Regional anesthesia for vascular surgery: does the anesthetic choice influence outcome?

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Purpose of review
Outcomes following surgery are of major importance to clinicians, institutions and most importantly patients. This review examines whether regional anesthesia and analgesia influence outcome after vascular surgery.

Recent findings
Large database analyses of contemporary practice suggest that utilizing regional anesthesia for both open and endovascular aortic aneurysm repair, lower limb revascularization and carotid endarterectomy reduces morbidity, length of stay and possibly even mortality. Results from such analyses are limited by an inherent risk of bias but are nevertheless important given the number of patients required in randomized trials to detect differences in rare outcomes. There is minimal evidence that regional anesthesia influences longer term outcomes except for arteriovenous fistula surgery where brachial plexus blocks appear to improve 3-month fistula patency.

Summary
Patients undergoing vascular surgery often have multiple comorbidities and it is important to be able to outline both benefits and risks of regional anesthesia techniques. Regional anesthesia in vascular surgery allows avoidance of general anesthesia and does provide short-term benefits beyond superior analgesia. Evidence of long-term benefits is lacking in most procedures. Further work is required on newer patient centered outcomes.

Keywords
anesthesia, epidural, nerve block, outcome, spinal, vascular surgical procedures

INTRODUCTION

Outcomes following surgery are of major importance to clinicians, institutions and most importantly patients. In order for patients and physicians to make shared, informed decisions about the optimal anesthetic technique for any procedure, clinicians must be able to provide contemporary evidence about benefit and risk.

Vascular surgery ranges from major operations with significant inherent perioperative risks to minor day surgery procedures, all of which are performed in patients who, as a group, are more likely to have multiple underlying comorbidities. Anesthetic options include a variety of neuraxial and peripheral regional anesthesia techniques, used either alone or in combination with general anesthesia or sedation. Avoiding general anesthesia may alone be of appeal, but regional anesthesia has also been shown to have benefits beyond excellent pain control and can even improve surgical outcome in some cases [1▪].

Outcome research is increasingly focusing on patient-centered outcomes such as functional capacity, comfort and emotional health which differ from institutional outcomes such as case throughput and length of hospital stay, and clinical outcomes such as morbidity and mortality [2▪▪,3]. This article focuses on abdominal aortic aneurysm repair, carotid endarterectomy (CEA), lower limb revascularization procedures, arteriovenous fistula (AVF) creation and amputation, and summarizes recent

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KEY POINTS

- Vascular surgery ranges from procedures with a relatively high risk of mortality today surgical operations.
- Vascular surgical patients often have multiple comorbidities.
- Evidence from contemporary randomized trials suggesting benefit is limited but large-database analyses suggest neuraxial anesthesia and epidural analgesia reduce morbidity in open and endovascular aortic aneurysm repair and lower limb revascularization.
- There is no randomized trial data suggesting that regional anesthesia for carotid endarterectomy reduces neurological complications or mortality.
- Utilizing regional anesthesia increases medium-term functional patency in arteriovenous fistula surgery.

evidence examining whether regional anesthesia influences outcome. Regional anesthesia, particularly in vascular patients, is not without risk however and this is also briefly discussed.

ABDOMINAL AORTIC ANEURYSM REPAIR

Advances in preoperative optimization, intraoperative management and critical care combined with the establishment of endovascular aneurysm repair (EVAR) have improved short-term perioperative outcomes after elective abdominal aortic aneurysm repair (AAAR) albeit 5-year survival remains disappointingly low [4–8].

Consistent with meta-analyses of other major surgical procedures [9,10], the most recent Cochrane review demonstrated that combined epidural analgesia and general anesthesia in open AAAR is associated with superior analgesia, lower pulmonary complications and a shorter intensive care stay when compared with general anesthesia and systemic analgesia [11]. This review, which includes studies dating back to 1987 that do not necessarily reflect contemporary practice however, also found combined epidural and general anesthesia reduces the risk of myocardial infarction (MI). This differs from findings above [9], and elsewhere [12] which suggest cardiac complications may be increased in patients undergoing major surgery with combined neuraxial and general anesthesia although these analyses of mainly non randomized data are subject to clear limitations [13] and not specific to open AAAR surgery. There is increasing evidence however that even brief periods of SBP less than 100 mmHg and mean pressures of less than 60–70 mmHg are associated with myocardial injury, acute kidney injury and death in noncardiac surgery [14▪]. It would seem prudent therefore, particularly in patients with vascular disease, to pay meticulous attention to blood pressure control not just intraoperatively but also postoperatively where hemodynamic monitoring and management may not be so proactive. Postoperative SBP less than 90 mmHg in noncardiac surgical patients has been linked to increased mortality, myocardial injury and stroke and this threshold is likely higher in patients with preoperative hypertension [15▪].

Meta-analysis of randomized trials did not demonstrate a reduction in mortality with the addition of epidural to general anesthesia in AAAR but retrospective, and by definition weaker, evidence suggests that epidural analgesia may reduce 5-year mortality in open AAAR [16]. This benefit was attributed to the reduction in early complications such as bowel ischemia, dialysis requirements and 30-day reintervention rates. The American Society of Anesthesiologists score was lower in the combined epidural and general anesthesia group however, and while adjusted for this remained a possible confounder.

The retroperitoneal AAAR surgical approach may be associated with enhanced recovery, and fewer pulmonary and gastrointestinal complications compared with the traditional transperitoneal approach [17,18], This approach also allows regional anesthesia to be utilized as the primary anesthetic with several case series suggesting that neuraxial anesthesia is advantageous in selected patients with severe pulmonary disease undergoing open AAAR [19–22].

Transverse abdominis plane and other truncal blocks are alternative analgesic options [23]. Emerging fascial plane blocks such as quadratus lumborum or erector spinae plane blocks are potentially attractive but have not yet been sufficiently investigated in open AAAR surgery. Continuous local anesthetic infusion via surgically placed preperitoneal multihole catheters provide analgesia inferior to epidural analgesia after open AAAR [24]. Intrathecal opioids represent another analgesic modality but while side effects of intrathecal morphine increase above 300 μg, the optimal dose for open abdominal surgery is yet to be determined [25].

More recently the minimally invasive EVAR, which is possible as an outpatient procedure, has become the mainstream treatment of AAAR [26,27▪]. EVAR is also increasingly being used in ruptured AAAR. EVAR is well suited for local and regional anesthesia techniques combined with conscious sedation. There are no randomized controlled studies evaluating EVAR outcomes in relationship to

anesthesia type, but large retrospective studies and meta-analysis of observational studies strongly associate local and regional anesthesia techniques with lower perioperative mortality, morbidity and a shorter hospital stay when compared with general anesthesia [28–30,31▪▪,32]. This mortality benefit appears even stronger in ruptured aneurysm EVAR procedures [33▪,34▪,35–37]. Peripheral nerve block (PNB) techniques have been successfully utilized for EVAR, including paravertebral [38], combined iliohypogastric/ilioinguinal [39] and combined femoral/genitofemoral [40] nerve blocks. While these may be useful alternatives for patients in whom neuraxial anesthesia is not feasible or local infiltration is insufficient, evidence of outcome benefit is yet to be demonstrated.

CAROTID ENDARTERECTOMY

Cervical epidural anesthesia and cervical plexus blocks (CPBs) are both recognized anesthetic techniques although the former is no longer popular, being associated with serious complications and higher failure rates compared with CPB [41,42]. Superficial, intermediate and deep CPBs have all been used alone or in combination, whereas blocks of the facial nerve, branches of the mandibular nerve and the accessory nerve, as well as infiltration posterior to or inside the carotid sheath may also be added. Supplemental local anesthetic infiltration by the surgeon is often necessary, depending on anatomical variations and surgical technique. Ultrasound guidance has popularized the intermediate CPB technique [43,44], where local anesthetic is injected into a plane just lateral and deep to the sternocleidomastoid muscle, but superficial to the prevertebral cervical fascia at the level of the fourth cervical vertebra. The US-guided intermediate CPB technique is relatively easy to perform and appears equally successful as the superficial CPB [45] although possibly inferior to the superficial and deep CPB combined [46]. The deep CPB is however associated with more complications [47] and there remain no randomized trials assessing whether these can be reduced by using ultrasound.

Regional anesthesia or surgeon-performed local anesthetic infiltration avoids the potential hemodynamic and cognitive effects of general anesthesia and allows real-time neurological monitoring during cross clamping rather than utilizing surrogate monitors such as electroencephalography and evoked potential monitoring. Meta-analyses and large randomized trials have previously failed to demonstrate that regional anesthesia reduces stroke, MI or mortality [48,49]. While a more recent meta-analysis of observational data has suggested that local (regional) anesthesia may be associated with lower perioperative morbidity and mortality [50▪] a different, also contemporary, database analysis failed to demonstrate a mortality benefit [51]. This latter analysis did however detect an increase in pulmonary complications in the general anesthesia group. The General Anaesthesia versus Local Anaesthesia for Carotid Surgery (GALA) trial and other smaller studies [49,52] did find a decreased need for intraoperative shunt placement with regional anesthesia but these findings did not correlate with improved cerebrovascular or cardiovascular outcomes. Subgroup analysis from the GALA trial has since suggested however that regional anesthesia and local anesthesia are associated with better postoperative neurocognitive outcomes, supported by relevant neurobiochemical assays [53]. Regional anesthesia for CEA has also been associated with, less patient-centered, benefits such as decreased cost, operating room expenses, postoperative resources and length of hospital stay [54–56].

Ultimately any benefits of regional anesthesia for CEA must be balanced against the potential of an uncontrolled airway, as well as possible patient anxiety, discomfort and stress [57]. Anesthetic choice must incorporate surgical, anesthetic and patient preference and currently general anesthesia combined with neuromonitoring remains by far the most widely used modality [55,57–59,60▪,61]. Regardless of technique it is likely that the collective perioperative team experience and routines in place are the most important factors influencing outcome.

LOWER LIMB REVASCULARIZATION

Epidural, combined spinal epidural and spinal are all acceptable regional anesthetic techniques for infrainguinal revascularization procedures although prolonged procedures can be uncomfortable. Good-quality postoperative analgesia clearly reduces pain but, importantly, also helps minimize the stress response to surgery, which causes tachycardia, hypertension and vasoconstriction, all of which are detrimental to both the patient and potentially to graft patency. While some historical studies suggested neuraxial anesthesia reduced early graft failure [62] there are still no large scale, contemporary randomized trials demonstrating a prolonged beneficial effect of regional anesthesia on graft patency or subsequent amputation rates.

Meta-analysis of randomized controlled trials has demonstrated neuraxial anesthesia for lower limb revascularization reduced pneumonia, but not MI or mortality [63]. Newer 'big data' from over 1 million patients, including those undergoing

vascular operations, suggests that neuraxial anesthesia may reduce not only pulmonary morbidity but also blood loss, wound infection, thromboembolic events, intensive care admissions and length of stay and that these benefits are greatest when regional anesthesia is used alone [9]. These data are mostly observational in nature however and the majority of the surgical procedures included were not lower limb revascularizations. A different large-database analysis of solely such procedures did recently demonstrate a reduction in length of stay and postoperative congestive cardiac failure but not MI with regional anesthesia and a trend toward reduced mortality [64].

ARTERIOVENOUS FISTULA

Axillary, infraclavicular or supraclavicular brachial plexus blocks may all be used. If an axillary block is chosen for brachial AVF it is necessary to ensure the medial brachial cutaneous nerve (MBCN) and the medial antebrachial cutaneous nerve, are blocked. Superficialization of brachiobasilic fistulae requires anesthesia of not only the MBCN, but also the intercostobrachial nerve (ICBN). Ultrasound-guidance increases successful blockade of both the MBCN and ICBN compared with conventional surface landmark-guided techniques [65▪,66]. Local anesthetic spread in a pectoralis II block can also block the ICBN although this does not always eliminate the need for local anesthetic supplementation [67].

Unlike general and local anesthesia, only regional anesthesia has been proven to improve medium-term functional AVF outcome when compared with local anesthesia [68]. Regional anesthesia -mediated sympathetic block increases fistula arterial inflow, outflow secondary to venodilation and also reduces vasospasm. These benefits of regional anesthesia may in turn reduce early thrombosis and a perioperative single shot brachial plexus block has been shown to increase both primary and functional patency in radiocephalic AVF at 3 months [68,69]. Regional anesthesia may also alter the operative plan whereby vasodilated distal vessels become amenable to surgery [68,70], and in other studies regional anesthesia reduces reoperation rates and length of stay [71]. A recent database analysis including over 30 000 patients compared general anesthesia with regional anesthesia and local anesthetic and suggested lower infection and bleeding in the combined regional anesthesia and local anesthetic group but interestingly early failure of arteriovenous grafts and AVF was slightly increased in the combined regional anesthesia and local anesthetic group [72]. This effect persisted when regional anesthesia and local anesthetic were examined separately. Satisfaction with both regional anesthesia and local anesthetic is high [68] but further work is required looking at other patient-centered outcomes such as quality of recovery and quality of life. Regional anesthesia potentially could improve quality of life by reducing AVF failure, therefore decreasing subsequent redo procedures and possibly the need for a long-term dialysis line which has many associated complications.

AMPUTATION

Vascular patients presenting for amputation have a relatively high risk of perioperative morbidity and mortality. These procedures are amenable to both general and regional techniques. Two recent analyses of national surgical quality improvement program data [73,74] showed no difference between regional anesthesia and general anesthesia with regard to postoperative complications, reoperation rates and length of stay. This differs however from other, also non-randomized, data which suggest that regional anesthesia may decrease blood loss, blood transfusion, pulmonary complications, arrhythmias and length of stay but not MI or mortality [75,76].

A potential significant benefit of regional anesthesia is prevention and management of postamputation pain (PAP) which can be severe and challenging to control. PAP can be categorized into neuropathic phantom limb pain (PLP) and phantom sensations, as well as nociceptive residual limb pain, commonly known as stump pain [77]. Regional anesthesia appears to be more effective in the treatment of stump pain compared with PLP although the duration of pain relief is highly variable [77]. Superior early pain control and a reduction in opioid requirements up to 1 week after surgery has been reported with PNBs and/or epidural analgesia when compared with general or spinal anesthesia with a lower rate of complications in the PNB group [78–81].

Inadequately treated acute PAP is a risk factor for development of chronic persistent pain. Despite the superior analgesia afforded by regional anesthesia and the potential to decrease central sensitization evidence of long-term benefit of regional anesthesia is limited [82]. Observational data suggest the use of PNB for prolonged periods (median 30 days) may decrease PLP in addition to decreasing acute stump pain [83,84] for up to 12 months. Whether traditional perineural infusions of up to 72 h are being discontinued prematurely is therefore a potential interesting area of study. Peripheral nerve stimulation is a newer modality that holds promise regards

reducing the incidence of PLP and may improve disability in patients with chronic neuropathic PAP [85▪].

COMPLICATIONS OF REGIONAL ANESTHESIA IN VASCULAR PATIENTS

Many vascular patients are prescribed medications that alter platelet function or other coagulation parameters and careful consideration of timing is required to avoid increasing the risk of regional anesthesia-related neuraxial bleeding. Recent updated guidance from the American Society of Regional Anesthesia and Pain Medicine is valuable in this regard [86▪]. Hypotension is another complication of neuraxial blockade, the risks and implications of which were described earlier [12,13,14▪,15▪]. Diabetes is another common comorbidity which potentially adds to the risk of regional anesthesia associated nerve injury [87].

Postoperative delirium is multifactorial in nature and a recent meta-analysis concluded that general anesthesia in vascular surgery is not a risk factor [88] despite evidence that in other procedures regional anesthesia-mediated reduction in opioid consumption may reduce delirium [89]. There is no evidence as yet that the longer term phenomenon of postoperative cognitive dysfunction is reduced by using regional rather than general anesthesia in any surgical procedure.

CONCLUSION

Any outcome studied must ideally be patient-centered, clearly defined, well validated and easy to measure [90]. Regional anesthesia does appear to have benefits in vascular surgery beyond reducing pain and opioid-related side effects although much of the recent evidence is of low-to-moderate quality despite the large numbers of patients analyzed. Future interesting areas of research include whether regional anesthesia influences more patient-centered outcomes such as quality of recovery and sleep, anxiety, satisfaction and overall quality of life [2▪▪,3] as well as more traditional outcome measures.

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Conflicts of interest

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