The Role of DUS, CTA, MRA in the Diagnosis and Selection of Treatment Options for PAD

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Disclosures

• Spectranetics Corporation: Medical advisory board, consultant, speaker, educational grants, trainer, investigator
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Vascular Testing for PAD

• Diagnosis
• Case Planning
• Surveillance
The Basics **BEFORE** Testing

- History: know the risks
- Physical exam
- Simple Screening:
  - ABI
  - PVR
  - SPP
Symptoms

• Classic Sx: 1/3
• Atypical Sx: 1/3
• No Sx: 1/3
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)-70% of patients with CAD will have PAD and visa versa.
## Non-invasive Vascular Testing

**Ankle Brachial Index (ABI)**

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arm</strong></td>
<td>120mmHg</td>
<td>120mmHg</td>
</tr>
<tr>
<td><strong>Dorsalis pedis artery</strong></td>
<td>90 mmHg</td>
<td>96 mmHg</td>
</tr>
<tr>
<td><strong>Posterior tibial artery</strong></td>
<td>120mmHg</td>
<td>80 mmHg</td>
</tr>
<tr>
<td><strong>ABI</strong></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
### 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>
Comparing ABI with SPP Measurement

SPP results are not affected by incompressible arteries secondary to:

- Diabetes
- ESRD
- Dialysis

Suspect all ABI results in patients with incompressible arteries.

<table>
<thead>
<tr>
<th>ABI</th>
<th>Suspect ABI values &gt;.9 as not reliable in Diabetic, ESRD, or Dialysis patients.</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;.9</td>
<td></td>
</tr>
<tr>
<td>.7 -.9</td>
<td></td>
</tr>
<tr>
<td>.4 -.7</td>
<td></td>
</tr>
<tr>
<td>.2 -.4</td>
<td></td>
</tr>
</tbody>
</table>

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

SPP = Adequate to Normal Perfusion
Sample PVR Waveforms

Normal
- Sharp peak
- Reflective wave (Dicrotic notch)
- Leading edge
- Baseline

Mild
- Descending slight bowing away from baseline
- Upstroke slight bowing towards baseline
- Loss of reflective wave (Dicrotic notch)

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>Chart deflection (mm)</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 (Dicrotic 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>0.41–0.60</td>
<td>Mild to Moderate</td>
</tr>
<tr>
<td>0.00–0.40</td>
<td>Severe</td>
</tr>
</tbody>
</table>

Note: ABI (Ankle-Brachial Index) is a simple non-invasive test that measures the ratio of blood pressure at the ankle to the blood pressure in the brachial artery.
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
DUS: normal

Native Extremity Arteries

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

<table>
<thead>
<tr>
<th>Artery</th>
<th>Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Iliac Artery</td>
<td>119 cm/s +/- 22 cm/s</td>
</tr>
<tr>
<td>Common Femoral Artery</td>
<td>114 cm/s +/- 25 cm/s</td>
</tr>
<tr>
<td>Superficial Femoral Artery</td>
<td>91 cm/s +/- 14 cm/s</td>
</tr>
<tr>
<td>Popliteal Artery</td>
<td>69 cm/s +/- 14 cm/s</td>
</tr>
</tbody>
</table>
Native Extremity Arteries

- **Stenosis**
  
<table>
<thead>
<tr>
<th>Stenosis</th>
<th>PSV Increase</th>
<th>Spectral Broadening</th>
<th>Reverse Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>No</td>
<td>No</td>
<td>Reverse flow present</td>
</tr>
<tr>
<td>1-19% Stenosis</td>
<td>PSV increase &lt; 30%</td>
<td>No</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**
  
  Abdominal Aorta
  - Ectatic/Dilated: > 2.0 - 3.0 cm, irregular
  - Aneurysmal: > 3.0 cm
DUS: proximal femoral vessels
DUS-stenosis

Increased velocities

Turbulent flow
CTA/ MRA imaging

What is the goal of testing?

- Diagnosis / unclear DUS or conflicting data
- Baseline exam or monitoring (AAA)
- Accurate assessment of disease severity & location

Case Planning
Case Planning

• Surgical vs. Endovascular
• Approach and access site(s)
  Femoral (Ante-grade or retro-grade)
  Popliteal
  Pedal
  Brachial
• Device(s) required
  CTO devices
  Wires
  Atherectomy (device type -----CALCIUM)
  Distal Protection (single vessel Run-off)
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

• Disadvantages
  - Exposes the patient to contrast and radiation
  - images obscured by Calcium: calcium artifact can create or obscure lesions.
  - requires repeat contrast exposure if intervention is indicated (consider instead angiogram/intervention if likelihood of finding disease is high)
  - distal (small vessel) patency may be difficult to assess if heavy calcium is present
Abdominal CTA

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

Reconstructed View
Same Level indicated

***You must learn to read axial cuts in addition to reconstructed images!!
CTA iliac/femoral level

level of Axial cuts

SFA Severe stenosis
CTA-distal vessels

Unclear anatomy

PT

AT

peroneal
CTA iliacs

Level of Axial cuts

Absent right CIA

Aneurysmal Left CIA
MR Angiography

• Advantages
  - non-invasive
  - no iodine based contrast
  - no radiation
  - better for small vessel visualization
  - Sensitivity/specificity 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
  - time—movement artifact
MRA: Distal aorta and run-off
MRA: 
AAA and run-off
Surveillance (post-intervention)

- History
- PE
- ABI/PVR/SPP
- DUS: 1-mo, (3-mo), 6-mo, 12-mo, then annually
- CTA: -not routinely done for most patients (unless indicated clinically)
  -AAA: contrast is needed to evaluate for endovascular leak
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.
• Confirm your diagnosis (most cases) with DUS
• Understand your goals with respect to MRA and CTA.

1) If diagnosis only is your goal, then careful exam and simple non-invasive screening may yield enough useful information to guide follow-up. CTA and MRA may be unnecessary and only add cost, unless simple screening tests have been non-diagnostic.

2) If treatment/intervention is your goal, a thorough physical exam and screening with ABI’s, PVRs, or DUS to confirm or exclude the diagnosis should still be the first step. CTA and MR are extremely useful for confirming the diagnosis and case planning. In selected cases, proceeding directly to contrast angiography allows for diagnosis and treatment in the same setting and may reduce contrast and radiation exposure.
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