Disclosure & Conflict of Interest

**NO** relevant financial relationships with any commercial interests.

**NO** Honorarium
Peripheral Arterial Occlusive Disease (PAOD)

What is it and why should you be interested?
PAOD

• General Information
• Detection of PAOD
• Treatment Options
• Morbidity & Mortality Of PAOD
• Overview of specific diseases
  – Aorto-Iliac Disease
  – Femoral-Popliteal Disease
  – Renal Artery Disease
  – Carotid Artery Disease
  – AAA & SAAAVE Act
Individuals With PAD Present With Distinct Syndromes

- **Asymptomatic:** Without obvious symptomatic complaint (but usually with a functional impairment)

- **Classic Claudication:** Lower extremity symptoms confined to the muscles with a consistent (reproducible) onset with exercise and relief with rest

- **“Atypical” leg pain:** Lower extremity discomfort that is exertional, but that does not consistently resolve with rest, consistently limit exercise at a reproducible distance, or meet all “Rose questionnaire” criteria

- **Critical Limb Ischemia:** The most advanced manifestation of PAD: ischemic rest pain, ischemic non-healing ulcerations, gangrene—requires revascularization for limb salvage
Defining a Population “At Risk” for Lower Extremity PAD

- Age <50 years with diabetes, and one additional risk factor (e.g., smoking, dyslipidemia, hypertension, or hyperhomocysteinemia)
- Age 50 to 69 years and history of smoking or diabetes
- Age 70 years and older
- Leg symptoms with exertion (suggestive of claudication) or ischemic rest pain
- Abnormal lower extremity pulse examination
- Known atherosclerotic coronary, carotid, or renal artery disease

ACC/AHA Practice Guidelines for the management of patients with PAD. Circ 2006;113:e463
## Differentiating True Claudication from Pseudoclaudication

<table>
<thead>
<tr>
<th>Character of Discomfort</th>
<th>Intermittent Claudication</th>
<th>Pseudoclaudication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cramping, tightness, tiredness</td>
<td>Same or tingling, weakness, clumsiness</td>
<td></td>
</tr>
<tr>
<td>Location of Discomfort</td>
<td>Buttock, hip, thigh, calf, foot</td>
<td>Same</td>
</tr>
<tr>
<td>Exercise induced</td>
<td>Yes</td>
<td>Yes or No</td>
</tr>
<tr>
<td>Distance to Claudication</td>
<td>Same each time</td>
<td>Variable</td>
</tr>
<tr>
<td>Occurs with Standing</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Relief</td>
<td>Stop walking</td>
<td>Often must sit or change body positions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition</th>
<th>Location of Pain or Discomfort</th>
<th>Characteristic Discomfort</th>
<th>Onset Relative to Exercise</th>
<th>Effect of Rest</th>
<th>Effect of Body Position</th>
<th>Other Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent claudication</td>
<td>Buttock, thigh, or calf muscles and rarely the foot</td>
<td>Cramping, aching, fatigue, weakness, or frank pain</td>
<td>After same degree of exercise</td>
<td>Quickly relieved</td>
<td>None</td>
<td>Reproducible</td>
</tr>
<tr>
<td>Nerve root compression (e.g., herniated disc)</td>
<td>Radiates down leg, usually posteriorly</td>
<td>Sharp lancinating pain</td>
<td>Soon, if not immediately after onset</td>
<td>Not quickly relieved (also often present at rest)</td>
<td>Relief may be aided by adjusting back position</td>
<td>History of back problems</td>
</tr>
<tr>
<td>Spinal stenosis</td>
<td>Hip, thigh, buttoks (follows dermatome)</td>
<td>Motor weakness more prominent than pain</td>
<td>After walking or standing for same length of time</td>
<td>Relieved by stopping only if position changed</td>
<td>Relief by lumbar spine flexion (sitting or stooping forward)</td>
<td>Frequent history of back problems, provoked by intra-abdominal pressure</td>
</tr>
<tr>
<td>Arthritic, inflammatory processes</td>
<td>Foot, arch</td>
<td>Aching pain</td>
<td>After variable degree of exercise</td>
<td>Not quickly relieved (and may be present at rest)</td>
<td>May be relieved by not bearing weight</td>
<td>Variable, may relate to activity level</td>
</tr>
<tr>
<td>Hip arthritis</td>
<td>Hip, thigh, buttoks</td>
<td>Aching discomfort, usually localized to hip and glutetal region</td>
<td>After variable degree of exercise</td>
<td>Not quickly relieved (and may be present at rest)</td>
<td>More comfortable sitting, weight taken off legs</td>
<td>Variable, may relate to activity level, weather changes</td>
</tr>
<tr>
<td>Symptomatic Baker's cyst</td>
<td>Behind knee, down calf</td>
<td>Swelling, soreness, tenderness</td>
<td>With exercise</td>
<td>Present at rest</td>
<td>None</td>
<td>Not intermittent</td>
</tr>
<tr>
<td>Venous claudication</td>
<td>Entire leg, but usually worse in thigh and groin</td>
<td>Tight, bursting pain</td>
<td>After walking</td>
<td>Subsides slowly</td>
<td>Relief speeded by elevation</td>
<td>History of iliofemoral deep vein thrombosis, signs of venous congestion, edema</td>
</tr>
<tr>
<td>Chronic compartment syndrome</td>
<td>Calf muscles</td>
<td>Tight, bursting pain</td>
<td>After much exercise (e.g., jogging)</td>
<td>Subsides very slowly</td>
<td>Relief speeded by elevation</td>
<td>Typically heavy muscled athletes</td>
</tr>
</tbody>
</table>

Adapted from J Vasc Surg, 31, Dormandy JA, Rutherford RB, for the Trans-Atlantic Inter-Society Consensus (TASC) Working Group, Management of peripheral arterial disease (PAD), S1-S296, Copyright 2000, with permission from Elsevier (1).
Peripheral Arterial Occlusive Disease

• "Atherosclerosis of the peripheral arteries, or 'arteriosclerosis obliterans,' PAD, is the most common cause of symptomatic obstruction in the peripheral arterial tree."¹

• The prevalence of PAD increases with age:
  - 3%² (40-59 years)
  - 8%² (60-69 years)
  - 19%² (over 70 years)

Prevalence of PAD in a defined population

Prevalence of PAD (ABI <0.9)

POPADAD\textsuperscript{1} - 20%

Minn Regional PAD Screening Program\textsuperscript{2} - 26.5%

Systolic HTN in the Elderly (SHEP)\textsuperscript{3} - 26%

PAD Awareness, Risk, and Treatment: New Resources for Survival (PARTNERS)\textsuperscript{4} - 29%

\textsuperscript{1} Elhadd. Pract Diab Int 1999;16:163-166
\textsuperscript{2} Hirsch. Vascular Medicine 2001;6:87-96
\textsuperscript{3} Newman. JAMA 1993;270:487-489
\textsuperscript{4} Hirsch. JAMA 2001;286:1317-1324
Projected Increase in the Prevalence of PAD

<table>
<thead>
<tr>
<th>Age group</th>
<th>2000</th>
<th>2020</th>
<th>Prevalence rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-59</td>
<td>2.2</td>
<td>2.3</td>
<td>3%</td>
</tr>
<tr>
<td>60-69</td>
<td>1.6</td>
<td>3</td>
<td>8%</td>
</tr>
<tr>
<td>70+</td>
<td>4.8</td>
<td>6.8</td>
<td>19%</td>
</tr>
<tr>
<td>Total</td>
<td>8.6</td>
<td>12.1</td>
<td></td>
</tr>
</tbody>
</table>

PAOD: Clinical Presentation

- Asymptomatic: 20-50%
- Classic claudication: 10-35%
- Atypical leg pain: 40-50%
- Critical limb ischemia: 1-2%
Peripheral Arterial Circulation

Internal Carotid
4-7 mm

Subclavian
6-8 mm

Aorta

Renal
5-7 mm

Common Iliac
7-10 mm

Superficial Femoral
4-6 mm

Popliteal
3-5 mm

Peroneal
2-3 mm

PAOD FOUND in ALL VESSELS

<table>
<thead>
<tr>
<th>Stage</th>
<th>Fontaine</th>
<th>Rutherford</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Asymptomatic</td>
<td>0</td>
</tr>
<tr>
<td>II a</td>
<td>Mild Claudication</td>
<td>0</td>
</tr>
<tr>
<td>II b</td>
<td>Mod-Severe Claudication</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>III</td>
<td>Ischemic Rest Pain</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>IV</td>
<td>Ulceration/Gangrene</td>
<td>III</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

# Clinical categories of acute limb ischemia

## Rutherford classification

<table>
<thead>
<tr>
<th>Findings</th>
<th>Doppler signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Sensory loss</td>
</tr>
<tr>
<td>I. Viable</td>
<td>None</td>
</tr>
<tr>
<td>II. Threatened</td>
<td></td>
</tr>
<tr>
<td>a. Marginally</td>
<td>Minimal/none</td>
</tr>
<tr>
<td>b. Immediately</td>
<td>More than toes</td>
</tr>
<tr>
<td>III. Irreversible</td>
<td>Profound, anesthetic</td>
</tr>
</tbody>
</table>

PAOD Risk Factors

- Diabetes
- Smoking
- History of CAD
- Elevated cholesterol or decreased HDL
- Hypertension

- Sedentary lifestyle
- Obesity
- Increased plasma homocysteine
- Male gender
- Age >65
PAOD: Risk Factors

Traditional:
- Tobacco
- Diabetes mellitus
- Age > 65
- Hypertension
- Dyslipidemia

Non Traditional:
- Hyperhomocysteinemia
- Elevated CRP
- Elevated fibrinogen
- African-American
- ESRD/CKD
Peripheral Vascular Disease

Relative Risk Factors

1. Calculated relative risk increase at 5-year intervals
2. Rel. Risk is 1.1 per 10mg/dL increase in total cholesterol

Traditional Risk Factors for PAD

- Current smoker: Odds Ratio 4.23
- Diabetes: Odds Ratio 2.08
- Hypertension: Odds Ratio 1.75
- Hypercholesterolemia: Odds Ratio 1.67
- Self-reported history of coronary artery disease: Odds Ratio 2.03

Comparing Physical Health for Chronically ill U.S. Adults

- Congestive Heart Failure
- Chronic Lung Disease
- Average Adult
- Average Well Adult

Natural History of Intermittent Claudication

Population > 55 years of age

Intermittent claudication
5%

Peripheral vascular outcomes

Stable claudication
73%
Worsening claudication
16%
Lower extremity bypass surgery
7%
Major amputation
4%

Other cardiovascular morbidity/total mortality

Nonfatal cardiovascular event (MI/stroke)
20%
5-year mortality
30%

Cardiovascular cause
75%

Overlap of Atherosclerotic Disease

Patients with one manifestation often have coexistent disease in other vascular beds.


38% overlap ≥2 vascular beds
Coexistence of Diseased Vascular Beds*

PAD patients with CHD
- Damaraju: 78%
- Tuttle: 76%
- Erdoes: 57%

CBVD patients with CHD
- Iyer: 76%
- Mathur: 71%
- Dietrich: 54%

*Charts from The 1999 Advisory Board Company


CBVD = cerebrovascular disease
Peripheral Arterial Occlusive Disease

Mortality Rates: PAD versus No PAD

Epidemiology of PAD

Criqui, M. Circ 1985;510-5
Mortality is very high in patients with severe PAD (ABI < 0.4)

Relative 5-year mortality

Patients (%)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast cancer</td>
<td>15</td>
</tr>
<tr>
<td>Colon/rectal cancer</td>
<td>38</td>
</tr>
<tr>
<td>Severe PAD</td>
<td>44</td>
</tr>
<tr>
<td>Non-Hodgkin’s lymphoma</td>
<td>48</td>
</tr>
</tbody>
</table>

PAD Survival Curve

Normal Subjects

Asymptomatic PAD

Symptomatic PAD

Severe Symptomatic PAD

Percent Survival

Year
Five year mortality rates
PAD versus Cancer

Five Year Mortality Rates

- Lung Cancer
- Colon/Rectal
- PAD
- Hodgkin's
- Breast cancer

0% 20% 40% 60% 80% 100%

*Criqui M. Presentation: Vascular Medicine of the Lower Extremities at the American Diabetes Association’s Scientific Sessions June 1999
Five Year Mortality: PAD Versus Major Cancers

Patients (%)

Prostate Cancer*: 8
Hodgkin's Disease*: 18
Breast Cancer*: 23
PAD†: 32
Colorectal Cancer*: 39
Lung Cancer*: 86

# PAD is a CAD “Risk Equivalent”

<table>
<thead>
<tr>
<th>Event</th>
<th>CAD alone (n=28,867)</th>
<th>PAD alone (n=3,246)</th>
<th>CAD + PAD (n=3,264)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality</td>
<td>2.4%</td>
<td>2.4%</td>
<td>4.6%</td>
</tr>
<tr>
<td>CV death</td>
<td>1.6%</td>
<td>1.4%</td>
<td>3.2%</td>
</tr>
<tr>
<td>CV death, MI, stroke, or hospitalization for atherothrombolic event(s)</td>
<td>13.0%</td>
<td>17.4%</td>
<td>23.1%</td>
</tr>
</tbody>
</table>

Grundy, S Circ 110:227, 2004
PAD, DM, and Cardiac Mortality

474 Men Age 68 Followed Prospectively for 14 Years

+PAD, +DM (p<0.001)

No DM, PAD
+DM, -PAD
+PAD, -DM
+PAD, +DM (p<0.001)
PAOD: Detection
Many patients with definite intermittent claudication do not complain of this symptom to their physician!
PAOD
How do you detect it?

• Screen appropriate patient population
• Patient History
• Physical examination
• Non-invasive tests
• Invasive tests
Who should be screened?

- Patients with symptoms of PAOD
- Patients with history of coronary disease
- Older patients
- Patients with PAOD risk factors = "at risk"
Who Should Undergo ABI Testing?


- All patients with exertional leg symptoms
- Abnormal lower extremity vascular exam
- Age 50-69 years and smoking or DM
- Age > 70 years
PAOD  Patient History

- Have patients fill out a checklist of:
  - family history
  - risk factors
  - physical symptoms
- Review the checklist and probe for any PAOD-related clinical symptoms / complaints
Acute Arterial Occlusion

The 5 P’s of large artery occlusion

- Pain
- Pulselessness
- Pallor
- Paresthesias
- Paralysis
Patient History

- Questions to ask **patients with possible lower extremity disease:**
  - What is your typical activity level?
  - Do you experience any discomfort in the calf, thigh, buttock or hip area that occurs with walking, climbing stairs?
  - Describe the symptom, onset, duration and resolution?
  - Do you experience rest pain, leg pain when in bed?
  - Have you had any sores or skin ulcerations that won’t heal?
  - Any changes in the color, temperature or appearance of your skin?
  - Any problems with impotence or pain in your genitals?
Patient History

• Questions to ask patients with possible Renal Artery Stenosis:
  – Do you take blood pressure medications?
  – Do the medications keep your blood pressure under control?
  – Do you have a history of heart disease or have you experienced congestive heart failure?
  – If no: Have you ever had shortness of breath and/or had problems with fluid in your lungs?
Patient History

Questions to ask patients with possible **Carotid Artery Disease**

Have you ever had any of the following symptoms?

- Blurred vision or temporary blindness
- Speech difficulty
- Temporary numbness or paralysis
PAOD  Physical Exam

- Assess skin appearance
- Check for hair loss on distal limbs
- Check for edema and tenderness
- Check all pulses
- Check both pressures in upper extremity & Lower extremities in **SUPINE** position
- Check for bruits
- Brief neurologic exam
- Cardiac exam
Elevation Pallor

Dependent Rubor
PAOD
Patient History and Physical Exam

Positive for:
• Visual disturbance
• Speech disturbance
• Numbness/paralysis
• Dizziness/syncope
• Ataxia

Follow-up Tests for:
Cerebral Vascular Disease

Positive for:
• Intermittent claudication
• Pain at rest
• Sores/Gangrene
• Impotence
• Genital Pain
• Changes in skin (color, appearance, coolness etc.)

Follow-up Tests for:
Aorto-iliac disease
Femoral-popliteal occlusive disease

Positive for:
• Uncontrolled hypertension
• Deteriorating renal function
• Recurrent pulmonary edema in absence of cardiovascular disease

Follow-up Tests for:
Renal Vascular Disease
PAOD

Diagnostic Tests

• **Non-invasive tests**¹
  – ABI (Ankle/Brachial Index) Rest & Exercise
  – Exercise Test
  – Segmental Pressures
  – Segmental Volume Plethysmography
  – Duplex Ultrasonography
  – MRA (Magnetic Resonance Arteriography)
  – CTA

• **Invasive tests**¹
  – Peripheral Angiogram

¹ Krajewski and Olin  Chapter 11  Peripheral Vascular Disease. 2nd ed. 1996
Ankle Brachial Index

SUPINE position all extremities
PAOD Diagnostic Test
ABI (Ankle-Brachial Index)

Courtesy of: Fred St. Goar MD, CVI Medical Group Inc., Mountain View
### ABI Testing: Highly Sensitive and Specific

Effectiveness of ABI vs Other Common Screening Tests

<table>
<thead>
<tr>
<th>Diagnostic Test</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABI</td>
<td>95</td>
<td>99</td>
</tr>
<tr>
<td>Pap smear</td>
<td>30-87</td>
<td>86-100</td>
</tr>
<tr>
<td>Fecal occult blood test</td>
<td>37-78</td>
<td>87-98</td>
</tr>
<tr>
<td>Mammography</td>
<td>75-90</td>
<td>90-96</td>
</tr>
</tbody>
</table>

### ABI (Ankle-Brachial Index)

$\text{ABI} = \frac{\text{Ankle pressure}}{\text{Brachial pressure}}$

<table>
<thead>
<tr>
<th>ABI Results</th>
<th>Clinical Interpretation</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 1.3</td>
<td>Vessels noncompressible</td>
<td>Results not useful</td>
</tr>
<tr>
<td>1.01 to 1.30</td>
<td>Possible partial vessel noncompressibility</td>
<td>Correlate with history</td>
</tr>
<tr>
<td>0.97 to 1.0</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>0.8 to 0.96</td>
<td>Mild ischemia</td>
<td>Active patient should be able to walk 2 blocks without pain</td>
</tr>
<tr>
<td>0.4 to 0.79</td>
<td>Moderate to severe ischemia</td>
<td>Pain occurs before patient walks 2 blocks</td>
</tr>
<tr>
<td>≤ 0.39</td>
<td>Severe ischemia</td>
<td>Danger of limb loss</td>
</tr>
</tbody>
</table>

Rice, KL and Walsh ME. Nursing 98, Feb. 1998
German Epidemiological Trial on ABI
Diehm C et al., Circulation 2009;120:2053-61
DIABETIC MEDIAL CALCINOSIS-

In the Non-Invasive World-----
There is a difference between STIFF and STENOTIC
Essence of Arterial Testing in Diabetics

Annals of Vascular Surgery 2011

- 187 LEA with a diabetic foot that had an intra arterial angiography with ABI

- The ABI is notoriously unreliable in diabetic patients secondary to medial calcinosis. **

- Compromised in and outflow arteries in combination with a stiff vessel wall, inflow or outflow disease may be missed all together in the ABI.

- Therefore, ABI will and may underestimate angiographic atherosclerotic disease in diabetic patients

Toe Brachial Index (TBI)

Non-compressible arteries
Utilizes Infrared and Detects Capillary Perfusion
(generally not affected by medial calcinosis)

- Toe Pressure Cuff and Waveform Analysis

- TBI > 0.80 = Normal (or 80% of Brachial Pressure)
- TBI <0.65 = Abnormal.
- TBI <20 Rest Pain
- TBI pressures <30mmhg = Wound healing will be unsuccessful ***** (Laser Doppler)

- Scission, R, Neuymer, M (2003), Physiological Testing Techniques and Interpretation
PAOD Diagnostic Test
Segmental Pressure Test

Courtesy of: Fred St. Goar MD, CVI Medical Group Inc., Mountain View, CA
Lower Extremity Physiological-Arterial Testing

What’s in a Report

1. Waveform Analysis***
2. Doppler
3. Segmental Pressures
4. PPG
5. Pre and Post Reactive Hyperemic Pressures and Doppler Signals
6. Very Technologist Dependant
Doppler and PVR Waveform Comparative Analysis

Qualitative Waveform Descriptors: CW Doppler / Zero Crossing Recorder
(Level and Disease Severity, At or Proximal to the Transducer)

Pre Exercise Waveforms

Post Exercise Waveforms
PAOD Diagnostic Test
Exercise Test

• May be useful in quantifying the severity of intermittent claudication

• In general, if ankle pressure falls by more than 20% of the baseline value and requires more than 3 minutes to recover, the test is considered abnormal.”

### Interpretation of Systolic Limb Blood Pressures

<table>
<thead>
<tr>
<th>Location of Pressure Measurement</th>
<th>Normal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankle Pressure</td>
<td>&gt; Brachial pressure</td>
</tr>
<tr>
<td>Ankle Pressure Index</td>
<td>1.0-1.2; Abnormal value &lt;0.95</td>
</tr>
<tr>
<td>Ankle Pressure after exercise</td>
<td>Normal decrease &lt;20% of baseline</td>
</tr>
<tr>
<td>Proximal Thigh Pressure</td>
<td>30-40 mmHg higher than brachial pressure</td>
</tr>
<tr>
<td>Segmental Pressures</td>
<td>&lt;20 mmHg difference between two levels</td>
</tr>
<tr>
<td>Toe Pressure</td>
<td>&gt;60% of brachial pressure</td>
</tr>
<tr>
<td>Toe Index</td>
<td>Normal &gt; 0.60</td>
</tr>
</tbody>
</table>

Jaff MR., Dorros G. J Endovasc Surg. 1998;5:146-158
Occurrence of Digital Photoplethysmography Waveforms in Patients with Lower-Extremity Critical-Limb Ischemia (2010 JVU)

**Study Group**

- 1661 consecutive lower-extremity physiological exams were.
- CLI was identified in 140 patients
- Leaving 95 patients and 107 extremities in the final analysis.

**Conclusion**

Less than 60% of the extremities with flat line digital waveforms there was one or more audible pedal Doppler signal, requiring a more detailed noninvasive evaluation with a Doppler ABI end point.

** Automated digital PPG devices may be inadequate for ABI evaluation of patients with CRITICAL LIMB ISCHEMIA (CLI).**

PAOD Diagnostic Test
Duplex Scanning

Courtesy of: Fred St. Goar MD, CVI Medical Group Inc., Mountain View, CA
What Should U DO?

Physiologic Testing
1. Patients that are non compressible need to be exercised. All need to be exercised
2. Patients with ABI of <1.0
3. Patients with Suspected Claudication need to be exercised, NOT SCREENED

Arterial Duplex
1. Stents
2. Grafts
3. Aneurysms
4. Known Interventions
5. Patient Who Cannot be Exercised
PAOD Diagnostic Test
Magnetic Resonance Angiography

• Uses MRI technology\(^1\)
• Studies done to show efficacy\(^1\)
  – Owens: MRA had “greater sensitivity than conventional contrast arteriography for detecting distal runoff vessels”\(^2\)
  – Cambria: MRA is accurate... and in selected patients may eliminate the need for contrast arteriography...”\(^3\)
• Some limitations still exist\(^1\)
  – Diagnostic failures in patients with vascular clips and prosthetic joints.\(^4\)

1. Krajewski and Olin  Chapter 11, Peripheral Vascular Disease 2nd ed. 1996
Angiography

- Most accurate in CLI
- Invasive
- Risks
  - Bleed
  - Radiation
  - Dye load
  - etc
Reducing the Morbidity and MORTALITY of PAD
**Two Major Goals in Treating Patients With PAD**

<table>
<thead>
<tr>
<th>Limb outcomes</th>
<th>Cardiovascular morbidity and mortality outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved ability to walk</td>
<td>• Decrease in morbidity from non-fatal MI and stroke</td>
</tr>
<tr>
<td>• Increase in peak walking distance</td>
<td></td>
</tr>
<tr>
<td>• Improvement in quality-of-life (QoL)</td>
<td>• Decrease in cardiovascular mortality from fatal MI and stroke</td>
</tr>
<tr>
<td>Prevention of progression to CLI and amputation</td>
<td></td>
</tr>
</tbody>
</table>
PAOD  Treatment Options

• Medical
  – Risk Factor Modification*
  – Exercise Therapy*
  – Drug Therapy*

• Endovascular Therapy
  – Peripheral Transluminal Angioplasty*
  – Peripheral Stenting*
  – Atherectomy (adjunctive)
  – Thrombolytic Therapy (adjunctive)

• Surgery
  – Bypass grafts*
  – Amputation*
  – Endarterectomy

*Rosenfield K, Isner JM, Chap. 97 Textbook of Cardiovascular Medicine 1998
PAOD    Medical Treatment

• Risk Factor Modification*
• Exercise Therapy*
• Drug Therapy*
  – Trental (pentoxifylline)*
  – Pletal® (cilostazol)
  – Vasodilator agents*
  – Antiplatelet agents*
  – lipid lowering agents*

*Rosenfield K, Isner JM, Chap. 97 Textbook of Cardiovascular Medicine 1998
Beneficial Effects of Smoking Cessation in Patients with PAD

- Decreases likelihood of:
  - Amputation\(^1\)
  - Need for revascularization\(^2\)
  - Failure of arterial bypass grafts\(^3\)

- Improves pain free and maximal walking times compared to patients who continue to smoke\(^4,5\)

- Improves survival\(^6\)

---

Risk Factor Modification: 
*Antihypertensive therapy*

- **Heart Outcomes Prevention Evaluation Study (HOPE):**
  - subgroup analysis [4051] showed that ACE inhibition [ramipril 10 mg] significantly reduced cardiovascular events in patients with PAD.

- **Ahimastos:**
  - ramipril 10 mg was associated with significant increases in both PFWT & MWT vs. placebo
    - [24 weeks]

Antihypertensive therapy should be administered to hypertensive patients with lower extremity PAD to a goal of less than 140/90 mmHg (non-diabetics) or less than 130/80 mm/Hg (diabetics and individuals with chronic renal disease) to reduce the risk of myocardial infarction, stroke, congestive heart failure, and cardiovascular death.

Beta-adrenergic blocking drugs are effective antihypertensive agents and are **not** contraindicated in patients with PAD.

The use of *Ace-inhibitors* is reasonable for symptomatic patients with lower extremity PAD to reduce the risk of adverse cardiovascular events.

Medical Management of PAD

Glycemic Control

**UKPDS**- Intensive therapy yielded a reduction in microvascular complications and MI but *no change in the amputation risk*.

**DCCT**- Intensive therapy was associated with a reduction in cardiovascular events but had *no effect on the risk of PAD complications*.

**Strong Heart Study**- intensive glycemic control was associated with a *decreased* likelihood of lower extremity amputation.

UKPDS. *Lancet* 1998;352:837-853
DCCT. *Am J Cardiol* 1995;75:894-903
Resnick. *Diab Care* 2004;27:1885-91
Proper **foot care**, including use of appropriate footwear, chiropody/podiatric medicine, daily foot inspection, skin cleansing, and use of topical moisturizing creams, should be encouraged and skin lesions and ulcerations should be addressed urgently in all diabetic patients with lower extremity PAD.

Treatment of **diabetes** in individuals with lower extremity PAD by administration of glucose control therapies to reduce the **hemoglobin HbA1C to less than 7%** can be effective to reduce microvascular complications and potentially improve cardiovascular outcomes.
### Antithrombotic Trialists’ Collaboration (ATC): Meta-Analysis of Vascular Events in Antiplatelet Trials in Patients With PAD

<table>
<thead>
<tr>
<th>Category</th>
<th>APT</th>
<th>CTRL</th>
<th>Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent claudication</td>
<td>6.4%</td>
<td>7.9%</td>
<td>23±9</td>
</tr>
<tr>
<td>Peripheral artery bypass graft</td>
<td>5.4%</td>
<td>6.5%</td>
<td>22±16</td>
</tr>
<tr>
<td>Peripheral angioplasty</td>
<td>2.5%</td>
<td>3.6%</td>
<td>29±35</td>
</tr>
<tr>
<td>All high-risk patients</td>
<td></td>
<td></td>
<td>22±2 (P&lt;.001)</td>
</tr>
</tbody>
</table>

N=921 Data from 197 randomized trials comparing an antiplatelet agent (APT; aspirin, clopidogrel, dipyridamole, or a glycoprotein IIb/IIIa antagonist) vs control or another antiplatelet agent. APT=antiplatelet; CTRL=control. Antithrombotic Trialists’ Collaboration. BMJ. 2002;324:71-86.
Effect of Any Aspirin on the Prevention of Composite Cardiovascular End Points

N=5,269 patients (any ASA), 1° composite endpoint CV death, MI, stroke

<table>
<thead>
<tr>
<th>Source</th>
<th>Aspirin</th>
<th>Control</th>
<th>Weight, %</th>
<th>RR (95% CI)</th>
<th>Favors Aspirin</th>
<th>Favors Control</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belch et al,² 2008</td>
<td>105/638</td>
<td>108/638</td>
<td>41.3</td>
<td>0.97 (0.76-1.24)</td>
<td></td>
<td></td>
<td>0.82</td>
</tr>
<tr>
<td>Catalano et al,²¹ 2007</td>
<td>7/185</td>
<td>19/181</td>
<td>3.5</td>
<td>0.36 (0.16-0.84)</td>
<td></td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td>BMFT-II,²⁴ 1998</td>
<td>5/170</td>
<td>7/164</td>
<td>2.0</td>
<td>0.69 (0.22-2.13)</td>
<td></td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>Study group on pharmacological</td>
<td>2/108</td>
<td>2/115</td>
<td>0.7</td>
<td>1.06 (0.15-7.43)</td>
<td></td>
<td></td>
<td>0.95</td>
</tr>
<tr>
<td>treatment after PTA,²⁰ 1994</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McCollum et al,³² 1991</td>
<td>53/266</td>
<td>61/263</td>
<td>23.1</td>
<td>0.80 (0.58-1.11)</td>
<td></td>
<td></td>
<td>0.18</td>
</tr>
<tr>
<td>Heiss et al,²⁸ 1990</td>
<td>5/132</td>
<td>4/67</td>
<td>1.5</td>
<td>0.63 (0.18-2.29)</td>
<td></td>
<td></td>
<td>0.49</td>
</tr>
<tr>
<td>Colwell et al,²² 1989</td>
<td>36/110</td>
<td>40/121</td>
<td>18.3</td>
<td>0.99 (0.68-1.43)</td>
<td></td>
<td></td>
<td>0.96</td>
</tr>
<tr>
<td>Donaldson et al,²³ 1985</td>
<td>4/33</td>
<td>0/32</td>
<td>0.3</td>
<td>8.74 (0.49-155.97)</td>
<td></td>
<td></td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Hess et al,²⁰ 1985</td>
<td>5/160</td>
<td>3/80</td>
<td>1.3</td>
<td>0.83 (0.20-3.40)</td>
<td></td>
<td></td>
<td>0.80</td>
</tr>
<tr>
<td>Goldman and McCollum,²⁵ 1984</td>
<td>0/22</td>
<td>2/31</td>
<td>0.3</td>
<td>0.28 (0.01-5.53)</td>
<td></td>
<td></td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Kohler et al,³¹ 1984</td>
<td>2/50</td>
<td>2/50</td>
<td>0.7</td>
<td>1.00 (0.15-6.82)</td>
<td></td>
<td></td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Schoop and Levy,³³,³⁴ 1984</td>
<td>14/200</td>
<td>7/100</td>
<td>3.2</td>
<td>1.00 (0.42-2.40)</td>
<td></td>
<td></td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Green et al,²⁶ 1982</td>
<td>3/32</td>
<td>0/17</td>
<td>0.3</td>
<td>3.82 (0.21-69.88)</td>
<td></td>
<td></td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Harjola et al,²⁷ 1981</td>
<td>0/200</td>
<td>3/100</td>
<td>0.3</td>
<td>0.07 (0.00-1.38)</td>
<td></td>
<td></td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Ehrensmann et al,²⁴ 1977</td>
<td>0/215</td>
<td>0/213</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td>0.55</td>
</tr>
<tr>
<td>Hess and Keil-Kuli,²⁹ 1975</td>
<td>5/92</td>
<td>6/84</td>
<td>1.9</td>
<td>0.76 (0.24-2.40)</td>
<td></td>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td>Hess and Keil-Kuli,²⁹ 1975</td>
<td>4/42</td>
<td>2/40</td>
<td>0.9</td>
<td>1.90 (0.37-9.93)</td>
<td></td>
<td></td>
<td>.44</td>
</tr>
<tr>
<td>Zeikert,³⁵ 1975</td>
<td>1/148</td>
<td>3/150</td>
<td>0.5</td>
<td>0.34 (0.04-3.21)</td>
<td></td>
<td></td>
<td>.34</td>
</tr>
<tr>
<td>Total</td>
<td>251/2623</td>
<td>269/2446</td>
<td>0.88</td>
<td>0.76 (0.10-1.04)</td>
<td></td>
<td></td>
<td>.13</td>
</tr>
</tbody>
</table>

34% reduction in non-fatal stroke (P=0.02)

CAPRIE Trial

(Clopidogrel vs ASA in Pts at Risk for Ischemic Events)

Randomized trial comparing clopidogrel 75 mg/d with aspirin 325 mg/d

Population: 19,185 patients with recent MI, ischemic stroke, or symptomatic PAD

Results

- Clopidogrel reduced combined risk of stroke, MI, and vascular death by 8.7% vs aspirin ($P = 0.043$)
- Risk reduction was 23.7% for PAD subgroup
- Adverse event rates were similar for 2 groups

NO reliable studies have definitely documented that antiplatelet therapy is efficacious in the treatment of intermittent claudication
Risk Factor Modification:

Antilipidemic therapy

The **Heart Protection Study**

- documented that the use of a statin reduced cardiovascular morbidity and mortality in patients with *peripheral arterial disease* by ~ 25%

Heart Protection Study: 2007
PAD Subset Analysis

N=4,588

20% reduction in risk of non-coronary revascularization in PAD patients randomized to statin

No effect of simvastatin on LE amputation

38% reduction in new or worsening intermittent claudication with simvastatin.

Am J Cardiol 1998;333-335
Medical Management of PAD

**Antilipidemic therapy**

4S- 38% reduction in new or worsening intermittent claudication with simvastatin

Aronow/Mondillo- simvastatin 40 mg/day significantly increased the PFWT[D] compared to placebo at 6 months

Mohler- Atorvastatin [80 mg/day] increased the time to onset of claudication [pain free walking time] by **63% vs. 38%** among placebo [p=0.025]

Giri- PAD patients taking statins had significantly **less functional decline** over time [usual & rapid pace walking velocity, p=0.013 & 0.006, respectively] vs. placebo

---

Pederson et al. 4S. *Am J Card* 1998;81:333-38
Giri et al. *JACC* 2006;47:998-1004
Cilostazol (Pletal)

- **Meters**
  - **Baseline**
  - **12 weeks**

<table>
<thead>
<tr>
<th>Group</th>
<th>Measure</th>
<th>Cilostazol</th>
<th>Placebo</th>
<th>Cilostazol</th>
<th>Placebo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain Free WD</td>
<td>100</td>
<td>50</td>
<td>75</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Absolute WD</td>
<td>200</td>
<td>100</td>
<td>125</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

- **Increase**
  - Pain Free WD: 35% Increase
  - Absolute WD: 41% Increase

Dawson, Circulation 1998
Medical Management of PAD

Pharmacologic therapy

Meta-analysis of 8 placebo controlled trials of cilostazol

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Increase in MWD</th>
<th>Increase in PFWD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placebo</td>
<td>21%</td>
<td>40%</td>
</tr>
<tr>
<td>Cilostazol</td>
<td>44%*</td>
<td>60%*</td>
</tr>
<tr>
<td>50mg BID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cilostazol</td>
<td>50%*</td>
<td>67%*</td>
</tr>
<tr>
<td>100mg BID</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P<0.05 vs. placebo

Medical Management of PAD

Pharmacologic therapy

Trental (pentoxifylline)*

WE DO NOT USE
NO BENEFIT
POOR data
Medical Management of PAD

Pharmacologic therapy

Class I

1. Cilostazol [100mg BID] is indicated in patients with PAD and intermittent claudication (in the absence of heart failure). [Level of evidence: A]

2. A therapeutic trial of cilostazol should be considered in all patients with lifestyle-limiting claudication. [Level of evidence: A]
Exercise Training for Peripheral Arterial Disease

Hiatt et al: Circ, 1994
Benefits of Exercise Training

• **Cochrane** review of 22 randomized trials

• **Significant improvement in:**
  
  – Maximum walking time (5.12 minutes)
  
  – Pain-free walking distance (82.2 m)
  
  – Maximum walking distance (113 m)
- Supervised exercise should be made available as part of the initial treatment for all patients with peripheral arterial disease [A]
- The most effective programs employ a treadmill or track walking that is of sufficient intensity to bring on claudication, followed by rest, over the course of a 30-60 minute session. Exercise sessions are typically conducted 3 times a week for 3 months [A]
Blessings and Curses of Supervised Exercise Program

- Cost effective
  - but $0 reimbursement

- Risk free...
  - but co-morbidities may preclude participation

- Improved QOL...
  - but requires serious patient commitment
And This Seems So Obvious...

<table>
<thead>
<tr>
<th>Study Description</th>
<th>Known CAD</th>
<th>% Lipid lowering Rx</th>
<th>% Anti-platelet Rx</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTNERS¹ Primary Care Setting</td>
<td>Excluded</td>
<td>56%</td>
<td>54%</td>
<td></td>
</tr>
<tr>
<td>N=366 known PAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rehring, et al.²</td>
<td>Excluded</td>
<td>31% (statin)</td>
<td>n/a</td>
<td>54% diabetics with HgB A1c&gt;7.0% 32% Ace-I or ARB</td>
</tr>
<tr>
<td>Kaiser Colorado Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=1,733 known PAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREVENT III³</td>
<td>Included</td>
<td>46%</td>
<td>67%</td>
<td></td>
</tr>
<tr>
<td>N=1,404 CLI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REACH Registry⁴</td>
<td>Included</td>
<td>70%</td>
<td>82%</td>
<td>70% Ace-I or ARB</td>
</tr>
<tr>
<td>N=8,273 symptomatic PAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Atherosclerotic Risk Factor Control in Patients with PAD

Retrospective review of 1733 patients with PAD

• 56%: SBP > 130 mmHg
• 31%: statin use [48% with LDL > 100 mg/dl]
• 54%: HbA$_{1C}$ level of >7%

Conclusions: “Despite a national consensus of PAD as a CAD equivalent, patients are currently undertreated with regard to risk factor modification. Until broader recognition of PAD exists, vascular surgeons must continue to champion medical as well as surgical treatments for these patients”

PAOD Treatment Options

• Medical
  – Risk Factor Modification*
  – Exercise Therapy*
  – Drug Therapy*

• Endovascular Therapy
  – Peripheral Transluminal Angioplasty*
  – Peripheral Stenting*
  – Atherectomy (adjunctive)
  – Thrombolytic Therapy (adjunctive)

• Surgery
  – Bypass grafts*
  – Amputation*
  – Endarterectomy

*Rosenfield K, Isner JM, Chap. 97 Textbook of Cardiovascular Medicine 1998
PAOD

Goals of Therapy

• **Primary goal**: 
  - Reduce or eliminate ischemic symptoms
  - Prevent progression of disease

• **Secondary goal**: 
  - Prevent cardiovascular complications

When Should Intervention be Considered?
Hirsch AT et al., JACC 2006;47:1-192

Class I

• Endovascular procedures are indicated for individuals with a vocational or lifestyle-limiting disability due to intermittent claudication when there has been an inadequate response to exercise or pharmacological therapy
PAOD

Endovascular Therapy

• Peripheral Transluminal Angioplasty
• Peripheral Stenting
• Atherectomy (numerous techniques) + Thrombectomy
• Thrombolytic Therapy
  – Streptokinase
  – rt-PA

*Rosenfield K, Isner JM, Chap. 97 Textbook of Cardiovascular Medicine 1998
State of Peripheral Stenting

- Stenting is FDA approved in the Iliac Artery, SFA, Renal Artery, Carotids
- Clinical trials (current and upcoming) are being conducted in other peripheral areas to determine safety and efficacy
Cardiovascular interventionist’s involvement with PAOD

- More global approach to vascular disease
  - Coexistence of CAD and PAOD
  - Similar disease process
  - Similar therapies
  - Technical expertise in catheter based therapy
  - Successful treatment in one area impacts others
Why does endovascular therapy make sense?

- Technological advances
- Cost-saving approach
- Viable alternative to surgery with reduced morbidity & mortality in many more patients
- Change in threshold of intervention

Rosenfield K, Isner JM. Chap. 97 Textbook of Cardiovascular Medicine, 1998
Advantages of endovascular therapy in PAOD Treatments

Potential advantages of peripheral angioplasty over surgery in peripheral vascular disease\(^1\):

- No general anesthesia or lengthy incisions
- Shorter hospitalization
- Lower morbidity and mortality
- Earlier intervention in the course of the disease
- Less complicated reapplication w/ recurrence
- Higher subset of patients may benefit from it

Cost effectiveness of endovascular therapy in Aorto-Iliac Disease

Williams et al (1994)¹:

– Compared hospital charges and lengths of stay in patients undergoing PTA w/ stenting versus bypass surgery

  • “Hospital charges for stent procedures ranged 25% to 66% less than for aorto-iliac or aorto-femoral bypass”
  • “Length of stay ranged 33% to 82% less than when aorto-iliac or aortofemoral bypass were undertaken.”

# Cost effectiveness of endovascular therapy in Renal Artery Stenosis

Xue et al. (1999)\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>PTRA</th>
<th>PTSP</th>
<th>RABG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Success Rate</td>
<td>91%</td>
<td>98%</td>
<td>92%</td>
</tr>
<tr>
<td>Complication Rate</td>
<td>13%</td>
<td>16%</td>
<td>37%</td>
</tr>
<tr>
<td>Initial Treatment Cost</td>
<td>$1,402</td>
<td>$2,573</td>
<td>$15,393</td>
</tr>
</tbody>
</table>

\(^1\) Xue F, et al. Radiology 1999;212:378-84

PTRA=Percutaneous transluminal renal angioplasty
PTSP=Percutaneous transluminal stent placement
RABG=Renal arterial bypass grafting
## Carotid Stenting and Endarterectomy: A Cost Comparison

### Outcomes on severe extracranial lesions:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>CEA</th>
<th>Ctd. Stenting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Total length of stay (days)</td>
<td>2.93 ± 1.89</td>
<td>1.79 ± 1.25</td>
</tr>
<tr>
<td>Mean ICU length of stay</td>
<td>1.20 ± 1.09</td>
<td>0.42 ± 0.87</td>
</tr>
<tr>
<td>Average total hospital variable direct costs (VDC)</td>
<td>$4964</td>
<td>$3355</td>
</tr>
<tr>
<td>Cath lab and OR VDC</td>
<td>~$2700</td>
<td>~$2700</td>
</tr>
<tr>
<td>Approx. Total VDC</td>
<td>$7664</td>
<td>$6055</td>
</tr>
</tbody>
</table>

Nine surgeons performed 139 CEAs
Two cardiologists performed 36 carotid stenting procedures at outpatient facility

PAOD

Overview of Specific Diseases
Welcome to Medicare AAA Screening

Effective for services furnished on or after January 1, 2007, payment may be made for a one-time ultrasound screening for AAA for beneficiaries who meet the following criteria

(i) receives a referral for such an ultrasound screening as a result of an initial preventive physical examination

(ii) receives such ultrasound screening from a provider or supplier who is authorized to provide covered diagnostic Services

(iii) has not been previously furnished such an ultrasound screening under the Medicare Program

https://secure.codecorrect.com/knowledge/article_print.cfm?aid=137441&documenttype=42
PAOD
Aorto-Iliac and Femoro-Popliteal Arterial Diseases
Aorto-Iliac and Femoro-Popliteal
Common stenotic sites

• Infrarenal abdominal aorta (at bifurcation)\(^1\)
• Common femoral artery\(^2\)
• Superficial femoral artery at the adductor canal\(^1\)

2. Krajewski LP, Olin JW. Chap. 11 in Peripheral Vascular Disease 2nd Ed. 1996
Aorto-Iliac Disease
Clinical Symptoms

• Isolated aorto-iliac occlusion:
  – Diminished femoral pulses
  – Claudication in buttocks and thighs
  – Impotence in men

• Multisegment disease involving the aorto-iliac, femoro-popliteal as well as tibial occlusive disease:
  – Short-distance claudication
  – Pain at rest
  – Ischemic necrosis of the feet

* Krajewski LP, Olin JW. Chap. 11 Peripheral Vascular Disease 2nd Ed. 1996
Femoro-popliteal Disease
Clinical Symptoms\(^1\)

- Intermittent Claudication
- Pain at rest\(^*\)
- Ischemic ulceration\(^*\)
- Gangrene\(^*\)
- Ischemic neuropathy\(^*\)
- Muscle mass atrophy in lower extremity and foot\(^*\)

\(^*\)Obstructive process involves multiple levels

1 Krajewski LP, Olin JW. Chap. 11 Peripheral Vascular Disease 2nd Ed. 1996
Intermittent Claudication

• **Definition:**
  – Exercise-induced lower extremity pain that is caused by ischemia and relieved by rest\(^1\)

• **Prevalence:**
  – Approximately 3.4 million people in the US experience intermittent claudication\(^2\)

• **Primary symptom of lower-extremity occlusive disease**\(^2\)

---

2. Creager M, Hiatt W. Mgmt of Peripheral Artery Disease ACC 1999
Rest Pain

Characteristics:

- Usually occurs at night when the person lies supine
- Dull aching sensation in the toes or forefoot
- Pain is relieved when legs are lowered to floor
- Indicative of severe arterial insufficiency and usually involves multiple arterial segments

* Krajewski LP, Olin JW. Chap. 11 Peripheral Vascular Disease 2nd Ed. 1996
Aorto-Iliac and Femoro-Popliteal diseases
Diagnostic Tests

• **Non-invasive tests**
  – ABI (Ankle/Brachial Index)
  – Segmental Doppler Pressures
  – Exercise Testing
  – Duplex Ultrasound
  – MRA (Magnetic Resonance Arteriography) or CTA

• **Invasive tests**
  – Peripheral Angiogram
Aorto-Iliac Arterial Disease Surgery

- **Aortofemoral Bypass**
  - Primary patency at 5 years of 81-85%\(^1\)
  - Perioperative mortality 5-8%\(^1\)
  - Reserved for severe diffuse disease cases\(^2\)
  - Indicated for Rutherford class \(\geq 3\)\(^2\)

Aorto-Iliac Arterial Disease
Endovascular Treatment

- **Percutaneous Transluminal Angioplasty (PTA)**
  - Associated with patency at 5 years of 65-80%\(^1\)
  - Perioperative mortality 0.1%\(^2\)
  - Treatment of choice\(^3\)
  - Rutherford class \(\geq2\)^3

Aorto-Iliac Arterial Disease
Endovascular Treatment

- **PTA with Stent**
  - Associated with patency at 4 years of 86%\(^1\)
  - Perioperative mortality 0%\(^1\)
  - Reserved for suboptimal PTA cases\(^2\)
  - Rutherford class \(\geq 2\)^2

<table>
<thead>
<tr>
<th>Study</th>
<th>Technical Success Rate</th>
<th>2-Year Patency Rate</th>
<th>5-Year Patency Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Becker (1989)$^1$</td>
<td>92%</td>
<td>81%</td>
<td>72%*</td>
</tr>
<tr>
<td>n=2,697</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tegtmeyer (1991)$^2$</td>
<td>94.7%</td>
<td>94%**</td>
<td>85%**</td>
</tr>
<tr>
<td>n=340</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Not all studies had this much follow-up.
**Cumulative patency rates

1. Data from multiple studies compiled by: Becker GJ et al. Radiology 1989;170:921-940
### Femoro-Popliteal PTA Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Success Rate</th>
<th>Primary Patency Rate</th>
</tr>
</thead>
</table>
| **Golledge (1999)**  
  n=74 pts | 91%          | 1yr=58%*             |
| **Matsi (1994)**   
  n=106 pts   | 99% (stenoses)  
  80% (occlus.) | 1yr=47%  
  2yr=44%         |
| **Capek (1991)**   
  n=217 pts  | 93% (stenoses)  
  82% (occlus.) | 1yr=81%  
  3yr=61%  
  5yr=58%     |

*Hemodynamic success

PTA w/ Stents in Aorto-Iliac Disease

<table>
<thead>
<tr>
<th></th>
<th>Immediate Clinical success</th>
<th>Clinical benefit (2 yr)</th>
<th>Clinical benefit (43 mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmaz (1992)&lt;sup&gt;1&lt;/sup&gt;</td>
<td>99.2%</td>
<td>84%</td>
<td>69%</td>
</tr>
<tr>
<td>n=486 pts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Murphy (1995)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>98.9%</td>
<td></td>
<td>86.2%</td>
</tr>
<tr>
<td>n=83 pts</td>
<td></td>
<td></td>
<td>(at 48 mos)</td>
</tr>
<tr>
<td>Sullivan (1997)&lt;sup&gt;3&lt;/sup&gt;</td>
<td>90%</td>
<td>84%*</td>
<td></td>
</tr>
<tr>
<td>n=288 pts</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Cumulative patency rate

# PTA with Stents
## Femoro-Popliteal

<table>
<thead>
<tr>
<th>Study</th>
<th>Success Rates</th>
<th>1-Year Patency Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henry (1995)¹</td>
<td>97% (femoral)</td>
<td>81% (femoral)</td>
</tr>
<tr>
<td>n=126 pts</td>
<td>80% (popliteal)</td>
<td>50% (popliteal)</td>
</tr>
<tr>
<td>Chatelard (1996)²</td>
<td>100%</td>
<td>80%</td>
</tr>
<tr>
<td>n= 35 pts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do-Dai-Do (1992)³</td>
<td>100%</td>
<td>69% *</td>
</tr>
<tr>
<td>n=52 pts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Secondary patency rate

---

Aorto-Iliac Stent Results

- Pre-procedure
- Post-procedure

 Courtesy of Don Schwarten, MD
Femoro-Popliteal PTA Results

- Pre-procedure
- Post-procedure

Courtesy of Don Schwarten, MD
Aorto-Iliac and Femoro-Popliteal Arterial Diseases

• 2 Key take away points:
  – Iliac Stenting compared to aortofemoral bypass surgery offers:
    • A less invasive alternative
    • Comparable patency rates.
    • More cost effective means for revascularization
5 Year Primary Patency Rates

Angioplasty±Stenting

- 51-88%
- 56-76%
- 56-65%
- 40-56%
- 10-40%

Bypass Grafting

- 80-90%
- Vein 60-75%
- Synthetic 55-62%
- 60-70%
- 35-40%
- 50-60%
PAOD
Renal Artery Disease
Prevalence of Atherosclerotic Renal Artery Stenosis

% of patients with $\geq 50\%$ renal artery stenosis

AAA (Abdominal aortic aneurysm)
AOIL (Aorto-iliac disease)
LEOD (Lower extremity occlusive disease)
RAS (Renal artery stenosis)

Renal Artery Stenosis

• Prevalence
  – 2 to 4 million (in US) have Renovascular disease\textsuperscript{1}

• HTN caused by RAS is usually poorly controlled by medications\textsuperscript{2}

• Severe RAS may lead to insufficient blood flow to the kidneys and result in renal failure\textsuperscript{3}

Renal Artery Stenosis
Sites and Characteristics

- Ostial in nature
- Site not specific to renal, includes aorta
- 65-70% of all renovascular lesions are caused by atherosclerosis\(^1\)
- Common stenotic sites
  - Proximal 2 cm of the renal artery\(^1,2\)
  - Renal artery bifurcation sites\(^1\)
- Distal arterial or branch involvement is uncommon\(^1\)
- Bilateral disease is common in patients >50 years\(^3\)

Renal Artery Stenosis
Clinical Symptoms

• Uncontrolled hypertension\(^1\)
• Steady decline in renal function\(^1\)
• Cardiac dysfunction: flash pulmonary edema, CHF or unstable angina\(^2\)

1. Rosenfeld K., Isner J, Disease of Peripheral Vessels, Textbook of Cardiovascular Medicine, 1998
PAOD   Renal Artery Stenosis

• Clues to diagnosis of Renovascular Disease
  – Onset of diastolic hypertension after age 55
  – Exacerbation of previously well-controlled HTN
  – Malignant HTN
  – Resistant HTN
  – Epigastric bruit (systolic/diastolic)
  – Unexplained azotemia
  – Azotemia while receiving Ace Inhibitors
  – Atrophic kidney or discrepancy in size between the kidneys
  – Generalized Atherosclerosis

* Olin JW, Novich AC Chap. 18 Renovascular Disease in Peripheral Vascular Disease 2nd Ed 1996
Hypertension

Mild/Moderate

Medical Therapy

Severe or increasing

Is Pt. a candidate for angioplasty or surgery

Yes

Renal Duplex Scan

0% to 59% Stenosis

Medical Therapy

investigate for other cause

60-90% Stenosis/Occlusion

Angiography, selective renal vein renins

Revascularization (PTA/bypass nephrectomy)

No

Medical Therapy

*From Taylor DC et al: J Vasc Surg 7:363, 1988*
Renal Arterial Stenosis Diagnostic Tests

• Non-invasive test
  – Renal Duplex Ultrasound Scan
  – Captopril Renography
  – Magnetic Resonance Angiography (MRA)
  – CTA

• Invasive test
  – Renal Angiography
## Renal Arterial Stenosis

### Diagnostic Tests

<table>
<thead>
<tr>
<th>Diagnostic Tests</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captopril Renography</td>
<td>90%</td>
<td>93%</td>
<td>Sensitivity decreases in: pts. w/ bilateral RAS or in pts. w/ significant azotemia</td>
</tr>
<tr>
<td>Duplex Ultrasound</td>
<td>98%</td>
<td>98%</td>
<td>Positive predictive value=99%, Negative predictive value=97%</td>
</tr>
<tr>
<td>IV Dig. Sub. Arteriogram</td>
<td>88%</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>MRA</td>
<td>100%*</td>
<td>92%*</td>
<td>*In pts. w/ RAS ≥50%, Drawback: limited availability, expense and time</td>
</tr>
</tbody>
</table>

*In pts. w/ RAS ≥50% Drawback: limited availability, expense and time

Olin JW. And Novick AC. Chap. 18 Peripheral Vascular Diseases 2nd ed. 1996
## Duplex Ultrasound Scan in RAS

### Diagnostic Criteria for Classification of RAS by Duplex Scanning*

<table>
<thead>
<tr>
<th>Renal Artery Diameter Reduction</th>
<th>Renal Artery PSV</th>
<th>RAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt; 180 cm/s</td>
<td>&lt; 3.5</td>
</tr>
<tr>
<td>&lt; 60%</td>
<td>≥ 180 cm/s</td>
<td>&lt; 3.5</td>
</tr>
<tr>
<td>≥ 60%</td>
<td>&lt; or ≥ 180 cm/s</td>
<td>≥ 3.5</td>
</tr>
<tr>
<td>Occlusion</td>
<td>No signal</td>
<td>No signal</td>
</tr>
</tbody>
</table>

PSV= Peak Systolic Velocity  
RAR= Renal –to-Aortic Ratio

Renal Artery Stenosis

• **Indications for treatment:**
  – Renovascular Hypertension
  – Renal Insufficiency
  – Recurrent Pulmonary Edema/CHF with normal LVEF
  – Renal transplant arterial stenosis or bypass stenosis producing hypertension, azotemia or both

*Freed M. MD, Grines C. MD, Safian R. MD, The New Manual of Interventional Cardiology  1996*
Renal Arterial Stenosis - Surgery

- Renal Revascularization
  - Associated with patency at 2 years of 96%\textsuperscript{1}
  - Perioperative mortality 2-7%\textsuperscript{2,3}
  - Accepted standard for ostial disease, though PTA w/stent may be equally effective w/ less risk\textsuperscript{4}

Renal Arterial Stenosis
Endovascular Treatment

• Percutaneous Transluminal Renal Angioplasty (PTA)
  – Associated with 5 year cumulative patency rate of 80-89%\(^1\)
  – Perioperative mortality <1%\(^1\)
  – Preferred treatment for nonostial lesion type\(^2\)

## Renal Artery Stenosis
### PTRA Results

<table>
<thead>
<tr>
<th>Success Rate</th>
<th>5-Year Patency*</th>
<th>HTN cured/improved</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Klinge (1989)</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Athero:</td>
<td>80%</td>
<td>77%</td>
</tr>
<tr>
<td>FMD:</td>
<td>89%</td>
<td>86%</td>
</tr>
<tr>
<td><strong>Sos (1983)</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Athero:</td>
<td>57%</td>
<td>84%</td>
</tr>
<tr>
<td>FMD:</td>
<td>87%</td>
<td>93%</td>
</tr>
</tbody>
</table>

*Cumulative patency rates

---

Renal PTRA Results

- Pre-procedure
- Post-procedure
RIGHT RENAL ARTERY STENOSIS
## Renal Artery Stenosis

### PTRA vs. Surgery

<table>
<thead>
<tr>
<th></th>
<th>Success Rate</th>
<th>Primary Patency Rate*</th>
<th>Secondary Patency Rate*</th>
<th>HTN Cured or Improved</th>
<th>Improved/unchanged RF</th>
<th>Major comp.§</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTRA</td>
<td>83%</td>
<td>75%</td>
<td>90%</td>
<td>83%**</td>
<td>96%**</td>
<td>17%</td>
</tr>
<tr>
<td>Surgery</td>
<td>97%</td>
<td>96%</td>
<td>97%</td>
<td>89%**</td>
<td>75%**</td>
<td>31%</td>
</tr>
</tbody>
</table>

*24 months follow-up

**Without additional treatment

§ Serious clinical complications (renal artery occluded, septic symptoms, renal artery perforation, pancreatitis, postoperative bleeding, deep wound infection, peripheral embolization, cardiac insufficiency and deep venous thrombosis.)
Renal Artery Stenosis

• **PTRA with Stenting**
  – Associated with cumulative primary patency rate at 5 years of 84% \(^1\)
  – Procedure mortality 0% \(^1\)
  – Approved stent now, but large body of experience demonstrating excellent results. \(^2\)

# Renal Artery Stenosis

## PTRA with Stents

<table>
<thead>
<tr>
<th></th>
<th>Success rate</th>
<th>Primary patency</th>
<th>Secondary patency</th>
<th>HTN cured/improve</th>
<th>HTN stable</th>
<th>RF improve/stable</th>
</tr>
</thead>
<tbody>
<tr>
<td>**Henry (1998)**¹</td>
<td>99.6%</td>
<td>80%*</td>
<td>99%*</td>
<td>80%</td>
<td>20%</td>
<td>96%</td>
</tr>
<tr>
<td>n=210 pts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Blum (1997)**²</td>
<td>100%</td>
<td>84%†</td>
<td>92%†</td>
<td>78%</td>
<td>22%</td>
<td>100%</td>
</tr>
<tr>
<td>n=68 pts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 6 year follow-up
† 5 year follow-up

---

1. Henry M et al. Renal Artery Stenosis Treatment with Endoprosthesis, Presented at the Advanced Endovascular Therapies 1998 NY Meeting
Renal Artery Diseases

• 2 Key take away points:
  – Early detection and Endovascular intervention for patients with renal artery disease directly effects HTN and RF outcomes.
PAOD
Carotid Artery Disease
Carotid Arterial Disease
PTA with Stenting results

Pre-procedure

Post-procedure

Courtesy of Michael H. Wholey, MD, MBA
### Symptomatic Carotid Disease CEA Trials

<table>
<thead>
<tr>
<th>Trial</th>
<th>% Stenosis</th>
<th>N</th>
<th>F/U (yr)</th>
<th>Stroke risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASCET</td>
<td>70-90</td>
<td>659</td>
<td>1.5</td>
<td>26%</td>
</tr>
<tr>
<td>ECST</td>
<td>70-90</td>
<td>778</td>
<td>3</td>
<td>22%</td>
</tr>
<tr>
<td>VA</td>
<td>70-99</td>
<td>291</td>
<td>1</td>
<td>265</td>
</tr>
<tr>
<td>NASCET</td>
<td>50-69</td>
<td>1108</td>
<td>5</td>
<td>26.45</td>
</tr>
</tbody>
</table>
Carotid Endarterectomy
Asymptomatic disease

- ACAS 60-99% stenosis, n=1662, 2.7 yr mean FU

- Surgical Rx: 5.1% vs Medical Rx 11%
  ...Or 1.2% RRR per year-ipSTK or death

- However...low risk of perioperative stroke/death and benefit limited to men

JAMA 1995; 273: 1421
Endovascular Interventions
Peripheral Arterial Occlusive Disease

• **Strong concomitant disease prevalence**
  – Perform early screening, detection and intervention in patients with CAD, Renal, Carotid and Peripheral disease, to reduce mortality and morbidity

• **Viable alternative to surgery**
  – Competitive in cost-effectiveness
  – Comparable clinical and patency rates
  – Less invasive procedures
  – Offers therapy for surgical high-risk patients