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CHOICE OF ANESTHESIA AND INTRAOPERATIVE MONITORING FOR LOWER EXTREMITY REvascularization

John E. Ellis, MD, P. Allan Klock, MD, Jerome M. Klatte, MD, and Scott P. Laff, MD

The number of patients undergoing lower extremity revascularization has increased as surgeons attempt to improve functional status in elderly patients. In our institution, many of our vascular patients are referred for revision or repeat operations. They often have complex medical histories and diseases of multiple organ systems. Their co-existing diseases present additional challenges beyond those of routine anesthetic management. Patients now frequently present to the hospital on the same day as surgery, despite the complexities of their medical condition. Others present for emergent or urgent surgery. In all of these situations, the primary goal of anesthetic management is to prevent the development of perioperative complications. These patients are at particularly high risk for perioperative cardiac complications, including myocardial ischemia and infarction, low cardiac output (forward failure), and pulmonary edema (backward failure). Indeed, Krupski et al.1 have shown that the incidence of cardiac morbidity after infrainguinal procedures may exceed that associated with abdominal aortic procedures. In addition to maintaining adequate cardiac function, another goal of our anesthetic and perioperative care is to ensure adequate perfusion and prevent hypercoagulable responses to surgery so as to maintain graft patency in the immediate postoperative period. Lastly, pulmonary, renal, neurologic, and hepatic dysfunction may occur following vascular surgery; proper intraoperative and postoperative management may help to prevent these adverse outcomes as well.

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From the Department of Anesthesia and Critical Care, University of Chicago, Chicago, Illinois

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We believe that vascular surgery represents a tremendous stress to patients whose reserve is already minimal. A recent study showing increased mortality in patients who receive surgery rather than thrombolytic therapy for acute limb ischemia attests to our present inability to protect all patients from surgical stress. However, preliminary work suggests that anesthetic techniques that reduce this stress response may improve outcome. We believe that ideal anesthetic management of these patients may decrease morbidity and mortality and hasten recovery and hospital discharge. These combined effects should increase the cost-effectiveness of lower extremity revascularization. This article summarizes contemporary clinical practice, reviews current controversies in the choice of anesthetic and intraoperative monitoring for these patients, and suggests needed future clinical research.

PREMEDICATION

Premedication is useful in helping to ablate the perioperative stress response. The goals of premedication are to sedate patients before invasive procedures such as arterial cannulation or epidural catheter placement, to continue routine cardiac and antihypertensive therapy, and in some cases to acutely institute prophylactic antianginal therapy. When choosing a sedative, the clinician must remember that benzodiazepines, particularly diazepam, have long half-lives and unpredictable effects in the elderly. We generally reserve the use of oral benzodiazepine premedication for those patients who are unusually anxious or who use benzodiazepines on a daily basis. We prefer to give patients morphine sulfate, 0.05 to 0.1 mg/kg intramuscularly on call to the operating room. When patients arrive in the preoperative holding area, additional intravenous fentanyl (narcotic) or midazolam (short-acting benzodiazepine) may be administered as needed. This premedication regimen results in improved patient comfort during the placement of invasive monitors and a smoother induction of the regional or general anesthetic. However, some patients experience mild arterial oxygen desaturation with a morphine-based premedication; we therefore advocate the routine administration of supplemental oxygen after premedication.

We have patients take their usual antihypertensive and cardiac medications with a sip of water during the morning of surgery to attenuate perioperative hypertensive responses. It is important that the patient coming to the hospital the day of surgery be instructed in this regard. When patients have not taken their chronic medicines, we either obtain them from the pharmacy and administer them with a sip of water just before surgery or use parenteral substitutes. Angiotensin-converting enzyme (ACE) inhibitors appear to predispose to hypotension in the induction of general anesthesia (and probably regional anesthesia as well). Some clinicians choose to withhold ACE inhibitors on the morning of surgery or give patients only half the normal dose of drug before surgery. The decision to acutely institute prophylactic antianginal therapy in the immediate preoperative period is discussed below.

CARDIOVASCULAR MONITORING

We believe that the type of anesthetic provided (e.g., regional versus general) should not dictate the use of invasive cardiovascular monitoring. The exception to this is transesophageal echocardiography (TEE), which is used only in patients undergoing general anesthesia. Routine monitors during anesthesia for vascular surgery should include pulse oximetry and capnography. Pulse oximetry may fail in patients who are hypothermic or vasoconstricted or have low cardiac output; warming of the extremity where the oximeter probe is placed may help prevent failure. Capnography should be used in all patients who are intubated and/or ventilated. It is also useful in monitoring the sedated patient who has received a regional anesthetic. Capnography is used in the sedated patient by attaching the sampling line to the oxygen nasal cannula or the facemask. This attachment can be aided by the use of a plastic "mask adapter" or by cutting a plastic 14- or 16-gauge intravenous catheter and taping it to the cannula or mask.

The proper use of electrocardiographic (ECG) monitoring is critical because the presence of perioperative myocardial ischemia dramatically increases the likelihood of postoperative cardiac morbitidy. ECG monitoring facilitates the diagnosis of arrhythmias, but its primary goal is the detection of myocardial ischemia. The clinician must monitor the V5 lead if he or she expects to be able to diagnose perioperative myocardial ischemia. This lead choice is crucial: The V5 lead shows ischemic changes in 75% of patients who develop perioperative myocardial ischemia on a 12-lead ECG, versus 33% in lead II (see Fig. 1). If the patient has had a stress test that shows ECG changes in a particular lead, that lead should be monitored during the perioperative period. Many modern monitors are able to display and analyze the ST segments of two simultaneous ECG leads. While the simultaneous display of leads V4 and V5 increases the sensitivity of ischemia detection to 80%, most clinicians chose to display leads II and V5. This combination offers superior detection of atrial arrhythmias in lead II and provides 80% sensitivity for detecting myocardial ischemia. Some clinicians...
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![Graph](image-url)

**Figure 1.** The distribution of ischemic ST-segment changes in each of the 12 leads considered individually. The estimated sensitivity was calculated from the number of changes in a single lead as a percentage of the total number of episodes. Sensitivity was highest in lead V5 (75%). (From London MJ, Hellenberg M, Wong MG, et al: Intraoperative myocardial ischemia: Localization by continuous 12-lead electrocardiography. Anesthesiology 69:232-241, 1988, with permission.)
argue that leads V4 and V5 both display only lateral ischemia, whereas the combination of leads II and V5 should reflect both lateral and inferior ST-segment changes. If a three-electrode system is all that is available, a modified bipolar V5 can be used, such as the C55 lead, made by placing the right arm electrode in its normal position and the left arm electrode in the precordial V5 position and displaying lead I on the oscilloscope.\(^\text{22}\) In addition, operating room monitors must be in a diagnostic mode (flat frequency response over the range of 0.05 to 60 Hz) to allow the clinician to accurately diagnose ST-segment changes.\(^\text{24}\) Modern operating room monitors automate ST-segment analysis and trend recording, warning the physician when the ST-segment change exceeds a threshold amount. Our work has shown that these simple devices are reasonably sensitive and specific for confirming myocardial ischemia detected by conventional multilead ECG.\(^\text{25}\) Unfortunately, in our practice, approximately one quarter of patients undergoing lower extremity revascularization have baseline abnormalities in the ECG which preclude accurate diagnosis of myocardial ischemia. These abnormalities, which include left ventricular hypertrophy with repolarization abnormalities, paced rhythm, bundle branch block, and digoxin effect, are often seen in the patients at highest risk.

We have also shown that TEE can help to assess global and regional function of the left ventricle during vascular surgery.\(^\text{27}\) The development of new regional wall motion or thickening abnormalities suggests the presence of myocardial ischemia. However, TEE may be an excessively sensitive indicator of myocardial ischemia; most ischemic episodes are transient and do not result in adverse outcome.\(^\text{29}\) Episodes of TEE-detected regional ischemic dysfunction which do not resolve, however, herald poor outcome.\(^\text{30}\) Recent studies suggest that TEE has little incremental value over continuous ECG monitoring in predicting cardiac complications in patients undergoing noncardiac surgery.\(^\text{31}\) There are significant questions regarding the cost-effectiveness of this expensive monitoring modality. Further research is needed to define the circumstances in which the utility of this monitor justifies its cost. Meanwhile, we continue to use intraoperative TEE in patients whose cardiac anatomy and function are unknown, in those with known left ventricular dysfunction, and in those whose ECG does not permit the diagnosis of myocardial ischemia. TEE is also useful in evaluating the source of emboli in the patient with acute limb ischemia or recent stroke (Fig. 2).\(^\text{17}\)

We routinely use invasive hemodynamic monitoring in patients undergoing lower extremity revascularization. Our preference is to place a radial arterial line in almost all such patients, as the associated morbidity is low.\(^\text{22}\) This provides real-time information on blood pressure that can guide pharmacologic therapy of the rapid hemodynamic fluctuations that accompany induction of and emergence from anesthesia. Arterial cannulation also facilitates blood drawing in the crucial first 24 hours after surgery. Arterial catheterization is difficult in approximately 10% of patients, most of whom are women. Guide wire techniques may improve the rate of success.\(^\text{32}\) If arterial catheterization is impossible, we usually forego placement in other arteries or surgical placement ("cut-down") and rely instead on noninvasive blood pressure measurement.

We also commonly place central venous pressure (CVP) catheters for a variety of reasons. Blood loss may be insidious and unrecognized during prolonged, revision, intrapulatal, or in situ procedures. Cardiac preload is reduced by epidural and spinal anesthesia. This is due to the venodilation caused by the sympathetic properties of these anesthetic techniques. As the spinal or epidural anesthetic recedes, the patient's blood volume is distributed back to the central circulation. This "auto-transfusion" can lead to elevated filling pressures, which may precipitate congestive heart failure if not recognized and treated appropriately. However, in our experience, we more commonly find the CVP helpful in diagnosing and treating postoperative hypovolemia. The early diagnosis and treatment of even subtle hypovolemia are thought to be important in preventing postoperative renal dysfunction and early graft thrombosis. CVP monitoring facilitates judicious fluid loading and optimization of cardiovascular status. In some patients (for example, the female octogenarian with poor venous access), the placement of a triple-lumen catheter allows for concurrent volume loading, multiple drug infusions, and CVP monitoring. Triple-lumen central venous catheters are also useful in the patient who will have vein harvested from the upper extremities. The risks associated with central line placement can be minimized by attention to strict aseptic technique during placement by an experienced or closely supervised practitioner. The risks associated with an indwelling catheter can be minimized by inserting a single- or double-lumen catheter where feasible and removing the catheter as soon as it is no longer needed.

We do not believe that the information obtained from a pulmonary artery catheter (PAC) justifies the additional risks (including heart block, dysrhythmia, pulmonary artery rupture, and pulmonary infarction) associated with routine use of this monitor in this patient population.\(^\text{33}\) Berlauk et al found that patients who were monitored during lower extremity revascularization with PACs had a lower incidence of early graft occlusion than did patients who received CVP monitoring. However, this study has been criticized because patients in the PAC group received nitroglycerin and aggressive hemodynamic optimization, whereas those in the CVP group did not. Also, the investigators and practitioners were not blinded to the randomization groups, so the potential for introduction of bias during diagnosis and treatment was very high. We believe that the prophylactic use of nitrates in this study may have contributed more to the observed improved outcome than did the use of PACs. Therefore, we do not routinely use PACs, but rather restrict their use to the approximately one quarter of patients with the most severe co-morbidity. These conditions include severe left ventricular dysfunction (ejection fraction less than 25% or 30%), renal failure, diabetes mellitus with autonomic neuropathy, and severe cor pulmonale and

Figure 2. Transesophageal echocardiogram (TEE) of the descending thoracic aorta in an 84-year-old patient admitted with sudden-onset occlusion of a femoral artery 2 weeks after CABG surgery. Intraoperative TEE revealed mobile atheroma (large arrow) and intimal thickening (small arrow) in the descending thoracic aorta. A probe-patient foramen ovale was also identified (not shown), providing two possible mechanisms for systemic embolization.
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pulmonary hypertension documented by preoperative or intraoperative echocardiography. Some workers have recommended using PACs to detect myocardial ischemia because myocardial ischemia can produce papillary muscle dysfunction, mitral regurgitation, and a v wave on the pulmonary capillary wedge pressure (PCWP) tracing. However, subsequent work has shown that v waves are a nonspecific finding, and we cannot recommend PAC as a routine monitor for myocardial ischemia.

**CHOICE OF ANESTHETIC TECHNIQUE**

The choice of anesthetic for lower extremity revascularization is individualized for each patient. Table 1 summarizes advantages and disadvantages of the two approaches (regional versus general anesthesia). The patient may have a preference for one technique over another based on previous experiences. Technical factors may contribute to the decision: obesity, previous laminectomy, or severe kyphoscoliosis may make it difficult to establish regional blockade. Septicemia, local infection, anticoagulation, and certain neurologic diseases provide varying degrees of relative and absolute contraindications to regional anesthetic techniques. Regional anesthesia may be poorly tolerated by patients who are dyspneic, uncomfortable lying still for many hours, or demented and uncooperative. Sedation allows patients to better tolerate a regional anesthetic for a long procedure but must be administered judiciously, as these patients are often frail or at risk for pulmonary aspiration. The combination of a high level of regional blockade and sedation may rarely produce cardiovascular collapse. The patient with rest pain who has received narcotic premedication may become very sedated or even apneic when the pain is suddenly relieved by a regional anesthetic. The argument that regional anesthesia allows the patient to be a

<table>
<thead>
<tr>
<th>Regional Versus General Anesthesia for Lower Extremity Revascularization</th>
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<tbody>
<tr>
<td><strong>Anesthetic Technique</strong></td>
</tr>
<tr>
<td>Regional</td>
</tr>
<tr>
<td>2. Postoperative analgesia</td>
</tr>
<tr>
<td>3. Patient as monitor for myocardial ischemia (angina, dyspnea)</td>
</tr>
<tr>
<td>4. Possible prevention of postoperative hypercoagulability</td>
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<tr>
<td>5. Improved graft blood flow</td>
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<tr>
<td>6. Precursa thrombolytic therapy</td>
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<td>8. Reliability</td>
</tr>
</tbody>
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**Table 2. Graft Thrombosis Requiring Reoperation After Different Anesthetic Techniques for Lower Extremity Revascularization**

<table>
<thead>
<tr>
<th>Institution</th>
<th>General</th>
<th>Epidural</th>
<th>Spinal</th>
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</thead>
<tbody>
<tr>
<td>Johns Hopkins (n = 100)</td>
<td>22%</td>
<td>4%</td>
<td>—</td>
</tr>
<tr>
<td>New England Deaconess (n = 326)</td>
<td>0%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>Rush-Presbyterian (n = 80)</td>
<td>20%</td>
<td>2.5%</td>
<td>—</td>
</tr>
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monitor for myocardial ischemia by being able to complain of angina is spurious, as 90% of perioperative myocardial ischemia is painless. Regional anesthesia may offer several advantages, however, including avoidance of hyperdynamic responses to tracheal intubation and extubation, reduced incidences of postoperative respiratory and infectious complications, and reduced postoperative hypercoagulability and graft thrombosis (Table 2). In some cases, the combination of regional and general anesthesia may provide patients with the benefits of each technique.

The operative procedure may also dictate the choice of anesthetic. Prolonged in situ and/or defibrillation procedures are usually not amenable to a single-shot spinal technique; catheter spinal or continuous epidural techniques may be useful in these situations. The use of micrometers for continuous spinal anesthesia was abandoned after reports of cauda equina syndrome, but the use of larger catheters (such as those intended for use in the epidural space) does not appear to be a problem, as they permit better dispersal and dilution of local anesthetic in the cerebrospinal fluid. The incidence of post-dural puncture headache is low in elderly patients. More recently, we have used combined spinal epidural anesthesia for lengthy procedures. A standard epidural needle is placed into the lumbar epidural space, and through it, a longer spinal needle is advanced into the subarachnoid space. Long-acting local anesthetics (often supplemented with epinephrine and 0.1 to 0.2 mg of preservative-free morphine) are injected subarachnoid, the spinal needle removed, and an epidural catheter is passed. The spinal anesthetic provides the rapid onset of a reliable, dense, and long-lasting anesthetic. If the procedure takes longer than the 4 to 6 hours provided by the spinal anesthetic, the epidural catheter can be used to supplement surgical anesthesia and to provide postoperative analgesia.

The patient with a "difficult airway" presents a special problem. In such cases, it is our preference to secure the airway with an awake and/or fiberoptic intubation. Our purpose is to avoid potentially lethal respiratory complications from regional anesthesia, including seizures due to accidental intravascular injection of local anesthetics intended for the epidural space, or a high level of spinal or epidural anesthesia which would impair diaphragm function. Others may choose to perform judicious regional anesthesia, such as a continuous spinal anesthetic, during which repeated small doses of local anesthetic can be carefully titrated until an adequate sensory level is achieved. This approach avoids the potentially lethal complications of epidural local anesthetics: inadvertent intrathecal (resulting in high spinal) or intravascular (resulting in seizures) injection.

The formation of an epidural hematoma is a dreaded complication of any
neuraxial anesthetic technique. Every health care provider who participates in the care of patients who have had epidural or spinal anesthesia should be vigilant for the signs of an epidural hematoma and be aware of need for its emergent operative evacuation. Severe back pain or pressure is the earliest symptom of epidural hematoma formation. The pain often develops a radicular component, and the patient may develop focal neurologic findings that correlate with injury to the spinal cord or nerve root. Both CT and MRI are acceptable imaging modalities for the diagnosis of a lumbar epidural hematoma. Time is of the essence because if the spinal cord compression persists for longer than 6 to 12 hours catastrophic paralysis may result. If the patient is recovering from a general or a regional anesthetic, cord compression may have been present long before the patient started to complain. If a hematoma is diagnosed by CT, MRI, or myelography, the patient must have an emergent laminectomy and decompression if the risk of paralysis is to be minimized.

Coagulopathy therefore represents a relative contraindication to regional anesthesia. The degree of coagulopathy at which it becomes unsafe to perform regional anesthesia is unknown, is an area of great controversy, and must be part of the risk-benefit calculation for each patient. Preoperative nonsteroidal anti-inflammatory drugs such as aspirin and the use of subcutaneous heparin do not seem to be problematic, although anecdotal reports suggest that the use of thrombolytic therapy is a contraindication to the use of regional anesthesia. The placement of epidural catheters with subsequent systemic heparinization before arterial occlusion appears to be safe. However, the authors of the most often quoted study (performed in approximately 3100 patients) in support of such practice postponed surgery for a day for patients who had a "bloody tap" during attempted epidural catheterization. The surgery was then subsequently performed under general anesthesia. Beginning oral Coumadin (warfarin sodium) after surgery also appears safe in patients who have a pre-established epidural catheter. Many practitioners do not feel comfortable removing an epidural catheter from a patient who is coagulopathic or is receiving a heparin infusion. We advocate that the heparin infusion cease at least 4 hours prior to catheter removal and that any other coagulopathy be corrected prior to catheter removal.

General anesthesia for lower extremity revascularization has the advantage of obviating patient discomfort and lack of cooperation. It allows for adequate oxygenation and ventilation and facilitates hemodynamic manipulation. Its use is almost mandated in patients who are to have vein harvested from an arm (unless spinal and brachial plexus blocks are performed at the same time). General anesthesia has been associated with a higher incidence of postoperative respiratory complications in some studies. However, although reduction in cardiac complications is often a stated reason for avoiding general anesthesia, recent series (Table 3) have been unable to show such an effect in patients undergoing lower extremity revascularization. We do not believe that the evidence favoring regional anesthesia is so overwhelming that we would withhold a general anesthetic from most patients to whom we have offered a regional anesthetic.

Specific types of general anesthetic may be preferred for patients undergoing vascular surgery. High-dose narcotic anesthetics may be associated with less renal insufficiency and congestive heart failure following aortic reconstruction than are volatile anesthetics. This is thought to be due to the narcotics’ superior ability to blunt the adrenergic response to surgery. Continuous infusions of high doses of narcotics for the first night after coronary surgery dramatically lessen the severity of postoperative myocardial ischemia but fail to show a difference in outcomes such as death or myocardial infarction. Despite this, we usually provide general anesthesia with doses of narcotics, which, while generous, still permit extubation in the operating room. Future studies will address whether the benefits of prolonging anesthesia justify the risks and costs incurred by patients undergoing lower extremity revascularization.

Patients who receive general anesthesia must have a carefully controlled emergent and extubation, whether in the operating room or later in the intensive care unit. We prefer to perform tracheal extubation at the end of surgery in the operating room, with the same intense monitoring of hemodynamics used during induction of anesthesia. It is important to appreciate the complex physiology of the anesthetic emergence. This period is punctuated by large increases in catecholamine levels (Fig. 3) and a high incidence of myocardial ischemia. The anesthetist does not have the luxury of administering large amounts of opiates to blunt this response during the anesthetic emergence if he or she wishes to extubate the patient in the operating room. The emergence is a period of careful titration. Opiates are used to control pain and blunt sympathetic discharge while still allowing the patient to ventilate effectively. Therefore, while still intubated and breathing spontaneously, patients receive incremental doses of narcotic titrated to adequate respiration (respiratory rate 8 to 16/min; end-tidal Pco2 < 50 mm Hg). Additionally, intravenous drugs are usually required to control hemodynamics during emergence. Our usual practice is to titrate intravenous labetalol, metoprolol, or esmolol for extubation to keep heart rate below 80 beats per minute in the vast majority of patients who can tolerate β-adrenergic blockade.

We believe that routine, aggressive anti-ischemic therapy should be used in the early postoperative period because postoperative myocardial ischemia usually begins in the first 24 hours after surgery, occurs approximately twice as frequently as intraoperative myocardial ischemia, and increases by ninetold the likelihood of morbidity postoperative cardiac events. Prophylactic premedication with β-adrenergic blocking agents appears to reduce the incidence of perioperative myocardial ischemia. Therefore, we often use infusions of the short-acting and titratable β-adrenergic blocking drug esmolol to control heart rate during the first 24 hours after surgery. We have also performed preliminary studies with the α1 agonist clonidine; patients who receive prophylactic clonidine experience less intraoperative tachycardia and myocardial ischemia than patients who receive a placebo. We anxiously await the results of larger trials evaluating effects on clinical outcomes after vascular surgery of premedication with clonidine and the more selective α1 agonist dexmedetomidine in patients undergoing vascular surgery. Prophylactic use of nitrates and calcium channel blocking drugs, surprisingly, does not appear to be very effective in preventing perioper-
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coagulopathy, hemodynamic instability during rewarming after surgery, and myocardial ischemia. The recent advent of forced-air warming devices has revolutionized our ability to maintain normothermia. We believe that these devices represent the most important advance in the anesthetic care of vascular patients in the past 5 years.

A more controversial issue in perioperative management is the optimal level of the hematocrit. Concerns about the spread of viral illness have curtailed our use of blood products in the past decade, although recently some authors have deemed that the "pendulum has swung too far." Supporting these opinions are recent studies showing an increase in perioperative myocardial ischemia and cardiac morbidity following vascular surgery in patients who become anemic (hematocrit < 28%). Our current practice is to provide red cell transfusions to maintain the hematocrit at or above 30% in high-risk patients. We eagerly await studies evaluating the use of erythropoietin in vascular surgery patients. Although erythropoietin facilitates preoperative autologous donation of packed red cells, many patients who undergo lower extremity revascularization are too anemic to pre-donate. However, recent studies show that erythropoietin increases red cell mass and postoperative hematocrit and decreases blood loss in cardiac surgical patients, even when begun shortly before surgery and continued afterward. This suggests a possible role for erythropoietin in vascular surgery, despite its expense (several hundred dollars for a 1-week perioperative course).

Future studies must address the cost-effectiveness of our perioperative choices. We must decide in the coming era whether money is best spent, for example, on expensive, potent new narcotics that are short acting and allow for intense blockade of noxious stimuli during surgery (approximately $50 for a sufentanil anesthetic versus $3 for an equivalent amount of morphine) or an expensive muscle relaxant (approximately $86 for vecuronium) that does not increase the heart rate in the way that less expensive ($4) pancuronium does. In addition to the issues of heart rate changes, there have been suggestions that the residual neuromuscular blockade from long-acting, inexpensive pancuronium is associated with more postoperative respiratory complications than is the more expensive but shorter-acting relaxant atracurium. Many similar questions exist for other aspects of care. Does the additional time required to place and maintain epidural analgesia result in improved graft patency or quicker hospital discharge? Alternatively, would keeping patients anesthetized and ventilated overnight provide benefits greater than the initially increased costs? Should we routinely place pulmonary artery catheters to monitor cardiac function, or should we give all patients β-adrenergic blocking drugs or α1 agonists as prophylaxis against myocardial ischemia? Does aggressive surveillance for perioperative myocardial ischemia permit targeted treatment that reduces cardiac complications? Clinical research in this field in the next decade must address these issues if we are to be able to offer these surgical procedures to all who might benefit from them.

References


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**Figure 3.** Plasma catecholamines increased during skin closure in the general anesthesia (GA) group, and remained higher relative to the regional anesthesia (RA) group in the postoperative period. Multivariate analysis indicated that age and anesthetic regimen predicted increases in catecholamines during skin closure ($P < 0.005$), although duration of surgery, blood loss, and body temperature were not correlated. $**P < 0.01$, $^*P < 0.05$ compared with regional anesthesia group. (From Breslow MJ, Parker SD, Frank SM, et al: Determinants of catecholamine and cortisol responses to lower extremity revascularization. The PIRAT Study Group. Anesthesiology 79:1202–1209, 1993; with permission.)

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NITROGLYCERIN did not decrease the roughly one-third incidence of myocardial ischemia during anesthetic emergence and extubation. Despite these results, we continue to use nitroglycerin infusions routinely after vascular surgery performed under general anesthesia, not only for potential prophylaxis against myocardial ischemia but also for blood pressure control and the attenuation of platelet aggregation.

Hypothermia produces many problems. These include negative nitrogen balance, slowed metabolism of neuromuscular blocking drugs (which may make extubation at the end of surgery dangerous or difficult), shivering (which can double or triple myocardial oxygen demand in patients with little reserve),
44. Practice guidelines for pulmonary artery catheterization: A report by the American Society of Anesthesiologists Task Force on Pulmonary Artery Catheterization. Anesthesiology 78:280, 1993
RETROPERITONEAL AORTOILIAC RECONSTRUCTION

Jeffrey M. Reilly, MD, and Gregorio A. Sicard, MD

The retroperitoneal approach to the infrarenal aorta was the approach used by Dubost et al.20 for the first aortic reconstruction in a patient with an infrarenal abdominal aortic aneurysm. Despite this fact, this approach has never gained widespread acceptance for routine infrarenal aortic reconstruction. Most surgeons reserve this approach for patients who have had multiple previous abdominal surgeries, who have horseshoe kidneys, who are obese, who have had previous aortic surgery, who require concomitant left renal artery revascularization, or who have ostomies, abdominal wall excision or infection, a history of abdominal and/or pelvic irradiation, peritoneal dialysis catheters, and ascites.20,22,23,27,31,32,35,36 (Table 1). In these instances the retroperitoneal exposure of the aorta offers well-recognized and clear-cut advantages over the transabdominal approach to the aorta. Over three decades ago the report by Rob28 revived interest in the retroperitoneal approach for routine infrarenal aortic reconstruction, and since then numerous reports have demonstrated a clear superiority of the retroperitoneal approach in terms of intraoperative fluid replacement, postoperative pulmonary complications, length of ileus, and length of stay in the intensive care unit and in the hospital.3,12,14,21,23,25

These reports essentially corroborate our experience at the Washington University Medical Center. In both a retrospective analysis of our patients and a recently reported randomized prospective study, we have found that the retroperitoneal approach for routine aortoiliac reconstruction is associated with decreased length of ileus, fewer complications, a shorter length of stay, and lower hospital costs21-24 (Tables 2 and 3). Also, because this approach does not violate the peritoneal cavity, postoperative intra-abdominal adhesions with their attendant risk of early or late small bowel obstruction are avoided. Even more importantly, aortoenteric fistulas are an unheard of complication of aortic revascularization performed via the retroperitoneal approach. For these reasons, even in the absence of the relative indications listed above, we believe that the