Peripheral Artery Disease

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Disclosures

• None

Objectives

• Anatomy
• Pathophysiology
• Demographics
• Diagnosis
• Treatment

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**Intima**

- Luminal surface to IEL
- Endothelial cells
- Few leukocytes, connective tissue fibers, smooth muscle cells

**Media**

- IEL to EEL and adventitia
- Smooth muscle cells
- Elastin
- Collagen – type III

**Elastic Arteries**

- Prominent elastic fibers in proximal vessels
- High compliance
- Recoil
- Interspersed with type I collagen bundles
### Muscular Arteries
- Smaller distal vessels
- Less collagen and elastin, more smooth muscle cells
- Constrict and dilate more effectively

### Adventitia
- Fibrocellular connective tissue
- Vasa vasorum
- Some collagen and elastin
- Normally does not contribute to tensile strength
- In atherosclerosis, a diseased media relies on adventitia for tensile strength

### Vasa Vasorum
- Diffusion supports 0.5 mm or 30 musculoelastic bundles
- Vasa vasorum supply the rest

### Atherosclerosis
- Most common cause of peripheral arterial occlusive disease
- Preferentially involves the internal carotid, infrarenal aorta, and superficial femoral arteries
- Typically occurs at bifurcations
<table>
<thead>
<tr>
<th>Pathology</th>
<th>Intimal Thickening</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Intimal thickening</td>
<td>• Increased wall tensile stress</td>
</tr>
<tr>
<td>• Fatty streaks</td>
<td>• Increased wall thickness</td>
</tr>
<tr>
<td>• Fibrous plaques</td>
<td>• Occurs at bifurcations and areas of redistribution of wall stress in fetuses</td>
</tr>
<tr>
<td>• Plaque complication</td>
<td>• No lipid accumulation</td>
</tr>
<tr>
<td></td>
<td>• Occurs in same places as plaque, but not necessarily a precursor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fatty Streaks</th>
<th>Fibrous Plaques</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Intimal accumulation of foam cells</td>
<td>• Earliest definitive atherosclerotic lesion</td>
</tr>
<tr>
<td>• Affect all ages</td>
<td>• Appear by second decade</td>
</tr>
<tr>
<td>• Do not compromise lumen</td>
<td>• Subendothelial smooth muscle</td>
</tr>
<tr>
<td>• Abnormal overlying endothelial cells</td>
<td>• Fibrous cap of connective tissue</td>
</tr>
<tr>
<td>• Occurs throughout vascular tree</td>
<td>• Intact but fragile endothelium</td>
</tr>
<tr>
<td>• Not necessarily a precursor of plaque</td>
<td>• Attenuated media</td>
</tr>
</tbody>
</table>
### Plaque Complications
- Necrotic core of lipid, macrophages, and smooth muscle cells
- Calcification
- Endothelial disruption
- Ulceration
- Hemorrhage
- Embolism

### Pathophysiology
- Atherosclerosis may cause symptoms via:
  - stenosis or occlusion
  - thromboembolism
    - cardiogenic
    - arterioarterial
    - thrombosis of complicated plaque
- Inadequate tissue perfusion

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### Collateralization
- Collateralization refers to the formation of multiple arterial pathways that develop around a diseased axial vessel
- Resistance is always higher through collaterals than through axial vessels
- Axial vessel occlusions cause more severe symptoms if collaterals are undeveloped, which is why acute axial vessel occlusions may cause more profound ischemia

### Important Collateral Pathways
- External carotid
- Internal iliac, lumbar, internal mammary, and epigastric
- Profunda femoris
- Geniculate
### Risk Factors

- Tobacco use
- Diabetes
- Hyperlipidemia
- Genetics
- Hypertension

### Infrainguinal Arterial Occlusive Disease

- Affects 17% of people over 70
- Asymptomatic
- Claudication
- Critical limb ischemia

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### Claudication

- Pain in the large muscle groups distal to an arterial lesion after exercise
- Cramping, heaviness, fatigue
- Occurs consistently after a certain distance of walking
- Reliably abates when patient stops
- The patient is asymptomatic at rest because there are adequate collaterals for perfusion without increased metabolic demand

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- Affects 5% of the population over 50
- 75% of claudicants will remain stable
- 25% will deteriorate
  - 7 - 9% in first year
  - 2 - 3% per year after first year
- 5% will progress to critical limb ischemia
- 2% will progress to major amputation
Claudication

- 90% have concomitant CAD
- 5 year overall amputation 5%
- 5 year incidence of symptomatic coronary artery disease 23%
- 5 year incidence of stroke 13%
- 5 year mortality 20%
- 10 year mortality 50%
- 15 year mortality 70%

Critical Limb Ischemia

- Ischemic rest pain
  - intense pain across distal foot and arch
  - burning, stabbing, constant
  - worsened with elevation
  - dependent rubor
- Ulceration
- Gangrene
  - dry
  - wet

Critical Limb Ischemia

- 500 – 1000 / 1 million new cases annually
- 1 – 3% of PAD population
- 150,000 amputations per year attributable to CLI

Outcomes of CLI

Fig. A5. Fate of the patients presenting with chronic critical leg ischemia. CLI = critical limb ischemia. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II) Norgren, L. et al. Journal of Vascular Surgery, Volume 45, Issue 1, 85 - 867
**Five Year Mortality**

![Five Year Mortality Graph]

**Diabetic Foot Problems**

- Diabetic foot ulcers and amputations cost US health care providers over 10 billion dollars per year

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**Diabetic Foot Problems**

- 24 million diabetic patients in the US
- 90% are type 2
- 15% will require hospitalization for some complication
- 7.8% will account for > 60% of all non-traumatic foot amputations

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**Diabetic Foot Problems**

- Lifetime risk of ulcers or gangrene is 15 - 25%
- > 15% of patients with ulcers will end up with an amputation
- Every 30 seconds a leg is amputated somewhere in the world as a consequence of diabetes
### Diabetic Foot Problems
- 85% of amputations in diabetics are preceded by foot ulcerations
- Theoretically, improvement in foot ulcer therapy will decrease limb loss...
- However, no industrialized country has seen a decrease in diabetic limb loss in the modern era of medicine

### Diabetic Foot Problems
- Highest incidence in ethnic minority groups
  - Native Americans
  - Hispanics
  - African Americans
- A problem requiring intensive follow up and management is compounded by difficult access to care

### Diabetic Foot Problems
- Neuropathy
- Deformity
- Trauma
- Ischemia
- Infection

### Neuropathy
- Sensory nerves affected first
- Small diameter pain and temperature fibers are initially damaged
- Predisposes to pressure related trauma and minor skin Injuries
### Neuropathy

- Motor neuropathy is late
- Affects both long fibers innervating both intrinsic muscles of the foot and leg muscles

### Neuropathy

- Atrophy of intrinsic foot muscles
- Preserved flexor muscle strength results in “clawed position”
- Abnormal pressure points emerge at tips of toes
- Metatarsal heads relax

### Neuropathy

- Calluses form which later may ulcerate
- Small muscles of the foot atrophy

### Autonomic Neuropathy

- Dry skin
- Loss of sweat and oil gland function
- Dry skin predisposes to fissures
- Calluses and fissures breakdown
- Portals of entry for bacteria
### Ischemia

- Neuropathy causes shunting of blood through AV connections in the microcirculation
- Results in decreased tissue perfusion even with normal axial vessels
- Cutaneous oxygen saturation is decreased
- Compounded with neuropathy, ulceration results

### Ischemia

- Diabetes causes structural and functional changes in the capillary bed
- Thickened basement membrane
- Impaired migration of leukocytes
- Impaired vasodilation response to injury
- Blunted inflammatory response to injury

### Ischemia and Infection

- Because of this blunted inflammatory response, diabetic patients lack a crucial component of the body’s first line defense against pathogens and thus are more susceptible to foot infection

### Diabetes and PAD

- Diabetic foot problems, particularly in combination with PAD, are serious
- Even in the absence of axial vessel disease, they can be difficult to heal
<table>
<thead>
<tr>
<th><strong>Differential</strong></th>
<th><strong>History</strong></th>
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</thead>
<tbody>
<tr>
<td>• Neurogenic claudication</td>
<td></td>
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<tr>
<td>– spinal stenosis or nerve root compression</td>
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<tr>
<td>– history of back pain</td>
<td></td>
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<tr>
<td>– burning or shooting pain radiating down posterior leg</td>
<td></td>
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<tr>
<td>– numbness or paresthesias</td>
<td></td>
</tr>
<tr>
<td>• Neuropathy</td>
<td></td>
</tr>
<tr>
<td>• Arthritis</td>
<td></td>
</tr>
<tr>
<td>• Neuropathic ulceration</td>
<td></td>
</tr>
<tr>
<td>• Coronary artery disease</td>
<td></td>
</tr>
<tr>
<td>– MI</td>
<td></td>
</tr>
<tr>
<td>– CHF</td>
<td></td>
</tr>
<tr>
<td>– arrhythmia</td>
<td></td>
</tr>
<tr>
<td>– recent cardiac evaluation</td>
<td></td>
</tr>
<tr>
<td>• DM</td>
<td></td>
</tr>
<tr>
<td>• Smoking</td>
<td></td>
</tr>
<tr>
<td>• Hypertension</td>
<td></td>
</tr>
<tr>
<td>• Hypercholesterolemia</td>
<td></td>
</tr>
<tr>
<td>• Family history of atherosclerotic disease</td>
<td></td>
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<tr>
<td>• Cerebrovascular disease</td>
<td></td>
</tr>
<tr>
<td>– stroke</td>
<td></td>
</tr>
<tr>
<td>– TIA</td>
<td></td>
</tr>
<tr>
<td>– amaurosis</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Physical Exam</strong></th>
<th><strong>Vascular Exam</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Complete heart and lung exam</td>
<td></td>
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<tr>
<td>• Neurologic exam</td>
<td></td>
</tr>
<tr>
<td>– carotid bruits</td>
<td></td>
</tr>
<tr>
<td>– superficial temporal pulses</td>
<td></td>
</tr>
<tr>
<td>– cranial nerves</td>
<td></td>
</tr>
<tr>
<td>– motor</td>
<td></td>
</tr>
<tr>
<td>– sensory</td>
<td></td>
</tr>
<tr>
<td>• Complete bilateral pulse exam</td>
<td></td>
</tr>
<tr>
<td>– Doppler</td>
<td></td>
</tr>
<tr>
<td>• monophasic</td>
<td></td>
</tr>
<tr>
<td>• multiphasic</td>
<td></td>
</tr>
<tr>
<td>– 0, 1+, 2+, 3+, widened pulses</td>
<td></td>
</tr>
<tr>
<td>– Bruits and thrills</td>
<td></td>
</tr>
</tbody>
</table>
**Vascular Exam**
- Dependent rubor
- Shiny skin
- Loss of hair
- Diminished nail growth
- Ulceration and gangrene

**Vascular Lab Testing**
- Segmental pressures and ABI
- Can be affected by vascular calcification or edema

**ABI**
- Claudication 0.6
- Rest pain 0.3
- Tissue loss 0.2

**Exercise Testing**
- Treadmill or calf raises decrease peripheral resistance
- Flow increases based on Ohm's law
- If there is a proximal stenosis, flow increase is limited and pressure will drop
Vascular Lab Testing

- Pulse volume recordings
  - normal
  - blunted
- Doppler waveforms
  - multiphasic
  - monophasic
- Digital pressures
- Not limited by vessel calcification
- Complements pressure testing
**Angiography**

- Diagnostic
- Therapeutic
- Complications
  - nephrotoxicity
  - contrast allergy
  - arterial injury
  - embolization
  - hematoma
  - pseudoaneurysm

**Treatment of Claudication**

- Risk factor modification
  - smoking cessation
  - hypertension
  - hyperlipidemia
  - diabetes
- Cilostazol
  - rheologic agent
  - increases walking distance
  - contraindicated in CHF
- Supervised exercise program
  - 30 minutes of cardiovascular exercise daily
  - 5 days per week
Treatment of Claudication

- Procedural intervention for claudication is reserved for patients with lifestyle-limiting claudication and failure of medical therapy
- Often, this is related to single level, proximal disease
  - aortoiliac
  - femoral
  - ABI 0.6

Treatment of Rest Pain or Tissue Loss

- Risk factor modification
- Restoration of in-line vascular flow
- Management of the wound
- Often, this is related to multi level or distal disease
  - popliteal
  - tibial
  - ABI 0.3

Peripheral Artery Disease

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Open vs. Surgery; Decision Making

- Anatomy
- CLI vs. Claudication
- Overall health of the patient
Percutaneous / Endovascular

- Balloon Angioplasty
- Stents
- Debulking (atherectomy)
### Percutaneous Treatment Results Are Better...

- Proximal vessels (aorta > iliacs > SFA > tibials)
- Short lesions
- Focal lesions
- Stenosis > occlusions

### Percutaneous Treatments Are Worse...

- Distal or smaller vessels
- Long lesions
- Diffuse lesions
- Occlusions
- At joints or bifurcations
  - common femoral
  - profunda
  - popliteal

### Percutaneous Treatments

- Local anesthesia
- Fewer cardiac and pulmonary complications
- Outpatient procedure

### Percutaneous Treatments

- Radiation
- Nephrotoxicity
- Arterial injury
- Embolization
- Hematoma
- Pseudoaneurysm
- Rarely as durable as bypass or open repair
## Surgery

- Procedural intervention for claudication is reserved for patients with lifestyle-limiting claudication and failure of medical therapy
- Rest pain
- Tissue loss

## Surgical Options

- Endarterectomy
- Bypass
  - normal inflow
  - normal outflow

## Levels of Disease Determines Options

<table>
<thead>
<tr>
<th>Disease</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortoiliac</td>
<td>- aortoiliac endarterectomy&lt;br&gt;- aortofemoral bypass&lt;br&gt;- axillary femoral bypass</td>
</tr>
<tr>
<td>Femoropopliteal</td>
<td>- femoral endarterectomy&lt;br&gt;- femoropopliteal bypass</td>
</tr>
<tr>
<td>Tibial</td>
<td>- femorotibial bypass&lt;br&gt;- popliteal tibial or pedal bypass</td>
</tr>
</tbody>
</table>

## Contraindications to Surgery

- Prohibitive medical comorbidities
  - coronary
  - pulmonary
- Unreconstructible vessels
- Nonambulatory status (consider primary amputation)
- Extensive tissue loss (consider primary amputation)
Bypass Conduit

- Greater saphenous vein
- Other autogenous vein
  - lesser saphenous
  - cephalic
  - basilic
- Prosthetic (polyester or Polytetrafluoroethylene)

Primary Amputation

Amputation

- Nonambulatory patients with CLI
- Patients with extensive tissue loss
- Unreconstructible patients
  - foot sepsis
  - intractable pain
Level Selection

- Goals of amputation
  - Eliminate infected, necrotic, and painful tissue
  - Wound that heals successfully
  - Residual limb that can accommodate prosthesis

Level Selection; Energy Expenditure

- Unilateral below-knee amputees
  - 10% to 40% increase
  - 50-100% Prosthetic use
- Above-knee amputees
  - 50% to 70% increase
  - 10-30% prosthetic use
- True ambulation rates decrease significantly at 5 years

Level Selection

- Physical findings
  - First step
  - Extent of gangrene and infection dictates
  - Dependent rubor = gangrene
  - Palpable pulse immediately proximal = nearly 100% healing rate
- Clinical judgment
  - 80-90% accurate

Amputation

- Digit
- Transmetatarsal
- Below knee
- Above knee
Amputation

- Overall mortality
  - BKA 30 day: 6%  3 year: 40%
  - AKA 30 day: 13% 3 year: 60%
- 50% of patients will need contralateral amputation in 3 years

Remember to e-mail us your questions.

Our doctors will respond to your emailed questions.