The Role of Duplex US, CTA, and MRA in the Dx and Rx of PAD

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Disclosures

- Spectranetics Corporation: Medical advisory board, consultant, speaker, educational grants, trainer, investigator
- Boston Scientific: Medical advisory board, speaker, fellow training faculty, educational grants, trainer, investigator
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- Gore: investigator
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- Ostialcorp: Medical Advisory Board; stock holder
- Asia Pacific Medical Technologies: Stock Holder
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The Basics

- History: know the risks
- Physical exam
- ABI
- PVR
- Skin perfusion pressure
Clinical Signs of Limb Ischemia

- Nonhealing wounds
- Shiny skin
- Loss of hair growth
- Cool skin temperature for one limb but not the other
- Pale or bluish skin
- Reduced capillary fill times
- Pallor on elevation and rubor on dependency

Who should undergo non-invasive testing?

Age > 70 years or older
Age 50-69 with a history of diabetes or smoking
Age < 49 with diabetes and one additional risk factor (smoking, hypertension, elevated cholesterol)
Abnormal lower extremity pulse examination
Known atherosclerotic disease in other vascular beds (coronary, carotid, renal arteries)
## Non-invasive Vascular Testing

### Ankle Brachial Index (ABI)

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm</td>
<td>120mmHg</td>
<td>120mmHg</td>
</tr>
<tr>
<td>Dorsalis pedis artery</td>
<td>90 mmHg</td>
<td>96 mmHg</td>
</tr>
<tr>
<td>Posterior tibial artery</td>
<td>120mmHg</td>
<td>80 mmHg</td>
</tr>
<tr>
<td>ABI</td>
<td>120/120 = 1.0</td>
<td>96/120 = 0.80</td>
</tr>
</tbody>
</table>
## Grading of the ABI

<table>
<thead>
<tr>
<th>ABI</th>
<th>Severity of PAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1.1</td>
<td>Calcified, not compressible</td>
</tr>
<tr>
<td>0.9-1.0</td>
<td>Normal</td>
</tr>
<tr>
<td>0.8-0.9</td>
<td>Mild</td>
</tr>
<tr>
<td>0.6-0.8</td>
<td>Moderate</td>
</tr>
<tr>
<td>0.4-0.6</td>
<td>Severe</td>
</tr>
<tr>
<td>&lt;0.4</td>
<td>Critical</td>
</tr>
</tbody>
</table>
“normal” or elevated ABI

• Beware in diabetics and CKD patients.
• Calcified vessels will yield a “normal” or elevated ABI because these vessels are non-compressible.
• If the exam and clinical presentation don’t correlate with the ABI, further non-invasive testing is required.
• ABIs may also be “normal” with pelvic/iliac/inflow disease----confirm with an exercise ABI
Skin Perfusion Pressure (SPP)

Assesses *micro*-circulatory health:

- A distal arterial test
- Utilizes laser Doppler to evaluate *reactive hyperemia*
- Measures in millimeters of mercury (mmHg) the pressure at which blood flow first returns to capillaries following controlled release of occlusion
- Indicator of healing potential and disease severity
**Sample PVR Waveforms**

**Normal**
- Sharp peak
- Reflective wave
- Descending edge
- Baseline

**Mild**
- Descending: slight bowing away from baseline
- Loss of reflective wave

**Moderate**
- Rounded peak
- Delayed upstroke

**Severe**
- Delayed upstroke and downstroke
- Extremely reduced amplitude

**Critical**
- Complete loss of amplitude

*Normal arterial waveforms have sharp slopes and peaks, whereas abnormal waveforms begin to flatten out. Look for the overall changes in amplitude, slope and shape.

**Definitions of Pulse Volume Recording (PVR) Categories**

<table>
<thead>
<tr>
<th>PVR Category</th>
<th>Thigh and Ankle</th>
<th>Calf</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt; 15</td>
<td>&gt; 20</td>
</tr>
<tr>
<td>2</td>
<td>&gt; 15*</td>
<td>&gt; 20*</td>
</tr>
<tr>
<td>3</td>
<td>5 to 15</td>
<td>5 to 20</td>
</tr>
<tr>
<td>4</td>
<td>&lt; 5</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>5</td>
<td>Flat</td>
<td>Flat</td>
</tr>
</tbody>
</table>

* The difference between normal and mild categories is the absence of reflective waves (diastolic notch).

**Guide to ABI Results**

<table>
<thead>
<tr>
<th>ABI Results</th>
<th>Severity of Blockages</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1.40</td>
<td>Noncompressible</td>
</tr>
<tr>
<td>1.0–1.40</td>
<td>Normal</td>
</tr>
<tr>
<td>0.91–0.99</td>
<td>Borderline (equivocal)</td>
</tr>
<tr>
<td>0.41–0.90</td>
<td>Mild to Moderate</td>
</tr>
<tr>
<td>0.00–0.40</td>
<td>Severe</td>
</tr>
</tbody>
</table>

*For more information, see the Society for Cardiovascular Angiography and Interventions et al. (2011) ACCF/AHA focused update of the guidelines for the management of patients with peripheral artery disease. J Am Coll Cardiol 59(19): e45-e258.*
### SPP and PVR Interpretive Guidelines

<table>
<thead>
<tr>
<th>Capillary Assessment</th>
<th>Arterial Assessment</th>
<th>Clinical Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP &lt;30 mm Hg</td>
<td>PVR: Likely severely abnormal</td>
<td>Wound Healing Unlikely - Referral needed</td>
</tr>
<tr>
<td>SPP 30-40 mm Hg</td>
<td>PVR: Likely Moderately abnormal</td>
<td>Cautionary Zone - Monitor patient closely</td>
</tr>
<tr>
<td>SPP 40-50 mm Hg</td>
<td>PVR: Likely mild / Moderately abnormal</td>
<td>Medical or Other Conservative Treatment - Monitor patient closely</td>
</tr>
<tr>
<td>SPP &gt;50 mm Hg</td>
<td>PVR: Likely normal</td>
<td>Sufficient perfusion for healing - Treat patient</td>
</tr>
</tbody>
</table>
SPP results are not affected by incompressible arteries secondary to:

- Diabetes
- ESRD
- Dialysis

Suspect all ABI results in patients with incompressible arteries.

**ABI**

- Suspect ABI values >.9 as not reliable in Diabetic, ESRD, or Dialysis patients.

### Comparing ABI with SPP Measurement

<table>
<thead>
<tr>
<th>SPP (mmHg)</th>
<th>CLI</th>
<th>Significant PAD</th>
<th>Mild to Moderate PAD</th>
<th>Suspect ABI values &gt;.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-40</td>
<td>CLI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-50</td>
<td></td>
<td>Significant PAD</td>
<td></td>
<td>Suspect ABI values &gt;.9</td>
</tr>
<tr>
<td>&gt; 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SPP = Adequate to Normal Perfusion
Lesion Characterization and Assessment

Color-coded Duplex Sonography (CCD)

Magnetic Resonance Arteriography (MRA)

Contrast Arteriography
Duplex Ultrasound

• Advantages:
  - simple and cheap
  - noninvasive
  - no contrast
  - great for surveillance

• Disadvantages:
  - more qualitative than quantitative
  - technician dependent (especially below the knee or with pelvic vessels)
  - obese patients: limited pelvic/abdominal views
Diagnostic Criteria: Native Extremity Arteries

- **Guidelines** (not validated criteria) for blood flow velocities in normal lower extremity arterial segments as measured during duplex scanning:

  - External Iliac Artery: 119 cm/s +/- 22 cm/s
  - Common Femoral Artery: 114 cm/s +/- 25 cm/s
  - Superficial Femoral Artery: 91 cm/s +/- 14 cm/s
  - Popliteal Artery: 69 cm/s +/- 14 cm/s
# DUS: Stenosis

## Diagnostic Criteria: Native Extremity Arteries

### Stenosis

<table>
<thead>
<tr>
<th>Degree</th>
<th>PSV Increase</th>
<th>Spectral Broadening</th>
<th>Flow Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL</td>
<td>No PSV increase</td>
<td>No spectral broadening</td>
<td>Reverse flow present</td>
</tr>
<tr>
<td>1-19% Stenosis</td>
<td>PSV increase &lt;30%</td>
<td>No spectral broadening</td>
<td>Reverse flow present</td>
</tr>
<tr>
<td>20-49% Stenosis</td>
<td>PSV increase &lt; 2x</td>
<td>No post-stenotic turbulence</td>
<td>Reverse flow present</td>
</tr>
<tr>
<td>50-99% Stenosis</td>
<td>PSV increase &gt; 2x</td>
<td>Post-stenotic turbulence</td>
<td>Loss of reverse flow</td>
</tr>
<tr>
<td>OCCLUDED</td>
<td>No detectable Doppler Flow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*University of Washington validated criteria for classification of native artery stenosis.*

### Aneurysm

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal Aorta</td>
<td>Ectatic/Dilated</td>
<td>&gt; 2.0 - 3.0 cm, irregular</td>
</tr>
<tr>
<td></td>
<td>Aneurysmal</td>
<td>&gt; 3.0 cm</td>
</tr>
<tr>
<td>Peripheral Artery</td>
<td>Aneurysmal</td>
<td>&gt; 2x diameter of adjacent normal segment</td>
</tr>
</tbody>
</table>
DUS: proximal femoral vessels

- artery
- veins
DUS-stenosis

Increased velocities

Turbulent flow
CTA/ MRA imaging

What is the goal of testing?

Diagnosis / unclear DUS or conflicting data?

Baseline exam for monitoring?

Assessment of disease severity and extent?

How to treat/ procedural planning

Surgery vs Endovascular?
CT Angiography

• Advantages
  - Entire vascular tree can be quickly evaluated
  - non-invasive
  - IV access only needed
  - useful in case planning, approach and device choice
  - fast
  - high spatial resolution with both lumen and wall seen

• Dis-advantages
  - Exposes the patient to contrast and radiation
  - images obscured by Calcium: calcium artifact can create or obscure lesions.
  - requires an additional procedure (and contrast exposure) if intervention is indicated.
Abdominal CTA

- Computed Tomography Angiogram
- Abdominal aortic aneurysm
- Dense calcification of aorto-iliac arteries
CTA aorta to iliac vessels

Reconstructed View
Same Level indicated

Iliac bifurcation
CTA iliac/femoral level

level of Axial cuts
CTA-distal vessels

Unclear anatomy
CTA iliacs

- Level of Axial cuts
- Absent right CIA
- Aneurysmal Left CIA
MR Angiography

• Advantages
  - non-invasive
  - no standard contrast
  - no radiation
  - better for small vessel visualization
  - Sens/spec 95%/97% vs CTA with 91%/91%*****

• Disadvantages
  - highly technique dependent (false +/-)
  - highly reader dependent (false +/-)
  - not all centers have MR
  - pacer/ICDs & metallic implants may preclude use
  - Gadolinium-Nephrogenic Systemic Fibrosis risk
MRA: Distal aorta and run-off
MRA: AAA and run-off
Conclusions:

• Don’t forget the basics (a good H &P)
• High index of suspicion in those with multiple risk factors.
• Make use of the simple (in-office) screening maneuvers.
• Understand your goals: (With respect to MRA and CTA)
  1) If diagnosis only is your goal, basic screening followed may be enough, though CTA and MRA may yield useful information to aid in diagnosis and determine extent of disease, as well as a guide to follow-up.
  2) If treatment is your goal from the outset, ABI’s or PVRs to include or exclude the diagnosis, then duplex ultrasound may be enough to confirm the Dx. CTA and MR are useful for case planning but may also add unnecessary exposure to contrast and radiation, especially in CKD pts, while proceeding directly to contrast angiography allows for diagnosis and treatment in the same setting.
Thank You

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