CHAPTER 13

Anesthesia for Vascular Surgery

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Coexisting Diseases

- **Cardiac**: A major source of morbidity and mortality as many patients have coronary artery disease (CAD). Risk factors: congestive heart failure (CHF), myocardial infarction (MI), hypertension (HTN), angina, arrhythmias, valvular heart disease.
- **Pulmonary**: Many patients may have a smoking history and may have chronic obstructive pulmonary disease (COPD) or underlying malignancy.
- **Renal**: HTN, diabetes, arteriosclerosis, and volume depletion may → renal insufficiency.
- **Central nervous system** (CNS): Vascular disease is a “whole-body” phenomenon. Presence of carotid bruits, history of cerebrovascular accident (CVA) or transient ischemic attacks (TIAs), amaurosis fugax, or syncope may require further evaluation.
- **Endocrine**: Diabetes and its end-organ complications are a concern. Tight glucose control should be achieved.
- **Hematologic**: Many patients are on anticoagulants. Ascertain a thorough history of type, dose, and last time taken. Coagulation profile (prothrombin time [PT]/partial thromboplastin time [PTT]/International Normalized Ratio [INR]/platelets) should be available. It may be necessary to continue clopidogrel in patients with drug-eluding cardiac stents. Check with the cardiologist if clopidogrel can be stopped safely.

Preoperative Medications

See Table 13-1.

Preoperative Testing

- Based on individual patients’ comorbidities, risk of surgery, and exercise tolerance.
- Further testing may not be necessary based on new ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Care for Non-cardiac Surgery (Figure 13-1).
- **High risk** (reported cardiac risk often > 5%):
  - Aortic and other major vascular surgery.
  - Peripheral vascular surgery.
- **Intermediate risk** (reported cardiac risk generally < 5%): Carotid endarterectomy.

CAROTID ARTERY SURGERY

Preoperative Considerations

**Indications**

- TIAs associated with severe ipsilateral carotid stenosis (> 70% occlusion).
- Severe stenosis in patients with minor stroke.
- Moderate occlusion (30–70%) in patients with ipsilateral symptoms.
### Patient Characteristics
- Generalized atherosclerosis may be present, particularly in coronary arteries.
- Coexisting HTN and diabetes may ↑ morbidity when uncontrolled.
- Preexisting neurologic deficits should be documented.

### Monitoring
- Arterial catheterization is used for close regulation of blood pressure.
- Electrocardiogram (ECG): Monitor for ischemia in leads II and V5; utilize continuous ST segment analysis if available.
- Pulmonary artery (PA) catheterization is usually not necessary.

### Table 13-1. Management of Preoperative Drug Therapy

<table>
<thead>
<tr>
<th>Medication</th>
<th>Side Effect or Potential Concern in the Perioperative Period</th>
<th>Recommendation for Perioperative Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin</td>
<td>Platelet inhibition may ↑ bleeding. ↓ GFR.</td>
<td>Continue until day of surgery. Monitor fluid and urine status.</td>
</tr>
<tr>
<td>Clopidogrel</td>
<td>Platelet inhibition may ↑ bleeding. Rare thrombotic thrombocytopenic purpura.</td>
<td>Hold for 7 days before surgery except for CEA and severe CAD. Consider blood crossmatch. Avoid neuraxial anesthesia if not held for at least 7 days.</td>
</tr>
<tr>
<td>HMG-CoA reductase inhibitors</td>
<td>LFT abnormalities. Rhabdomyolysis.</td>
<td>Assess LFTs and continue through morning of surgery. Check CPK if myalgias.</td>
</tr>
<tr>
<td>ACE inhibitors</td>
<td>Induction hypotension. Cough.</td>
<td>Continue through perioperative period. Consider one-half dose on day of surgery.</td>
</tr>
<tr>
<td>Calcium channel blockers</td>
<td>Perioperative hypotension, especially with amlodipine.</td>
<td>Continue through perioperative period (consider withholding amlodipine on the morning of surgery).</td>
</tr>
<tr>
<td>Oral hypoglycemics</td>
<td>Hypoglycemia preoperatively and intraoperatively. Lactic acidosis with metformin.</td>
<td>When feasible, switch over to insulin preoperatively. Monitor glucose status perioperatively.</td>
</tr>
</tbody>
</table>

ACE, angiotensin-converting enzyme; CAD, coronary artery disease; CEA, carotid endarterectomy; CPK, creatine phosphokinase; GFR, glomerular filtration rate; HMG-CoA, 3-hydroxy-3-methyl-glutaryl-CoA; LFT, liver function test.

(Adapted, with permission, from Barash PG. Clinical Anesthesia, 5th ed. Lippincott Williams & Wilkins, 2006: 936.)
**Anesthesia for the Subspecialties**

**Anesthesia for Vascular Surgery**

- **Cerebral function evaluation**: A temporary shunt may be placed if evaluation shows the development of cerebral ischemia; shunts carry a risk of thromboembolic complications.
- **Regional anesthesia**: Patient cooperation is necessary to evaluate speech and motor function.
- **General anesthesia**: Electroencephalogram (EEG), somatosensory evoked potentials (SSEPs), distal stump pressure, transcranial Doppler measurement of middle cerebral artery (MCA) flow velocity, cerebral oximetry.

**Anesthetic Management**

The use of general vs. regional anesthesia should be a decision made based on the experience of the anesthesiologist and surgeon. Many studies show no difference in outcome between the two techniques.

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**Figure 13-1. ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery.**


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- **General anesthesia**: Electroencephalogram (EEG), somatosensory evoked potentials (SSEPs), distal stump pressure, transcranial Doppler measurement of middle cerebral artery (MCA) flow velocity, cerebral oximetry.

**Anesthetic Management**

The use of general vs. regional anesthesia should be a decision made based on the experience of the anesthesiologist and surgeon. Many studies show no difference in outcome between the two techniques.
Regional anesthesia: Superficial and deep cervical plexus blockade of C2–C4 performed in a cooperative patient allow for adequate surgical anesthesia.

Advantages: Intraoperative neurologic examination (assessment of level of consciousness, speech, and contralateral handgrip) can be performed and may better assess cerebral perfusion during cross-clamping.

Disadvantages:
- Airway not secured and may be difficult to secure once surgery starts.
- Change in mental status may cause combative patient and allow for poor surgical field.
- No potential pharmacologic cerebral protection.

General anesthesia:
- Induction: Goal of induction is to maintain hemodynamic stability while maximizing cerebral protection.
  - Keep mean arterial pressure at or slightly above patient’s baseline.
  - Avoid tachycardia.
  - Thiopental, propofol, and etomidate ↓ cerebral metabolic rate (CMRO2) more than cerebral blood flow (CBF).
- Opioids can be used to avoid hypertensive response to endotracheal intubation.

Maintenance
- Isoflurane is volatile of choice due to its greatest ↓ in CMRO2, but desflurane has gained popularity due to its quick awakening.
- HTN: Treat with a vasodilator such as nitroglycerin or nitroprusside.
- Hypotension: Treat with a titratable direct-acting α agonist such as phenylephrine.
- β blockers: Use with caution, as profound bradycardia may be encountered with manipulation of carotid baroreceptors.
- Maintain normocapnia: Hypercapnia can cause cerebral steal syndrome, and hypocapnia can ↓ cerebral perfusion.

Carotid cross-clamping:
- Heparin 50–100 units/kg given before cross-clamping.
- Blood pressure kept elevated to ↑ CBF via circle of Willis.
- Shunt: Placed if there are changes in EEG during general anesthesia or there are changes on neurologic exam during regional anesthesia; may ↑ potential for ↑ morbidity from thromboembolic events; shunts may impede access to carotid and ↑ cross-clamp time; patients may still develop EEG abnormalities despite placement of shunt, which requires adjustment of the shunt.
- Traction on the carotid sinus may cause intense vagal stimulation, resulting in severe bradycardia and hypotension, and may require treatment with atropine (can be ↓ with local infiltration of field).
- Protamine 50–150 mg is given slowly for reversal of heparin prior to skin closure.

Postoperative Management and Complications
- Smooth emergence from general anesthesia is ideal in maintaining hemodynamic stability.
- Postoperative HTN—more common.
  - Causes: Pain, hypoxemia, hypercarbia, surgical denervation of the ipsilateral carotid baroreceptor.
ANESTHESIA FOR THE
SUBSPECIALITIES

ANESTHESIA FOR VASCULAR
SURGERY

ANESTHESIA FOR THE
SUBSPECIALITIES

ANESTHESIA FOR VASCULAR
SURGERY

Treatment: Short-acting agents such as nitroglycerin, labetalol, nicardipine.

Postoperative hypotension—less common.

Causes: Removal of atheroma exposes baroreceptors to higher pressures, causing brain stem–mediated hypotension and bradycardia.

Treatment: Usually resolves in 12–24 hr; obtain ECG to ensure no cardiac etiology; IV fluids and vaspressors if neurologic status is compromised.

Respiratory insufficiency:

Causes: Recurrent laryngeal nerve damage, hypoglossal nerve damage, impaired carotid body response to hypoxemia, neck hematoma.

Neurologic deficits:

Causes: Thromboembolism (leading to cerebral hypoperfusion), regional cerebral hyperperfusion.

AORTIC SURGERY

Preoperative Considerations

Anesthetic management of the patient for aortic surgery can be challenging, especially in the emergent, nonoptimized case,

Potential for large blood loss requiring aortic cross-clamp.

Aortic Cross-Clamp

Effects of aortic cross-clamp:

↑ left ventricular afterload.

↓ distal organ perfusion.

Worsening of severe HTN, myocardial ischemia, and valvular regurgitation.

Renal failure secondary to hypoperfusion.

Paraplegia from compromised flow to the spinal cord via the artery of Adamkiewicz.

Cross-clamp release causes hypotension as a result of:

Sudden ↓ in afterload.

Coagulopathy and ↑ bleeding.

Release of metabolites from ischemic lower body, causing diffuse vaso-dilatation.

Slow release of clamp, volume loading, briefly ↓ anesthetic depth, and intermittent dosing of vasopressors can alleviate the amount of hypotension.

Complications:

Paraplegia and spinal cord ischemia caused by surgical damage to artery of Adamkiewicz, which is the major artery supplying lower thoracic and lumbar spinal cord.

Anterior spinal artery syndrome: Loss of motor function and sensation to pinprick, with intact proprioception and vibration.

Protection against spinal cord injury: Short cross-clamp time, higher perfusion pressures, shunts, partial cardiopulmonary bypass (CPB), steroids, hypothermia, mannitol, cerebrospinal fluid drainage via lumbar drain

Renal failure:

Risk factors: Preexisting renal disease with emergency cases, prolonged cross-clamp times, prolonged hypotension.

Greater incidence with suprarenal over infrarenal clamping.

Ascending aorta = between aortic valve and innominate artery.

Aortic arch = b/w innominate artery and left subclavian artery.

Descending aorta = distal to the left subclavian artery.

Renal failure:

Risk factors:

Preexisting renal disease with emergency cases, prolonged cross-clamp times, prolonged hypotension.

Greater incidence with suprarenal over infrarenal clamping.
**Indications for Surgery**

**Aortic Dissection**

Tear in the tunica intima of the aorta results in a false lumen, allowing blood to flow into the media and potentially extend the length of the vessel.

**Risk Factors**

Connective tissue disorders (Marfan’s syndrome and Ehlers-Danlos syndrome) as a result of medial cystic necrosis.

**Complications**

Occlusion of aortic lumen, extension proximally to root, rupture into the pericardium causing tamponade.

**Classification** (see Figure 13-2):

- **Stanford classification:**
  - Type A (DeBakey types I and II) involves the ascending aorta.
  - Type B (DeBakey type III) involves the descending aorta.
  - Type A dissections require surgery, while type B dissections can usually be managed medically.

- **DeBakey classification:**
  - Type I involves the ascending aorta, aortic arch, and descending aorta.

*Figure 13-2. Classification of aortic dissections.*

Stanford type A includes any involvement of ascending aorta, while type B is limited to the descending aorta. DeBakey types I and II can also be considered Stanford type A. DeBakey type III is the same as a Stanford type B. (Reproduced, with permission, from Cohn LH (ed). *Cardiac Surgery in the Adult*, 3rd ed. New York: McGraw-Hill, 2008: 1196.)
- Type II is confined to the ascending aorta.
- Type III is confined to the descending aorta distal to the left subclavian artery.

**Aortic Aneurysms**
- Aneurysms are defined as a focal dilatation with at least a 50% ↑ over normal arterial diameter.
- Most commonly involves the abdominal aorta.
- **Etiology:** Atherosclerosis (most common), rheumatoid arthritis, syphilis, trauma.

**Complications**
- Aortic regurgitation, tracheal compression and/or deviation, hoarseness, superior vena cava syndrome, rupture.
- Rupture manifests as acute severe back pain.
- **Risk of rupture ↑ with increasing aneurysm size:** > 6 cm correlates to 50% rupture within 1 year.

**Treatment**
Repair is usually performed in patients with > 4-cm aneurysms; many patients are candidates for endovascular repair.

**Aortic Occlusive Disease**
- **Etiology:** Atherosclerosis.
- Occurs at aortic bifurcation (Leriche's syndrome).

**Treatment**
Aortobifemoral bypass and/or endarterectomy.

**Coarctation of the Aorta**
Congenital heart defect classified in relation to the ductus arteriosus:
- **Preductal type** often diagnosed during infancy:
  - Diminished pulses in lower extremities.
  - Lower-body cyanosis.
  - Upper-body perfusion from aorta; lower-body perfusion from pulmonary artery.
- **Postductal type** often diagnosed in adulthood:
  - Severity of lesion and amount of collateral circulation determines severity of symptoms.
  - Upper-extremity HTN.

**Monitoring**
- Large IV access above the diaphragm should be established prior to induction.
- Arterial catheterization (preferably on the right) can be obtained preinduction if significant comorbidities or wide changes in hemodynamics are expected during induction; otherwise, postinduction arterial line placement is suitable.
Central venous access with the insertion of a pulmonary artery catheter (PAC) can be obtained after induction. PAC detects left ventricle failure, particularly during suprarenal cross-clamping.

- Transesophageal echocardiography (TEE):
  - Highly sensitive and specific in the diagnosis of an acute aortic dissection.
  - Helpful particularly in type A dissections in the assessment of the aortic valve, tamponade, and left ventricular dysfunction.
  - Limited images of distal ascending aorta and proximal aortic arch because of interposition of trachea or bronchus between esophagus and aorta.

**Anesthetic Management**

**Surgery on the Ascending Aorta**

- Involves sternotomy and CPB.
- May need left radial artery, femoral or dorsalis pedis for arterial blood pressure monitoring, as the innominate artery may be clamped.
- CPB may be established via the femoral artery in cases involving dissections.
- Intraoperative course can be complicated by large volume shifts, blood loss, long cross-clamp times, and new or worsening aortic regurgitation, often requiring valve replacement.
- Nitroglycerin or nitroprusside is often used for precise blood pressure control.
- β blockers should be used with caution, as bradycardia can worsen aortic regurgitation.

**Surgery on the Aortic Arch**

- Involves sternotomy, CPB, and hypothermic circulatory arrest.
- Cooling to 15–18°C, steroids, mannitol, and thiopental can be used to achieve cerebral protection.
- Associated coagulopathies should be corrected during rewarming period.

**Surgery on the Descending Thoracic Aorta**

- Involves left thoracotomy without CPB for open procedures.
- One-lung anesthesia using double-lumen tube or bronchial blocker can facilitate surgical exposure.
- Shunts and left atrial–femoral artery and femoral vein–femoral artery bypasses can reduce complications caused by cross-clamping.
- CSF drains may be required if shunts or bypasses are not used.
- Elective cases can benefit from a thoracic epidural for postoperative pain management but may be complicated with use of anticoagulation.
- Endovascular repair considered for those not candidates for open repair.
- Right radial arterial line, as clamping of left subclavian artery may be necessary.
- Cross-clamping causes HTN above clamp and hypotension below clamp.
- Vasodilator agents (nitroglycerin and nitroprusside) ↓ blood pressure in the acute setting.
- Correction of coagulopathy and dosing of calcium chloride may benefit those receiving massive transfusions.
SURGERY ON THE ABDOMINAL AORTA

- Involves anterior abdominal or anterolateral retroperitoneal approach.
- Endovascular repair considered for those not candidates for open repair.
- Combined epidural–general anesthesia may provide benefit to ↓ release of stress hormones and ↓ requirements for inhalation agents.
- More distal cross-clamping produces less effect on left ventricular afterload and hemodynamics.
- Fluid replacement is of concern due to large surgical exposure.

Postoperative Management

- Most patients undergoing surgery to the proximal aorta should remain intubated and ventilated for the immediate postoperative period.
- Most patients undergoing surgery of the abdominal aorta can be extubated.
- Immediate postoperative goal is to maintain stable hemodynamic parameters and correct coagulopathies.

UPPER- AND LOWER-EXTREMITY REVASCULARIZATION

Preoperative Considerations

**Indications**

- Occlusive arterial disease from atherosclerosis and emboli.
- Aneurysms of peripheral vessels.
- Pseudoaneurysms.
- Vascular injuries.

Anesthetic Management

- Can be performed under regional or general anesthesia alone or as a combined regional-general technique.
- Neuraxial anesthesia: These patients may already be on antiplatelet medication or will require anticoagulation during surgery; timing of epidural placement and removal should be made accordingly.
- Vasopressor: Phentylephrine minimizes tachycardia.
- Arterial catheterization may be required for patients with co-morbidities and severe vascular disease.
- Maintain normothermia: Shivering can ↑ myocardial oxygen demand.
- Conservative fluid management, as many of these patients are prone to CHF.

Postoperative Management

- Patients are closely observed for graft occlusion and may need revision.
- Epidural catheters are typically left in place for postoperative analgesia.
- Extremes of blood pressure and heart rate should be avoided.