Low[a] Low[a] Moderate[a]
8. Antimicrobials	i. Consider the use of bundles programs to reduce SSI. ii. Prophylactic IV antibiotic dosing should begin 30 to 60 minutes preoperatively with re-dosing intraoperatively for procedures greater than 4 hours or with substantive intraoperative blood loss and extend no more than 24 hours postoperatively.	Low High
9. PONV	Risk-assess for PONV, routinely use multimodal PONV prophylaxis based on assessment, and use PONV rescue with a different class of anti-emetic.	High[a]

Table. Continued.

ERAS element	Suggestion	Evidence level
Intraoperative		
10. Anesthetic protocol	Use a multimodal analgesic strategy which includes non-opioid analgesics and regional anesthesia.	Moderate
11. Goal directed fluid therapy	Routinely use cardiac monitoring (arterial line and non-invasive cardiac output monitoring such as stroke volume variation) to support euvolemia.	Low[a]
12. Body temperature management	Use multiple strategies to maintain normothermia, including pre-warming and active warming of patients intraoperatively.	Moderate[a]
13. Surgical techniques (vein harvest, groin closure)	i. Close groin incisions with subcuticular sutures and use a negative-pressure dressing. ii. Harvest vein conduits with either continuous or skip open incisions rather than endoscopic harvest. iii. Consider hybrid surgery both for proximal and distal revascularization in high-risk patients. iv. Do not routinely use drains in the surgical wound.	Low Low Low Moderate
Postoperative		
14. Multimodal analgesia and opioid reduction strategies	Routinely use multimodal analgesic regimens to improve pain control and reduce opioid consumption.	High[a]
15. Oral feeding	Resume oral nutrition immediately postoperatively.	Moderate
16. Glycemic control	i. Glycemic goal of 180 mg/dL or less during the perioperative period. ii. Routinely use diabetic and nutritional counseling as part of interdisciplinary care for diabetic patients.	Moderate High
17. Urinary drainage	Remove urinary drainage catheters before leaving the operating room.	Low
18. Early mobilization strategy	Use a formal plan for early mobilization immediately postoperatively, with early physical therapy involvement when needed.	Low
19. Discharge education	Utilize both written and verbal discharge education, use follow-up phone calls with 24-48 hours of hospital discharge, and arrange clinic follow-up with both the surgeon and primary care at least once by 30 days postoperatively. Confirm transition plan to outpatient podiatry and/or wound care center when relevant.	Low[a] Moderate

HbA_{1c}, Hemoglobin A_{1c}; *IV*, intravenous; *NSAID*, non-steroidal anti-inflammatory drug; *PONV*, prevention of nausea and vomiting.
[a]Denotes some of the evidence is extrapolated from non-vascular patient cohorts.

Laboratory testing may identify a correctable cause for anemia (eg, iron deficiency). For example, in a large multi-center series of patients undergoing major elective surgery, including cardiac surgery, up to 60% of patients with anemia had low iron stores.[34] Subsequent treatment for iron deficiency can include either oral or intravenous routes, depending on the timeline to surgery, and there is evidence from one RCT and a pooled analysis of observational data from over 2500 patients to support that some patient populations may benefit from correction of iron deficiency, even with short courses of treatment.[35,36] Even though correction of anemia may reduce the need for transfusion, there is little evidence to support that it impacts overall morbidity and mortality, and there are no large studies to date to examine the effects in a vascular surgery-specific population.[35,37-41]

Caution is advised in translating certain anemia therapies to lower extremity revascularization amid presence of the United States Food and Drug Administration's limitations of use of erythropoietin-stimulating agents in patients undergoing cardiac or vascular surgery, and an adverse event profile that includes thrombotic events.[42] Use of intraoperative interventions, such as minimally invasive techniques and/or cell salvage for complex cases anticipated to have long operative time, may also be considered in order to reduce the need for perioperative transfusion, particularly in patients with pre-existing anemia.[43,44]

Suggestion: Evaluate the cause of and treat chronic preoperative anemia.

Quality of Evidence: Low.

2c. Frailty. Frailty is a syndrome of diminished physiological reserve that predisposes patients to adverse health outcomes, especially in the presence of a stressor. Although frailty and aging are not the same, frailty is associated with aging and with the presence of PAD.

Loss of muscle mass, walking limitation, and inflammation compound frailty in PAD, and, depending on the frailty instrument used, the prevalence of frailty in patients with symptomatic PAD varies from 16% to 70%.[45] In a retrospective study of almost 140,000 patients measuring frailty using the Risk Analysis Index, 30-day mortality was significantly higher for frail patients after infrainguinal revascularization (nonfrail, 1.1%; frail, 6.3%; very frail, 9.4%), and frailty was highly predictive of 30-day postoperative mortality[46] Frailty has also been shown to be associated with major complications after lower extremity bypass.[47] A prospective cohort study of patients with chronic limb-threatening ischemia (N = 643) undergoing endovascular or open revascularization found frailty (as measured by the clinical frail scale) associated with lower overall and amputation-free survival at 2 years.[48]

Specifically, a small RCT testing an outpatient comprehensive geriatric assessment and optimization program in elderly patients scheduled for elective aortic or infrainguinal bypass surgery was associated with reduced complications, shorter hospital LOS, and lower rate of patients discharged to a higher level of care dependency.[49] A patient who has a positive frailty screen should be followed up with a diagnostic assessment of frailty, and, when feasible, a comprehensive geriatric assessment with a tailored intervention. Based on observational data related to shared decision-making and/or prehabilitation experience from other cardiovascular conditions like aortic and carotid disease, these interventions seem advisable[50]; however, currently there are no published trials evaluating this for patients undergoing infrainguinal bypass.[51] Ultimately, variations in disease severity at presentation may limit feasibility or time available to undergo rehabilitation interventions, although it should be noted that even patients with ischemic wounds often do not need urgent revascularization.[52-54] In cases where urgent revascularization is required, the use of frailty screening may still be utilized to guide shared decision-making, consideration of alternate treatments that may still meet goals of care, or expectation setting around outcomes and recovery challenges.

Suggestion: Screen for frailty as a routine part of preoperative patient assessment.

Quality of evidence: Moderate.

2d. Delirium risk. Delirium can contribute to adverse events, prolonged hospital stays, non-home discharge destinations, and mortality following vascular surgery.[55,56] Delirium has been noted in medium- to large-size cohort studies utilizing validated delirium assessment scores to have incidences ranging from 5% to 29%[57-63]; rates as high as 42.3% have been identified in sub-cohorts of patients with chronic limb-threatening ischemia.[64] Risk factors identified from meta-analysis of observational studies include age, hypertension, diabetes, hearing impairment, history of transient ischemic attack or cerebrovascular accident, renal failure, lower preoperative hemoglobin, duration of surgery, emergent surgery, and estimated blood loss, whereas regional anesthesia was protective from development of postoperative delirium.[55] A single moderate-sized prospective study of patients with chronic limb-threatening ischemia undergoing surgical therapy also noted an association of poor nutritional status (Short Nutritional Assessment Questionnaire for Residential Care [SNAQ-RC] ≥3) with delirium.[56] Preoperative identification of cognitive risk using standardized cognitive scales such as the mini-mental state exam can also allow engagement of patients/families to discuss implications of proposed surgery, including the capacity to consent and risk of postoperative complications including delirium and brain health.[49,65]

Suggestion: Screen for delirium risk and implement preoperative practices to minimize onset of delirium as a routine part of practice.

Level of Evidence: Low.

2e. Psychosocial concerns. Anxiety, depression, and lack of social support in particular are described risk factors in the course of recovery after surgery. A variety of studies have demonstrated that psychosocial factors play a significant role in recovery and are predictive of surgical outcomes in patients with PAD.[66,67] Estimates of depression in PAD patients range from 11% to 48% in cross-sectional studies and from 3% to 36% in longitudinal studies.[68] Depression is associated with progressive declines in walking ability, increased inflammation, and increased risk of recurrent symptoms.[69-71] A single-center retrospective cohort study of 216 patients undergoing infrainguinal revacularization found that patients with depression have worse primary patency (hazard ratio, 1.77; 95% confidence interval [CI], 1.03-3.02; $P = .04$) and higher failure of revascularization (hazard ratio, 2.18; 95% CI, 1.22-3.88; $P < .01$).[70] Among Veterans with PAD, concurrent depression was associated with a 13% greater major limb amputation and 17% greater mortality risk compared with patients with PAD without depression.[72] Patients who have a positive screening test should be referred back to their primary care physician or to a mental health specialist for formal diagnosis and treatment.

Suggestion: Routinely screen for depression.

Quality of Evidence: Low.

2f. Tobacco and alcohol cessation. Tobacco is a leading risk factor in the development of PAD and is associated with substantial short- and long-term morbidity and mortality.[73,74] In a cohort of 2913 patients from the Vascular Quality Initiative registry undergoing infrainguinal bypass surgery, current smoking was associated with almost 30% increased risk of major adverse limb events at 1 year.[75] In a multi-center retrospective review of 693 patients undergoing infrainguinal bypass surgery from 2013 to 2017, patients who smoked more than one

pack of cigarettes per day were at a 1.48-times increase in the risk of major adverse limb events at 1 year compared with patients who smoked less than one pack per day.[76] In the perioperative period, nicotine replacement therapy and smoking cessation medications have proven efficacy for smoking cessation, which is of critical importance in this specific patient population.[77,78] Further, a cluster-randomized trial of 156 current adult smokers with PAD demonstrated feasibility of a brief surgeon-delivered smoking cessation intervention increasing interest in smoking cessation and is associated with declines in nicotine dependence at 3 months.[79,80]

In addition to limb-based outcomes, there is substantial published literature describing other benefits to preoperative smoking cessation. A systematic review and meta-analysis of 25 studies (2 RCT, 7 prospective cohort studies, and 16 retrospective studies) including over 20,000 cardiac and non-cardiac surgical patients, there was a 23% and 47% reduction in respiratory complications in patients who stopped smoking 4 and 8 weeks prior to surgery, respectively.[81] Another meta-analysis of four RCTs demonstrated smoking cessation interventions reduced surgical site infections, and pooled data from 140 cohort studies supports 1 month of smoking cessation being associated with improved post-surgical outcomes.[82,83]

Suggestion: Prescribe smoking cessation therapy before surgery.

Quality of evidence: High.

In two RCTs comprising 69 surgical patients, 1 month of preoperative abstinence from alcohol improved outcomes in a patients who imbibed at least five alcohol equivalents (or 15 units) per day.[84] A Cochrane review of these two studies describes postoperative morbidity is increased by two- to three-fold in patients who abuse alcohol, and another meta-analysis of multiple RCTs in mixed surgical cohorts shows that daily drinking increases the risk of non-surgical site infection, but does not increase postoperative mortality.[85]

Suggestion: Recommend alcohol cessation 4 weeks prior to surgery.

Quality of Evidence: Low.

2h. Medical risk. Patients undergoing lower extremity bypass surgery generally have multiple cardiovascular, pulmonary, renal, and metabolic comorbidities that will influence their medical risk, impact their perioperative outcomes, and dictate a multidisciplinary approach to preoperative evaluation and optimization. Medical preoperative assessment and optimization of each major risk factor should be undertaken in accordance with the most current clinical practice guidelines on perioperative evaluation, optimization, and management of patients undergoing non-cardiac surgery. Risk scores may be used to help stratify overall risk of surgery, and the Vascular Quality Initiative (VQI) mortality prediction model for patients with chronic limb-threatening ischemia performs well in American and European cohorts (C = 0.86).[86]

Cardiac risk. Patients with PAD have a higher risk of cardiovascular mortality than patients with coronary artery disease alone.[87] Multiple cardiac risk calculators are available; however, the model discrimination for predicting postoperative myocardial infarction after surgery are not accurate at predicting postoperative outcomes, meaning they are unlikely to be of benefit and thus are not universally recommended.[88-91] In clinical practice, functional capacity or ability to perform metabolic equivalents is a key determinant of preoperative assessment.[92] Unfortunately, in patients with PAD and limited mobility, standard measures of activity may not be able to be used. Although poor capacity alone is only weakly associated with impaired outcomes after lower extremity bypass surgery, cardiac and pulmonary prognosis is good if functional capacity is high, even in the presence of stable ischemic heart disease or other risk factors.[93] Based on multiple RCTs and multi-society guidelines, to mitigate cardiac risk, all patients with peripheral vascular disease should be offered antiplatelet therapy (81 mg ASA), high-intensity HMG-CoA reductase inhibitors even if the low-density lipoprotein (LDL) cholesterol $<$100 mg/dL, and antihypertensives where there is a persistent systolic blood pressure $>$ 140 mmHg, unless contraindicated.[92] The Coronary Artery Revascularization Prophylaxis (CARP) trial[94] showed no survival benefit with coronary revascularization before elective vascular surgery, and another RCT[95] of 430 patients with high-risk cardiac stress tests showed no difference in long-term outcomes in elective vascular surgery with preoperative coronary revascularization. However, secondary analysis of the data from the CARP trial demonstrated that preoperative revascularization of left main coronary artery stenoses ($\geq$50%) is associated with improved survival after elective vascular surgery.[96]

Pulmonary risk. There is an association of lower extremity atherosclerotic occlusive disease with chronic pulmonary disease due to its connection with current and prior nicotine abuse. There is no high-quality evidence on the effectiveness of routine preoperative chest radiography or pulmonary function tests in patients undergoing lower extremity bypass surgery.[97] Patients should only undergo these tests if they have new or unstable cardiopulmonary signs or symptoms, or if they are believed to be at such an increased risk of pulmonary complications that the results will alter management (ie, inform decisions or postpone surgery).[98-100]

Suggestion: Evaluate and optimize comorbidities prior to elective surgery and consider medical risks before urgent surgery.

Quality of evidence: High.

2i. Glycemic control. Over 20% of patients over 65 years have impaired fasting glucose, and up to one-third of

those patients do not carry a current diagnosis of diabetes.[101] Diabetes accelerates the progression of atherosclerosis[102-104] and is common in patients with peripheral artery disease and chronic limb-threatening ischemia.[54,105] There are conflicting reports of whether a diagnosis of diabetes alone adversely impacts outcomes after revascularization[106-110]; however, there is evidence to support that prolonged hyperglycemia as evidenced by an elevated hemoglobin A_{1c} (HbA_{1c}) is associated with worse outcomes.[102,111,112] Retrospective analyses of patients undergoing revascularization with abnormal HbA_{1c} (>7%) found that incremental increases in HbA_{1c} is associated with increasing risk of overall complications, adverse limb events, and major amputation, regardless of whether patients had a prior diagnosis of diabetes.[113,114] Complications were particularly significant in patients with very elevated HbA_{1c} values of >10%.[114]

Preoperative evaluation prior to lower extremity arterial bypass should include baseline HbA_{1c} measurement.[115,116] Because prediabetes and diabetes are also frequently undiagnosed, baseline HbA_{1c} measurement should be obtained regardless of a prior diagnosis of diabetes. For patients with elevated HbA_{1c} and no existing medical care plan, referral to a specialist should be obtained. For those already on anti-hyperglycemic medication and an elevated HbA_{1c}, particularly if it is >10%, there may be some benefit to attempts to improve hyperglycemic control prior to surgery.[114] Although there is no strong evidence to support a specific preoperative HbA_{1c} level prior to revascularization in patients with PAD, attempts to obtain strict control (HbA_{1c} <6%), as opposed to standard control (HbA_{1c}, 7%-8%), in high-risk patients with diabetes was associated with worse outcomes in a randomized control trial of 10,251 patients with type 2 diabetes mellitus.[117] Therefore, the preoperative goal should be relative improvement in hyperglycemia and must be weighed against the urgency of the procedure.

Recommendations for preoperative management of specific anti-hyperglycemic regimens in type 2 diabetics varies based on the anticipated fasting time and invasiveness of the procedure.[118] Although a feature of enhanced recovery is reduced fasting time, given the invasiveness of lower extremity arterial bypass, most oral anti-hyperglycemic patients should be held the day of surgery. This is particularly true for patients on Metformin who will receive intravenous contrast exposure during the procedure. Depending on the specific insulin regimen, insulin doses should be continued as prescribed or a slightly reduced (80%) dose the day prior to surgery and then held or moderately reduced (50%) the day of surgery.[118]

Suggestion: All patients should have a baseline HbA_{1c} level prior to revascularization. In patients with elevated HbA_{1c} levels, anti-hyperglycemic treatment should be initiated and/or titrated with the assistance of a specialist.

Quality of Evidence: High.

3. Perioperative antithrombotic strategy/plan

Based on an RCT and a prospective cohort study of over 1600 patients undergoing vascular surgery, aspirin reduces adverse cardiovascular events and mortality among patients with coronary artery disease and should be continued during the perioperative period.[119-121] Often, patients with coexistent coronary artery disease and PAD are on dual anti-platelet therapy, and based on multiple large observational studies of mixed surgical populations, the 2016 American College of Cardiology/American Health Association Guidelines recommend avoiding discontinuation of the second agent within 1 month after bare metal and 6 months after drug-eluting coronary stent placement.[121-125] When feasible, any anti-platelet medication other than aspirin must be stopped 7 days prior to surgery to reduce the risk of regional anesthesia techniques, and may be resumed 6 hours after block performance or epidural catheter removal.[126,127] Both warfarin and direct oral anticoagulants should be discontinued at least 5 days and 2 days in advance of surgery, respectively, to allow for regional anesthetic techniques and to reduce the risk of intra-operative bleeding.[128]

Resuming antiplatelet and anticoagulation medications. Little evidence is available on timing of perioperative resumption or initiation of anticoagulation and antiplatelet agents. The VOYAGER randomized control trial required randomization to therapy within 10 days post-procedure,[129] and the CASPAR trial maintained patients on aspirin and initiated clopidogrel in its therapy arm within 2 to 4 days postoperatively,[130] but published results from most other trials lack timing of post-operative initiation and focus on long-term risks of therapies. As detailed in the Global Vascular Guidelines on the Management of Chronic Limb-threatening Ischemia, risks and benefits of long-term medication regimens vary based on conduit type, disease stage, and the relative threat to bypass patency anticipated from anatomic and operative factors.[54]

In a Cochrane Review and meta-analysis of 16 studies with 5683 randomized patients, antiplatelet therapy had a beneficial effect on primary patency of bypass grafts compared with placebo or no therapy.[131] For vein bypasses, aspirin or dipyridamole monotherapy showed significant benefit in meta-analysis to primary graft patency only at 1 year (but not significant benefit at 1,3, 6, or 24 months); in contrast, significant primary patency benefit was seen at all time points up through 1 year for prosthetic conduit bypasses. In the CASPAR trial, randomizing dual antiplatelet therapy of aspirin and clopidogrel vs aspirin and placebo for below-knee popliteal bypasses, vein bypasses did not have a patency benefit, whereas a significant benefit was observed in prosthetic

bypasses over median follow-up of just under 1 year.[130] An increase in bleeding events with dual antiplatelet therapy was seen for venous grafts but not prosthetic grafts.[131]

Differential benefits of postoperative anticoagulant therapy have been noted for venous bypasses and prosthetic bypasses in moderate-sized RCTs.[132,133] In meta-analysis of vitamin K antagonists therapy compared with no anticoagulant therapy, a significant protective benefit from occlusion was only seen at 6 months, but not at 3 months, or 1, 2, or 5 years in venous bypasses and only at a late interval (5 years) after prosthetic bypasses.[134] In venous bypasses at all time points from 3 to 24 months, vitamin K antagonists were protective against occlusion compared with aspirin or dipyridamole.[134] However, major hemorrhagic events occurred more frequently among patients undergoing femoropopliteal bypass receiving warfarin plus aspirin vs aspirin alone.[135] In a small RTC, postoperative hematoma was greater among those receiving warfarin and ASA compared with ASA alone, but no differences were noted between the groups in the number of packed red blood cells transfused, or in the incidence rate of overall non-hemorrhagic wound complications, or the overall complication rate.[136] The combination of warfarin plus aspirin therapy appears to protect from occlusion in smaller diameter prosthetic bypasses[133] and from severe ischemia in femoropopliteal PTFE grafts when occlusion occurs.[137]

Prospective randomized evidence to date around use of novel oral anticoagulant agents following lower extremity bypass revascularization comes primarily from the VOYAGER PAD trial,[129] which randomized initiation of rivaroxaban 2.5 mg twice daily dosing vs placebo in addition to background antiplatelet therapy; of note, clopidogrel as an adjunct to study antithrombotic regimen could be administered for up to 60 days after a lower extremity revascularization at the discretion of the investigator.[138,139] Among the 2185 patients who underwent surgical lower extremity intervention (lower extremity bypass, endarterectomy, or both), a benefit was seen with rivaroxaban in prevention of acute limb ischemia events.[138] The median time from revascularization to study drug initiation among the surgical revascularizations was 6 days, and bleeding risk of rivaroxaban appeared to be consistent between those initiated on medication therapy less than 6 days from surgery vs 6 or more days from surgery. Bleeding events requiring an unplanned take-back procedure remained low (1.3%) and did not differ between rivaroxaban vs placebo therapies; similarly, in the long term, by 3 years, the cumulative incidence of major bleeding did not differ between rivaroxaban vs placebo within the surgical bypasses.[138]

Suggestion: Continue aspirin throughout the perioperative period.

Level of evidence: High.

Suggestion: Consider adjunctive anticoagulation therapy in prosthetic or high-risk bypasses.

Level of evidence: Moderate.

PREOPERATIVE RECOMMENDATIONS

4. Fasting. Based on meta-analysis of multiple RCTs in a range of surgical patients and according to both the American Society of Anesthesiologists' and European Society of Anesthesiology's preoperative fasting guidelines that give a strong recommendation based on high-quality evidence, patients should be allowed to drink clear fluids up to 2 hours before elective surgery, but should not eat any solid food for at least 6 hours for "light meals" or 8 hours for fatty foods and meat.[140,141] It is important to note that these recommendations apply to patients who undergo elective procedures, and a longer fasting period may be necessary in patients with risk factors for delayed gastric emptying such as obesity, diabetes, hiatal hernia, and gastroesophageal reflux disease.

Suggestion: Avoid overnight fasting; encourage clear fluids up to 2 hours and light foods up to 6 hours prior to the induction of general anesthesia.

Level of evidence: High.

5. Carbohydrate loading. Although the effectiveness of carbohydrate loading has not been fully established in patients undergoing vascular surgery, several RCTs in other surgical populations demonstrate a preoperative carbohydrate drink compared with placebo or fasting after midnight reduce insulin resistance and lessen the risk of hyperglycemia after surgery.[142-148] The most commonly studied preoperative carbohydrate regimen is 800 mL of a clear 12.5% carbohydrate drink the evening before surgery and 400 mL up to 2 hours before surgery.[144-148] A systematic review of 22 RCTs found that oral carbohydrate loading is safe up to 2 hours prior to surgery and can improve postoperative discomfort,[149] and a Cochrane Review of 27 RCTs of variable quality in mixed surgical populations conclude that preoperative carbohydrate loading reduces hospital length of stay.[150]

As many patients undergoing infrainguinal bypass have diabetes, the question of effectiveness and safety has been raised. It has been suggested that carbohydrate drink alternatives such as popular sports drinks may be more appropriate for patients with a diagnosis of diabetes; however, the evidence to support this practice is low.[7] Despite low quality evidence, it appears that oral carbohydrates are safe and effective in well-controlled diabetic patients, without a significant risk of hyperglycemia or aspiration.[151,152]

Suggestion: Patients without diabetes should receive a preoperative carbohydrate drink.

Level of evidence: High.

Suggestion: Patients with well-controlled diabetes should receive a preoperative carbohydrate drink.

Level of evidence: Low.

6. Venous thromboembolism prophylaxis. VTE risk can be significantly reduced by incorporating multiple strategies such as early mobility, mechanical prophylaxis, and chemoprophylaxis. Compiling data from over 100 RCTs of mixed populations comparing low-dose unfractionated heparin, low molecular weight heparin, and no chemoprophylaxis, the American College of Chest Physicians Guidelines on the prevention of venous thromboembolism (VTE) in nonorthopedic surgical patients notes that there is significant reduction in VTE when prophylactic doses of either of these anticoagulants are used and that bleeding complications are rare.[153]

The use of mechanical prophylaxis should be employed along with chemoprophylaxis or alone in patients who have a high risk of bleeding. Mechanical prophylaxis decreases the risk for postoperative VTE by preventing venous stasis and reducing plasminogen activator inhibitor-1, increasing endogenous fibrinolytic activity. Mechanical compression stockings should be avoided in patients with severe arterial disease despite intervention (systolic ankle pressure <60 mmHg; toe pressure <30 mmHg).[154] Intermittent pneumatic compression and venous foot pumps are not contraindicated in patients who have had infrainguinal bypass surgery, but mechanical prophylaxis should be avoided in patients with in situ bypasses, tibial bypass, or any other instance the compression device would place direct pressure on the conduit.[155]

Suggestion: Routinely use either low-dose unfractionated heparin or low molecular weight heparin with calf-length intermittent compression devices, when possible, starting either prior to surgery or within 24 hours of surgery end, and continuing throughout the hospitalization.

Quality of literature: High.

7. Pre-anesthetic sedative and analgesia medication. Preoperative anxiety is frequent and may lead to increased perioperative analgesic requirements. Multiple prospective and retrospective cohort studies demonstrate benzodiazepines can cause neurocognitive impairment and have unwanted sedative effects[156-159]; therefore, sedative or anxiolytic drugs should be avoided. This is particularly important in patients over 65 years old, as the American Geriatric Society has made a strong recommendation, with moderate evidence, against the use of benzodiazepines in older adults.[157]

Patients with PAD often have pre-existing chronic pain, due to ischemic rest pain and/or tissue loss, which are key features of this disease.[160] Perioperative pain management may be complicated by established analgesic regimens as well as advanced age and pre-existing comorbidities including renal impairment.[161] Dosed appropriately for age and renal function, multimodal opioid-sparing perioperative analgesia includes acetaminophen, non-steroidal anti-inflammatory drugs (NSAIDs), and gabapentinoids, all of which have been shown to decrease postoperative pain scores, facilitate opioid sparing pain management, and can be administered in a cost-effective manner.[159,162]

Patients who are currently using analgesics for chronic pain could benefit from an interdisciplinary approach and should have expectations set for postoperative pain management before the operation occurs. Abruptly stopping the patient's baseline opioid medication can result in inadequate postoperative pain control and increased risk of acute withdrawal in the postoperative period, and this is not recommended.[163] This is particularly true for patients taking methadone.[164]

For patients on buprenorphine (especially >12 mg/day), even dose decreases can cause withdrawal, and patients will need their pain specialist to gradually reduce the dose prior to any operation in which postoperative opioids will be used.[165]

Notably, revascularization may improve chronic ischemic pain, and outpatient tapers of all types of analgesics may be possible.

Suggestion: Do not routinely use sedatives to reduce anxiety preoperatively.

Level of evidence: Low.

Suggestion: Routinely use preoperative administration of acetaminophen, NSAIDs, and gabapentinoids as part of a multimodal opioid-sparing analgesia strategy.

Level of evidence: Low.

Suggestion: Continue existing preoperative pain regimens with minimal disruption.

Level of evidence: Moderate.

8. Antimicrobial prophylaxis and skin preparation to reduce surgical site infections. Surgical site infections (SSIs) can involve superficial or deep incisional tissues, and are typically caused by typical skin flora, although vascular surgical wounds and/or ischemic wounds can have a variety of organisms.[166] A bundled program to prevent the development of SSI is often recommended and may reduce SSI by 51% in a single-center observational study.[167] Specifically included in most bundles are perioperative normothermia, appropriate skin preparation and hair removal, preoperative antibiotic prophylaxis, and minimizing traffic in and out of the operating room.[168] Adjunctive use of antibiotics such as triclosan-coated suture or gentamicin-impregnated grafts have mixed results and have not been shown to consistently reduce SSIs.[169,170]

Skin preparation should be standardized, with the operative area being scrubbed on the day prior to and

immediately before surgery with a Chlorhexidine solution based on RCTs of heterogeneous clean-contaminated surgeries indicating benefit, though smaller RCTs and prospective observational studies of vascular reconstructions have not demonstrated benefit.[171-173] Based on meta-analysis of a small number of RCTs with heterogeneous surgical procedures and quasi-experimental cohort studies of vascular surgeries, hair clipping should be performed immediately preoperatively, with hair clipping preferred to shaving.[167,174,175]

Preoperative intravenous prophylactic antibiotics should be administered immediately prior to lower extremity bypass based on meta-analysis of RCTs.[176] Antibiotic duration has been primarily evaluated in patients without pre-existing infectious sources; in lower extremity bypass procedures with non-infected tissue, prophylactic antibiotics did not convey significant additional benefit when continued more than 24 hours postoperatively.[176] Extrapolated from cardiac and spine surgery, intraoperative antibiotic should be re-dosed within two serum half-lives of the agent[177-179] and may be additionally recommended for substantive procedural blood loss.[180]

Suggestion: Consider the use of bundles programs to reduce SSIs.

Quality of Evidence: Low.

Suggestion: Prophylactic intravenous antibiotic dosing should begin 30 to 60 minutes preoperatively with redosing intraoperatively within two serum half-lives of antimicrobial agent used or with substantive intraoperative blood loss, and extending no more than 24 hours postoperatively.

Quality of evidence: High.

9. Prevention of nausea and vomiting. Postoperative nausea and vomiting (PONV) is estimated to be 50% and 30% in the general surgical population, respectively, and may approach 80% in patients who are high risk for PONV.[181] The most commonly used PONV risk scoring systems are the Koivuranta and Apfel scores.[182,183] It is important to employ PONV mitigation strategies, such as minimizing the use of nitrous oxide and volatile anesthetics,[184] utilizing regional anesthesia such as peripheral nerve blocks and neuraxial anesthesia,[185] and including opioid-sparing, multimodal analgesia techniques.[186,187]

There is significant high quality evidence from multiple RCTs supporting the use of multimodal prophylaxis and treatment of PONV that can be generalized to major vascular surgery.[188] Pharmacologic agent classes and other interventions that are currently available include 5-HT3 receptor antagonists, corticosteroids, antihistamines, dopamine antagonists, propofol anesthesia, NK-1 receptor antagonists, anticholinergics, and acupuncture.[189] For rescue treatment, one should use an antiemetic from different class than what was used for prophylaxis.

Suggestion: Risk assess for PONV, routinely use multimodal PONV prophylaxis based on assessment, and use PONV rescue with a different class of anti-emetic.

Quality of evidence: High.

INTRAOPERATIVE RECOMMENDATIONS

10. Anesthetic protocol

Patients undergoing peripheral vascular procedures often have widespread atherosclerotic disease and suffer significantly from cardiac complications and death, mandating hemodynamic stability throughout surgery.[190,191]

Although the role of regional anesthesia in ERAS has gained interest in recent years, there remains no clear evidence favoring regional (spinal, epidural, or peripheral nerve blockade) or general anesthesia over the other. Individual studies have suggested specific benefits from regional anesthesia: these include attenuation of the neuroendocrine response to surgery,[192] reduction in blood loss,[193] improvement in pulmonary function,[194] reduction in myocardial ischemia,[195] enhancement of lower limb blood flow,[196] and reduction the incidence of graft thrombosis and thrombotic response to surgery.[197,198] Evidence of possible long-term benefit from regional anesthesia remains elusive, and there are data to suggest that the type of anesthesia given for peripheral vascular surgery does not significantly affect cardiac morbidity or mortality, overall mortality, or LOS.[193,198-200] However, an RCT of 50 patients found fewer intraoperative episodes of myocardial ischemia in patients undergoing infra-inguinal bypass surgery under combined femoral and sciatic nerve blockade compared with general anesthesia.[201]

Whether choosing a regional or general anesthesia approach, the intraoperative analgesic strategy should include at least one or two simple non-opioid analgesics such as acetaminophen, NSAIDs, an α2-agonist, or ketamine.[202]

Summary/Recommendation: Use a multimodal analgesic strategy that includes non-opioid analgesics and regional anesthesia tailored the expected duration of pain and postoperative course.

Quality of evidence: Moderate.

11. Goal-directed fluid therapy

Intraoperative fluid management is a fundamental part of enhanced recovery programs, and both hypovolemia and hypervolemia have been strongly associated with significant postoperative complications. These include: impaired peripheral organ perfusion, site infection, poor wound healing, tissue edema, fluid overload, acute kidney injury and sepsis, as well as increased morbidity and mortality, and longer hospital stay in patients undergoing major abdominal and colorectal surgery.[203-205] Several systematic reviews and meta-analyses including observational studies and RCTs have shown that goal-

directed fluid therapy decreases postoperative morbidity and mortality in surgical patients,[206] as well as reduces both the volume of fluids administered and the incidence of complications, while still protecting renal function.[205]

Patients presenting for infrainguinal arterial operations are fundamentally physiologically different from the general cohort of patients presenting for major abdominal and colorectal surgery; they are often older with multiple coexisting comorbidities. Furthermore, the nature of surgery is different. Subgroup analysis has shown no evidence to support the use of goal-directed fluid therapy in peripheral vascular surgery patients; however, basic physiological principles apply to this high-risk group of patients. Avoidance of intraoperative hypotension, defined as a 40% decrease from pre-induction mean arterial blood pressure with a cumulative duration of more than 30 minutes, and prevention of fluid overload are fundamental to avoiding adverse outcomes in this patient group.[207,208]

Suggestion: Routinely use cardiac monitoring (arterial line and non-invasive cardiac output monitoring such as stroke volume variation) to support euvolemia.

Quality of evidence: Low.

12. Body temperature management

Perioperative hypothermia (core body temperature <36 °C) is a result of cold operating room temperatures, exposure of the patient, and anesthesia-related impairment of central thermoregulatory control. Hypothermia leads to cardiac arrhythmias, coagulopathies, altered levels of consciousness, decreased drug metabolism, impaired renal function, leftward shift in the hemoglobin oxygen saturation curve, resulting in reduced oxygen delivery, and prolonged wound healing and increased SSIs. From a combination of RCTs and prospective and retrospective cohorts across many surgical specialties, there is evidence that maintaining normothermia reduces these undesired outcomes.[209] Strategies to maintain normothermia include preoperative warming (10 to 30 minutes prior to induction of anesthesia), intraoperative warming with a forced air heating blanket, and use of fluid warmers and pre-warmed irrigation.[209]

Suggestion: Use multiple strategies to maintain normothermia, including prewarming and active warming of patients intraoperatively.

Quality of evidence*:* Moderate.

13. Surgical access and techniques

Autologous blood salvage. In contrast to recommendations for aortic surgery,[2,210-212] there is insufficient evidence to recommend routine use of autologous blood salvage in lower extremity bypass cases, due to typically lower operative losses associated with these infrainguinal procedures.[43,44,213]

Groin incisions and closure. Groin incisions are prone to infections and surgical morbidity, and reported rates in literature range widely from approximately 3% to 30%.[214,215] A Cochrane Review of two RCTs that included 283 groin incisions found with low certainty that transverse incisions for the exposure of the common femoral artery resulted in fewer SSIs.[216] Another meta-analysis that included the same 2 RCTs and added 5 case-control studies compared transverse with longitudinal incisions in 5922 groins and found that transverse incisions had significantly lower incidence of surgical site infection (0.73% vs 3.68%; $P = .03$) and wound dehiscence, but that lymphatic complications were similar (8.58% vs 10.9%; $P = .87$).[217]

Multiple techniques are described in literature to optimize groin closure to reduce the risk for SSIs. A systematic review of eight RCTs shows that use of plastic adhesive skin coverings with or without antimicrobial properties does not reduce the incidence of SSIs.[218] Meta-analysis of 17 RCTs and seven observational studies noted that subcuticular sutures for skin closure had a significant reduction in SSI rates when compared with surgical clips or transdermal sutures (odds ratio, 0.33; 95% CI, 0.17-0.65; $P = .001$).[219] When evaluating adjuncts to closure, closed incision negative pressure wound therapy significantly reduced the risk of SSI compared with standard dressings (odds ratio, 0.34; 95% CI, 0.23-0.51; $P < .001$).[219] Use of local antibiotics, fibrin glue, silver alginate dressings, and platelet-rich plasma have inconsistent results, but have not shown any statistically significant effects on SSI rates in metanalysis.[219-223]

Similarly, a Cochrane Review of three RCTs demonstrates there is no evidence usage of drains will decrease groin incision complications.[224]

Patients at high risk for groin incisional complications (females, patients with obesity, patients with end-stage renal disease) may benefit from prophylactic sartorius muscle flap closure.[225,226] Although incisional breakdown was similar between the groups, the presence of a vascularized muscle flap overlying the vascular repair was associated with reduced need for reoperation and allowed more wounds to be managed with local wound care alone.

Suggestion: Avoid the use of drains in groin incisions.

Level of Evidence: Moderate.

Suggestion: When possible, use transverse groin incisions. Close groin incisions with subcuticular sutures and use a negative-pressure dressing.

Level of Evidence: Low.

Vein harvest. Along with the choice of conduit, the technique of vein harvest is equally critical. The largest retrospective study used the VQI database and evaluated 5066 patients from 2003 to 2013. Single continuous incision was used in 48.6%, skip incisions were used in 39.7%,

and endoscopic vein harvest was used in 12.7%. There was no difference in SSIs in the three groups, but there was a statistically significant reduction in patency of endoscopically harvested veins at 1 year.[227] Other retrospective studies have also demonstrated a reduction in patency of endoscopically harvested veins when used for lower extremity bypass.[228,229]

Suggestion: Harvest vein conduits with either continuous or skip open incisions rather than endoscopic harvest.

Level of evidence: Low.

Hybrid surgery. Hybrid surgery has had a rapid increase in the treatment of PAD and should be considered in patients who are high risk for traditional open surgery, but have lesions that may not be completely amenable to endovascular intervention.[230] Although hybrid surgery is increasingly utilized, the population is very heterogeneous, and the data are limited, which reinforces the importance of case selection and treating patients with complex PAD at centers equally capable of both open and endovascular approaches. The most commonly described hybrid infrainguinal revascularization is a common femoral artery endarterectomy with endovascular revascularization of the femoropopliteal artery segment. A retrospective study of 4478 patients undergoing either venous bypass or prosthetic bypass or hybrid revascularization found that patients that are submitted to a hybrid intervention are older than the other groups and more likely to be treated under regional anesthesia. Compared with those undergoing a hybrid approach, prosthetic bypass was associated with more deep SSIs, organ space SSI, postoperative sepsis, and unplanned 30-day readmission, and vein bypasses were associated with more superficial SSIs.[231] Similarly, a retrospective analysis of 1480 patients from the National Surgical Quality Improvement Program registry demonstrated superior short-term outcomes, especially with reduction of SSIs, with a hybrid approach.[232] A retrospective analysis of 850 propensity-matched patients from the VQI demonstrated that hybrid revascularization was associated with a lower rate of myocardial infarction and renal complications, shorter hospital LOS, and higher rate of discharge to home compared with bypass.[230] The 1-year outcomes suggested that patients in the bypass group had a higher likelihood of improvement in ambulatory status compared with patients in the hybrid group (16.7% vs 7.7%; $P = .044$); however, survival analysis showed no difference in overall survival or amputation-free survival between the two groups. A non-randomized prospective study of infrainguinal hybrid revascularization in 99 patients with chronic limb-threatening ischemia demonstrates high technical success rates, and patency at 2.5 years matches that of other reported infrainguinal bypasses.[233]

Suggestion: Hybrid surgery and distal endovascular revascularization can be considered in older patients and may reduce SSIs.

Level of evidence: Low.

POSTOPERATIVE RECOMMENDATIONS

14. Multimodal analgesia and opioid reduction. Regional anesthesia is thought to be superior to general anesthesia for early acute postoperative pain management and side effects; however, the evidence for improved patient satisfaction is limited.[234] There is good quality evidence to support multimodal analgesia for postoperative pain relief following surgery.[187] These techniques combine regional anesthetic techniques and non-opioid analgesics at multiple points in the pain pathway.[235] A Cochrane review identified a 20% to 25% reduction in pain intensity and a 30% to 50% reduction in analgesic consumption in surgical patients treated with a multi-modal strategy.[236] The use of clonidine is associated with reductions in pain, opioid consumption, and early postoperative nausea and vomiting.[237]

Acute pain management in vascular surgery patients with underlying chronic ischemic pain can often be challenging particularly in the postoperative period. One 30-day postoperative follow-up study showed that 61.3% of preoperative opioid users and 28.4% of opioid-naïve patients continued using opioids.[238] Given a 35% prevalence of chronic opioid use among patients with PAD and because revascularization often eliminates ischemic pain, a concerted effort should be made to taper existing pain medications.[239]

Suggestion: Routinely use multimodal analgesic regimens to improve pain control and reduce opioid consumption.

Level of Evidence: High.

15. Oral feeding. Postoperatively, patients should be encouraged to reestablish oral nutrition as early as possible, allowing patients to eat what they feel comfortable with and consume oral nutritional supplements daily. Patients with chronic limb-threatening ischemia undergoing either endovascular or open revascularization that have improved postoperative nutritional status fared better, even when their baseline nutritional status was poor.[13]

Suggestion: Resume oral nutrition as early as possible, if not immediately postoperatively, allowing patients to eat what they feel comfortable with and consume oral nutritional supplements daily.

Level of Evidence: Moderate.

16. Glycemic control. Patients may benefit from incorporating a dietician to provide nutritional counseling, a nurse diabetic educator, and endocrinology for patients who have known diabetes mellitus. Perioperative

hyperglycemia in vascular surgery patients has previously been defined as a glucose value of greater than 180 mg/dL within 72 hours of surgery.[240] The presence of perioperative hyperglycemia is strongly associated with increased 30-day mortality (5.7% vs 0.7%; $P < .01$), SSIs (5.7% vs 2.6%; $P = .01$), increased rates of renal failure, postoperative stroke, and need for readmission.[240] The prevalence of peripheral arterial disease in patients with diabetes mellitus is estimated to be 29%, with amputation rates in diabetic patients being five to 10 times higher than in non-diabetic patients.[54,241] Improving glycemic control provides for reduced numbers of SSIs, facilitates wound healing, and provides better patient outcomes. Even in the absence of a known diagnosis, most guidelines support starting insulin therapy intraoperatively and postoperatively for a blood glucose of >180 g/dL in supported hospitalized patients with a target of between 140 and 180 g/DL for most patients.[242,243] Careful postoperative glycemic control to limit extreme variability in glucose decreases adverse cardiac events[244]; however, caution is advised as aggressive treatment causing hypoglycemia may increase mortality.[117,245]

Suggestion: Glycemic goal of 180 mg/dL or less during the perioperative period.

Quality of evidence: Moderate.

Suggestion: Routinely use diabetic and nutritional counseling as part of interdisciplinary care for diabetic patients.

Quality of evidence: High.

17. Urinary drainage. Due to concern of catheter-associated urinary tract infection and guidance from the United States Centers for Disease Control and Prevention, the use of prolonged urinary catheters has decreased.[246] Although urinary catheters are often needed intraoperatively, there is little need for continuous postoperative urine output monitoring after lower extremity bypass, and catheters should be removed at the end of the operation, or as soon as possible in extenuating circumstances.

Suggestion: Remove urinary drainage catheters before leaving the operating room, or as soon as possible in extenuating circumstances.

Level of evidence: Low.

18. Early mobilization. PAD, and especially the more severe chronic limb-threatening ischemia, can lead to a significant decrease in a patient's baseline functional status. Evaluating the baseline functional status and setting appropriate goals and expectations is imperative to a successful postoperative mobility plan, and is associated with long-term independence and survival.[247] Clear communication of weight-bearing restrictions and immediate availability of appropriate off-loading shoes for patients with tissue loss who can partially or fully weight bear avoids delay in postoperative mobilization. Mobility is not necessarily limited to ambulation, and especially for those who are non-weight bearing, can include any active limb exercise. Depending on the patient's clinical condition, this could consist of simple interventions such as dynamic range of motion, sitting at the side of the bed, or pivoting to a bedside chair.[248] Successful mobilization strategies require a multidisciplinary approach, objective evaluation of patient safety and ability for early ambulation, and tracking progress with a formal mobility scale.[249] If patients are not progressing, then causes of failure need to be analyzed by the multidisciplinary team, including physical therapists, and corrective measures should be instituted quickly. Multi-disciplinary care teams for vascular surgery patients have demonstrated improved outcomes when incorporating podiatry and wound care centers.[250,251]

Suggestion: Use a formal plan for early mobilization immediately postoperatively, with early physical therapy involvement when needed.

Level of evidence: Low.

19. Discharge criteria and post discharge education. Patients undergoing vascular surgery have 30-day readmission rates as high as 20% and up to one-half of readmissions are deemed avoidable.[252-254] In line with fundamental ERAS philosophy, there is a published conceptual model of preventing readmissions in vascular surgery that includes patient education and timely communication from the preoperative phase to the postoperative phase of care.[4] A Cochrane Review of two RCTs concluded that written and verbal information on specific care instructions, medication lists, and when to seek medical attention at discharge significantly increased patient knowledge and satisfaction.[255,256] The data on follow-up postoperative phone calls has been mixed; a Cochrane Review of 33 studies of mixed methodology from different specialties was inconclusive; however, no adverse effects of the invention were reported.[257]

Suggestion: Utilize both written and verbal discharge education, use follow-up phone calls with 24 to 48 hours of hospital discharge, and arrange clinic follow-up with both the surgeon and primary care at least once at 30 days postoperatively.

Level of evidence: Low.

SUMMARY AND CONCLUSION

The main purpose of this consensus statement is to provide a framework from which to build a multidisciplinary program to implement best perioperative practices for patients undergoing lower extremity vascular bypass surgery. As demonstrated in other specialties, forming care teams to enhance patient optimization and shared decision-making, focus on physiologic stress minimization, and reduce variation in

postoperative convalescence promises to improve the safety and outcomes for patients undergoing infrainguinal bypass operations.

This consensus statement defines current standards based on the available medical literature, but there are many gaps in the published medical knowledge specific to this high-risk group of patients. Of the 36 practice suggestions made, only 11 are based on high-quality evidence. Although the few clinical studies available seem promising, studies of high methodological quality are needed. The lines of research to be developed could include any of the ERAS elements or combined elements, but are particularly needed in pre-admission optimization, prehabilitation, preoperative carbohydrate loading in diabetics, pre-anesthetic sedatives and analgesia, early mobility protocols, and post-discharge education.

AUTHOR CONTRIBUTIONS

Conception and design: KM, OL, HD

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Data collection: KM, ES, KA, SA, AS, MT, KD, IS, MD, CS, RU, SH, JS, OL, HD

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CORRECTION

In the May 2023 issue of the *Journal of Vascular Surgery*, the article by McGinigle et al (McGinigle KL, Spangler EL, Ayyash K, Arya S, Settembrini AM, Thomas MM, et al. A framework for perioperative care for lower extremity vascular bypasses: A Consensus Statement by the Enhanced Recovery after Surgery (ERAS®) Society and Society for Vascular Surgery. J Vasc Surg 2023;77:1295-315) contained an error in the department listed for the affiliation of Dr Katie Ayyash. The correct affiliation for Dr Ayyash is "Department of Anaesthesia and Critical Care, York and Scarborough Teaching Hospitals NHS Foundation Trust, York, United Kingdom"

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CORRECTION

In the May 2023 issue of the *Journal of Vascular Surgery*, the article by McGinigle et al (A framework for perioperative care for lower extremity vascular bypasses: A Consensus Statement by the Enhanced Recovery after Surgery (ERAS®) Society and Society for Vascular Surgery. J Vasc Surg 2023;77:1295-315) omitted a co-author. Dr Ashley K. Vavra, MD, MS, Northwestern Feinberg School of Medicine, Chicago, IL, should appear as the fourth author on this paper. Dr Vavra contributed to writing the article and critical revision of the article.