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Intraoperative management: peripheral vascular surgery

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Lower extremity atherosclerotic disease affects nearly 10 million people in the United States [1]. Recent advances in atherosclerosis include an understanding of the pathophysiologic role of inflammation in atherosclerosis and its progression [2], and the addition of magnetic resonance angiography (MRA) as a powerful diagnostic tool that has reduced the necessity for contrast angiography and its attendant risks. Medical and interventional radiologic techniques also help many patients to avoid more invasive surgical procedures. Subsequently, the vascular surgery patients who now enter the operating room for peripheral vascular surgery represent the subset whose lesions are refractory to medical management, not amenable to endovascular techniques, or who have significant comorbidities.

Treatment alternatives for peripheral vascular disease

Medical management

Intermittent claudication is the most common symptom of lower extremity peripheral vascular disease (PVD). Conservative management, including smoking cessation and exercise therapy programs, remains a mainstay of care. Outcome data support the value of exercise therapy in restoring physical activity tolerance among those with intermittent claudication [3]. Additionally, aspirin therapy is often used in the management of chronic lower extremity PVD, and

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in cerebral and coronary atherosclerotic disease. Consequently, over 70% of patients have no progression or improvement in symptoms after 5 to 10 years of conservative management. The remainder, however, have progressive symptoms that require additional intervention [4]. In those instances, revascularization has been shown to improve physical activity and other health dimension scores, suggesting that these invasive techniques can have a great impact on a patient's overall health [3].

Patients with intermittent claudication refractory to medical management require imaging to assess disease anatomy. MRA, which eliminates the need for arterial catheterization and the administration of iodinated contrast material, has largely replaced traditional angiography as the preferred imaging modality. Khilanani et al [5] compared the gold standard of angiography to MRA, demonstrating a 77% to 100% agreement between the two modalities, findings which were later confirmed by Morasch et al [6].

Endovascular techniques

Nonsurgical endovascular interventions for treating vascular disease have become increasingly popular as device technology has progressed. Endovascular interventions for vascular disease have grown from 90,000 procedures in 1994 to over 200,000 in 1997 [7]. Percutaneous transluminal angioplasty offers selected patients a treatment alternative with lower risk parameters than surgical revascularization. Often performed under local anesthesia, the morbidity is low with minimal recovery period and repeated procedures can be performed without precluding surgical therapy if needed [8].

Balloon angioplasty is particularly effective in patients with localized lesions less than 10 cm in length and unaffected adjacent segments [8]. Lesions of the iliac arteries are usually amenable to endovascular treatment because the vessels are large (7 mm to 12 mm) with good shear forces because of the high flow. Long-term patency rates for iliac disease treated with balloon angioplasty reach 70% and clinical success rates are in excess of 90% [9]. Other endovascular treatment modalities include stents, stent grafts, embolization devices, ultrasound angioplasty, thrombectomy devices, thrombolytic therapy, and radiation.

Thrombolytic therapy

Thrombolytic therapy can be used for patients with acute occlusion of a proximal artery that causes significant ischemia. In this setting, the use of thrombolytics can convert an urgent surgical procedure into an elective one and can achieve patency of occluded, but nondiseased, vessels for use in subsequent bypass procedures. The most commonly used thrombolytics include streptokinase, urokinase, and recombinant tissue plasminogen activator (rt-tPA). Of these, streptokinase has the greatest effects on systemic coagulation, reducing clotting factors V and VIII. A retrospective study from the Cleveland Clinic showed a

clinical success rate of 60% for streptokinase, 5% for urokinase and 91% for rt-tPA [7]. Complications of thrombolytics include bleeding and distal embolization [10].

Restenosis

Techniques for treating lower extremity PVD not only focus on immediate revascularization, but also on minimizing the chance for graft restenosis. Primary stenting has been shown to reduce the relative risk of long-term failure by 39% versus PTA alone [11]. Despite these improvements, restenosis remains a problem. Brachytherapy as a treatment modality to prevent restenosis is still in early developmental stages, with efforts focusing on ideal isotopes to minimize exposure and maintain therapeutic advantage. A recent randomized trial comparing PTA and brachytherapy reported a restenosis rate of 51.7% for PTA alone versus 25% for PTA with brachytherapy [7].

Anesthetic concerns

Preoperative evaluation

Comorbidities abound in patients with PVD. Thus, a thorough preoperative evaluation is essential to determine fitness for surgery and to formulate an anesthetic plan (see other chapters in this issue for a more complete discussion on these topics).

Coronary artery disease

Most of perioperative and late postoperative mortality in PVD patients is attributed to atherosclerotic heart disease [12,13]. A thorough cardiac history and evaluation of cardiac status is paramount, because many patients require further evaluation before elective surgery. Specific aspects of cardiac evaluation are addressed in another chapter.

Diabetes

The reported incidence of diabetes mellitus in patients with PVD is between 8% to 12%. Diabetes predisposes these patients to silent cardiac ischemia, cardiomyopathies and congestive heart. In addition, autonomic neuropathies can affect renal function and predispose the patient to hemodynamic instability. Surgical stress can alter glucose homeostasis and cause electrolyte and glucose abnormalities [14].

Hypertension

Hypertension afflicts nearly 60% of patient undergoing surgery for PVD. End-organ damage should be assessed, with poorly controlled hypertensive patients at increased risk for cardiovascular lability and cardiac complications [14,15].

Anesthetic goals

The anesthetic plan must be formulated taking into account patient comorbidities, along with physiologic and surgical goals. As demonstrated by Krupski et al [16], the incidence of cardiac morbidity after infrainguinal procedures can exceed those associated with surgery on the abdominal aorta. Therefore, the anesthetic plan for patients with PVD should include cardioprotective strategies. Creating and maintaining a favorable myocardial oxygen supply and demand is crucial throughout the perioperative period. Heightened surveillance for signs of myocardial compromise is also necessary, given the prevalence of cardiac morbidity and mortality.

Premedication

Preoperative anxiety and excitement is not only psychologically stressful for the patient, but also can increase myocardial oxygen consumption and precipitate myocardial ischemia. Pharmacologic premedication is often provided, but must be balanced with the risk of decreasing oxygen supply from excessive sedation and hypoxemia.

Monitoring

The choice of monitors is influenced by patient co-morbidities, surgical plan, and anesthetic technique. Pulse oximetry and noninvasive blood pressure monitoring is often used in the preoperative and operative periods. Capnography should be used in all patients who are intubated and is often used for sedated patients by attaching a sampling cannula to face mask or cannula. Other minimal standards should include monitoring of the electrocardiogram (ECG) for signs of myocardial ischemia. Lead V5 is particularly important in monitoring for ischemia. Lead V5 shows ischemic changes in 75% of patients who develop perioperative myocardial ischemia on a 12-lead ECG, versus only 33% in lead II. The combination of leads II and V5 improves both the detection of atrial arrhythmias and the sensitivity of detecting myocardial ischemia to 80% [17].

Invasive monitoring for lower extremity revascularization most often includes direct arterial cannulation. Invasive blood pressure monitoring can provide continual blood pressure measurement in a patient population prone to wide hemodynamic changes and parenteral access for laboratory analysis. However, the need for central venous monitoring, pulmonary artery catheterization, and transesophageal echocardiography is not routine and should be decided on a case-by-case basis [14].

Anesthetic technique

Regional versus general anesthesia

The best anesthetic plan for peripheral vascular surgery is controversial. Much of the literature supporting regional anesthesia concentrates on epidural

anesthesia, with little consideration given to peripheral nerve blocks. A review of the more relevant studies follows.

Myocardial protection

Surgical stress leads to increased myocardial workload and coronary vasoconstriction. Epidural anesthesia can block the endocrine response and provide sympathetic blockade leading to peripheral vasodilation, decreased afterload and decreased myocardial oxygen demand [18,19]. Whether these effects have significant clinical applicability for patients with PVD is unclear because studies demonstrate conflicting results.

In 1984, Yeager et al [20] published a sentinel study on outcomes in high-risk surgical patients, demonstrating a statistically lower postoperative death rate in patients receiving epidural analgesia and general anesthesia, compared with general anesthesia and routine post-operative intravenous (IV) analgesia. In addition, a lower incidence of infections and cardiovascular problems were also found in the epidural analgesia group. Limitations of the study included a mixture of several surgical procedures and inconsistent medication administration by way of the epidural catheter. Although not directly applicable to lower extremity revascularization, this study stimulated further research into the benefits of regional anesthesia.

Similar reductions in myocardial morbidity with epidural analgesia were reported by Tuman et al [21] In a prospective, randomized study of patients undergoing major vascular surgical procedures, a statistically significant reduction in myocardial morbidity was identified in the group receiving epidural-general anesthesia followed by epidural analgesia versus general anesthesia with postoperative IV patient-controlled analgesia. Reitz et al [22] evaluated epidural versus general anesthesia in patients undergoing major vascular surgery who had a myocardial infarction within the prior 3 months. In these patients, there was no difference in postoperative mortality, but a lower incidence of myocardial ischemic events, a lower reinfarction rate (4% versus 23%) and more hemodynamic stability in the epidural group.

However, other studies have failed to show significant differences in myocardial morbidity and mortality. Bode et al [23] looked specifically at patients undergoing peripheral vascular surgery with 433 patients randomly assigned to general, epidural, or spinal anesthesia. No significant difference in overall cardiac morbidity or overall mortality was found in any group. Similarly, Rivers et al [24] looked prospectively at 213 infrainguinal bypass procedures, comparing regional and general anesthesia. They found no significant difference in cardiac complications, with 25% in the epidural group and 28% in the general anesthesia group. Christopherson et al [25] also looked at infrainguinal revascularizations comparing epidural versus general anesthesia and found no significant differences in myocardial morbidity between the groups.

Overall, no clear evidence exists to show that epidural anesthesia for lower extremity revascularization results in myocardial protection. Although early

studies with major vascular procedures have showed benefit, many have confounding factors including inconsistent location of the epidural catheter, different drugs, and different endpoints. Further study with larger sample sizes may aid in delineating the utility of lumbar epidural (versus thoracic) techniques in lowering myocardial morbidity and mortality.

Graft occlusion

Graft occlusion still persists as a common postoperative complication in lower extremity revascularization, with infrainguinal bypass graft occlusion rates ranging from 2% to 20% [26]. Infrainguinal revascularization was prospectively studied by Christopherson et al [25], comparing epidural anesthesia to general anesthesia. Both groups had a low incidence of myocardial morbidity without statistical differences between groups. The incidence of vascular graft occlusion, however, was dramatically reduced in the group that received intraoperative epidural anesthesia (4/49 versus 22/51 with $P< 0.01$).

Schunn et al [27] retrospectively reviewed 303 primary femoropopliteal-tibial bypass procedures, with 145 performed under epidural anesthesia and 158 under general anesthesia. With nearly identical demographic profiles, there were no significant differences in the graft thrombosis rates for epidural versus general anesthesia. The investigators concluded that most graft failures relate to conventional factors, such as disadvantaged outflow vessels or technical complications. Pierce et al [28] similarly found no differences in graft patency among patients randomly receiving general, spinal, or epidural anesthesia.

Bode et al [23] also found no statistically significant difference in graft occlusion during a prospective, randomized study comparing regional versus general anesthesia for lower extremity bypass grafting, although the study design was faulted for not reflecting typical clinical practice patterns. Specifically, all patients had pulmonary artery catheters placed, and they were carefully monitored for 24 to 72 hours after surgery in an intensive care setting. This level of perioperative management may mask the specific impact of any one anesthetic technique and is difficult to translate to current clinical practice patterns [29].

Peripheral nerve blocks

Peripheral nerve blocks (lumbar plexus, sciatic, and femoral perivascular) offer the advantages of improved hemodynamic stability with preserved mobility in nonoperative extremities, the latter of which may decrease positional complications. Sedation is often coadministered and carries the same risks of hypoxia and unfavorable myocardial oxygen supply as does sedation with neuraxial techniques. Data regarding the use of peripheral nerve blocks for lower extremity revascularization are sparse, and studies measuring their effects on myocardial preservation and graft occlusion are needed.

Anticoagulation and anesthetic technique

Many patients presenting for lower extremity revascularization will require anticoagulant therapy in the perioperative period. Bleeding remains the major complication of anticoagulant and thrombolytic therapy, and risk factors include intensity and duration of anticoagulant effect, increased age, female gender, history of gastrointestinal bleed, and concomitant aspirin. The incidence of bleeding is generally low (<3%) for IV or subcutaneous heparin and low molecular weight heparin (LMWH). An increased incidence of bleeding exists with sodium warfarin (Coumadin) (INR >4; 7%) and thrombolytics (6 to 30%) [30].

The risk of bleeding complications with regional anesthesia remains an important consideration when planning the anesthetic. There are little data about the complications of peripheral blocks and anticoagulation. Significant blood loss, and not neurologic injury, is the most commonly reported complication when non-neuraxial regional blocks are placed in anticoagulated patients [31]. When neuraxial techniques are used, spinal hematoma remains a significant concern in the anticoagulated patient. Closed claim data analysis from the American Society of Anesthesiologists (ASA) documents that spinal cord injuries were the leading cause of claims during the 1990s [32].

Overall, spinal hematomas are rare events and have an incidence of less than 1 in 150,000 for epidurals and less than 1 in 220,000 for spinal anesthetics [31]. Vandermeulen et al [33] reported 61 cases of spinal hematoma associated with epidural or spinal anesthesia in their review of the literature published between 1906 and 1994. Among these 61 cases, 53 patients (8%) had either a clotting abnormality or difficulty block placement.

The American Society of Regional Anesthesia has recently published a comprehensive overview of current issues and recommendations regarding the use of neuraxial anesthesia and anticoagulants [31]. A brief review of these recommendations follows.

Thrombolytic and fibrinolytic therapy

Streptokinase, urokinase, and rt-tPA (alteplase, tenecteplase) are used to lyse clots in patients with thrombotic ischemia. Plasminogen activators increase the formation of plasmin that actively dissolves clot. As clot dissolves, fibrin degradation products are released and can have a wide range of effects on systemic coagulation. In addition, most patients receiving thrombolytics will also receive additional anticoagulant therapy with antiplatelet agents or heparin that can further compromise the normal coagulation cascade.

No published studies address regional anesthesia in patients receiving fibrinolytic/thrombolytic therapy. As of June 2003, only five cases of spinal hematomas involving neuraxial anesthesia and fibrinolytic/thrombolytic therapy have been reported [30,33–35]. In addition, there are little data regarding the length of time that neuraxial blocks should be avoided after thrombolytic therapy. The current recommendation after thrombolytic therapy is to avoid spinal or epidural anesthesia except in unusual circumstances [31].

Intravenous heparin

Often used intraoperatively in vascular surgery, intraoperative heparinization in the dose range of 5000 to 10,000 units IV does not preclude prior neuraxial or regional techniques. A large study failed to show a significant risk of regional techniques with systemic heparinization [36]. Current recommendations for neuraxial techniques and heparin administration include the following: (1) avoid in patients with other coagulopathies; (2) heparin administration should be delayed for 1 hour after needle placement; (3) indwelling neuraxial catheters should be removed 2 to 4 hours after the last heparin dose with evaluation of patient's coagulation status; (4) patients should be monitored postoperatively for signs or symptoms of hematoma; and (5) although occurrence of bloody or difficult neuraxial needle placement may increase risk, no data support mandatory cancellation of the case, but the use of clinical judgment and discussion with surgical colleagues are indicated.

Subcutaneous heparin

Widely used as deep vein thrombosis (DVT) prophylaxis, subcutaneous (SC) heparin has little risk in neuraxial blocks. Nine published series with over 9000 patients who received SC heparin demonstrated no complications [36]. Only four case reports of neuraxial hematomas exist in patients using SC heparin, confirming a small risk with the use of epidural and spinal anesthesia. Current recommendations do not contraindicate the use of neuraxial techniques with patients on SC heparin prophylaxis [31].

Low molecular weight heparin

Low molecular weight heparin (LMWH) was widely available in Europe before being approved for use in the United States, and is now currently indicated for thromboprophylaxis and treatment of DVT, pulmonary embolism, and myocardial infarction. European studies of over 9103 patients who received once daily dosing of LMWH demonstrated its safety with spinal or epidural anesthesia [36,37]. North American dosing of LMWH differs, however, with dosing every 12 hours and with the first dose to be given 12 to 24 hours after surgery. The risk of spinal hematoma in patients with LMWH has been estimated to be 1 in 3000 with continuous epidural anesthesia and 1 in 40,000 with spinal anesthetics [38,39]. Risk factors for spinal hematomas include female gender, increased age, traumatic placement, epidural and concomitant antiplatelet, or anticoagulant use. Additional risk factors include immediate LMWH administration (versus 12 to 24 hours postoperatively), twice daily LMWH dosing, and LMWH administration in the presence of indwelling epidural catheter. Current guidelines include the following:

1. Needle placement should occur at least 10 to 12 hours after the last thromboprophylactic dose of LMWH, and 24 hours after the last dose with therapeutic treatment regimens.

2. Neuraxial techniques should be avoided in patients given a LMWH dose 2 hours preoperatively as this coincides with peak anticoagulant activity.

Warfarin

Oral anticoagulants such as warfarin interfere with vitamin K-dependent synthesis of clotting factors II, VII, IX and X. Prothrombin and international normalized ratio (INR) are sensitive to factor VII and X activity with factor VII possessing the shortest half-life. INR increases to more than 1.2 when factor VII activity is approximately 40% of normal [40]. When instituting oral anticoagulant therapy, an INR less than 1.5 is associated with normal hemostasis. Recovery of hemostasis after discontinuation of warfarin, however, requires normalization of the INR because factor II and X activity recovers slowly and may still be inadequate with an INR of 1.4 or less [41]. No studies have examined the risk of bleeding with neuraxial procedures in patients who have recently discontinued warfarin therapy. Caution should be used in performing neuraxial techniques in the setting of warfarin therapy. In this situation, warfarin therapy should be discontinued (preferably 4 to 5 days before block placement) and prothrombin/INR measured before block placement, remembering that the return of factor II and X levels to normal is slow.

Antiplatelet agents

Nonsteroidal antiinflammatory drugs and aspirin

Aspirin's effects last for the lifetime of the platelet, whereas other nonsteroidal antiinflammatory drugs (NSAIDs) short-term effects normalize within 3 days [42,43]. Selective COX-2 inhibitors do not disrupt platelet aggregation. NSAIDs alone do not significantly increase the risk of spinal hematomas, but can increase risk when used with other anticoagulants. Current data demonstrate no added risk for bleeding complications when performing a neuraxial technique on patients using NSAID therapy alone.

Theinopyradine derivatives

Theinopyradine derivatives (ticlopidine, clopidogrel) exert their effects by inhibiting adenosine phosphate-induced primary and secondary platelet aggregation and interfering with platelet-fibrinogen binding and platelet interactions [44]. No published study examines neuraxial block placement in the presence of these agents. Current recommendations are discontinuation of ticlopidine for 14 days and clopidogrel for 7 days before neuraxial anesthesia.

Platelet GP IIb/IIIa inhibitors

Platelet GP IIb/IIIa inhibitors (abciximab, eptifibatide) interfere with the interaction of the platelet-fibrinogen and platelet-von Willebrand factor binding. With profound effects on platelet functioning, neuraxial techniques should be

avoided until platelet function has returned. Return of normal platelet aggregation ranges from 8 hours (eptifibatide, tirofiban) to 24 to 48 hours (abciximab) [31].

General anesthesia

General anesthesia remains a safe alternative for patients undergoing lower extremity revascularization surgery. Advantages of general anesthesia include the ability to manipulate hemodynamics and definitively control the airway. Additionally, the hypotension often associated with neuraxial techniques is avoided, as is the concern over surgical time outlasting either the neuraxial anesthetic or the patient's ability to maintain a comfortable position.

The physiologic goals with general anesthesia are the same as with regional anesthesia. Smooth and careful induction of general anesthesia with titration of anesthetic drugs, fluids, and vasoactive drugs with aggressive management of hemodynamic changes is required [45]. Similar care should be paid to emergence and extubation to avoid unfavorable increases in myocardial demand and decreased oxygen supply. Overall, a balanced anesthetic technique aimed at myocardial protection remains a safe alternative to regional anesthetics, with recent data showing no difference in the rates of perioperative myocardial ischemia or infarction.

Summary

Lower extremity atherosclerotic disease is common in the United States. Medical management and percutaneous endovascular techniques have been successful in restoring function to many patients with claudication. Patients undergoing operative revascularization now represent a subset of patients with complex lesions and significant cardiac co-morbidities. Regional techniques have desirable benefits in diverse surgical populations, although the literature is mixed regarding clear myocardial morbidity and mortality benefit for those undergoing lower extremity revascularization. Anticoagulant therapy is an important adjunct in vascular therapy but has important implications regarding choice of anesthetic technique. An appreciation of patient co-morbidities and their implications regarding premedication, monitoring, and anesthetic technique remain the key to intraoperative management of the peripheral vascular surgery patient.

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