Resting ABIs and the Diabetic Patient: How Reliable Are They?

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OBJECTIVES

1. Present basic concepts of non-invasive vascular imaging

2. Present basic concepts of lower extremity physiological testing

3. Review current trends and industrial standards of the ankle/brachial index (ABI)
Arterial Stiffness And Testing

- A High Ankle-Brachial Index is associated with increased cardiovascular disease morbidity.
- ABI >1.40 is suggestive of a non-compressible vessels.
- ABI >1.25 is also suggestive of non-compressible vessels (if other risk factors are involved, diabetes, hypertension...etc)

(Allison, Hiatt, Hisch, Coll, Criqui, Am Coll Cardiology, 2008; 51(13):1292-1298)
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. **
Resting ABI-
INDUSTRIAL/RESEARCH VALUES

- $>0.90 = \text{Normal}$
- $<0.90 = \text{Abnormal, stress testing is appropriate}$
- $<0.8 = \text{Probable Claudication}$
- $<0.5 = \text{Multi-level disease, or long segment occlusion}$
- $<0.3 \text{ ischemic rest pain- severe disease (ulcers will not heal)}$
Two Areas Being Missed By Partial AND Incomplete Studies

Peripheral Arterial & Cardiovascular Disease
ABI Technical Considerations

Normal ABI in a well-rested patient typically averages 1.10. ABI's equal to or greater than 1.00 are considered normal; however, an ABI that is greater than 1.40 is highly suggestive of arterial wall calcification.

- ABI of less than 1.00 is suggestive of arterial disease.
- Rarely does a normal extremity have an ABI of < 0.92; therefore, borderline values (0.92 - 1.00) should be viewed with caution.
- If ABI is < 1.00 but > 0.80, claudication may be suspected. The typical ABI range for patients with intermittent claudication is 0.50 to 0.70.
- An ankle brachial index of > 0.50 is a good indicator of single level arterial occlusive disease; < 0.50 suggests multi-level disease.
- Patients with rest pain, ischemic ulcer, or gangrene typically have an ABI of < 0.30. Patients with rest pain usually have severe, multi-level arterial disease.
- Critical ischemic limbs have an ABI of < 0.20. This level of ischemia is limb threatening, with tissue necrosis (tissue death) the end result.

Absolute Ankle Pressure Measurements

In a non-diabetic patient, if the ankle pressure is ≥ 60 mmHg, ischemic rest pain is unlikely; < 35 mmHg, and rest pain is probable. In diabetics, if the ankle pressure is ≥ 80 mmHg, ischemic rest pain is unlikely; < 40 mmHg, and rest pain is probable.

Ischemic foot ulcers are unlikely to heal with ankle pressures less than 40 - 50 mmHg in nondiabetics; 80 mmHg in diabetics.

Calf systolic pressures exceeding 85 - 70 mmHg will typically be sufficient to heal below the knee (BK) amputations.

Toe Brachial Index (TBI)

Because arterial calcification seldom occurs at the digital level, toe pressure and TBI are recommended for patients with noncompressible tibial arteries (≥ 300 mmHg). Although air plethysmography can be used for this measurement, photoplethysmography (PPG) is easier to use.

Toe Brachial Index (TBI): Toe pressure + Highest Brachial Pressure

TBI Relationship to Peripheral Arterial Disease (PAD)

<table>
<thead>
<tr>
<th>TBI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 0.80</td>
<td>No Significant PAD</td>
</tr>
<tr>
<td>0.20 to 0.50</td>
<td>Claudication</td>
</tr>
<tr>
<td>&lt; 0.20</td>
<td>Rest Pain</td>
</tr>
</tbody>
</table>
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 < 0.20 Rest Pain

- TBI pressures < 30mmhg = Wound healing will be unsuccessful *(Laser Doppler)*

- Scission, R, Neuymer, M (2003), Physiological Testing Techniques and Interpretation
DIABETIC MEDIAL CALCINOSIS - NOT SO SCARY!!! - IF YOU KNOW HOW TO TEST FOR IT

In the Non-Invasive World-----
There is a difference between STIFF and STENOTIC
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).**


**Table 2**

<table>
<thead>
<tr>
<th>63 Extremities</th>
<th>Average ABI</th>
<th>Percent of Total (n)</th>
<th>Percent without Ankle Waveforms (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT ABI only</td>
<td>0.31</td>
<td>24 (15/63)</td>
<td>53 (8/15)</td>
</tr>
<tr>
<td>DP ABI only</td>
<td>0.34</td>
<td>14 (9/63)</td>
<td>44 (4/9)</td>
</tr>
<tr>
<td>PT and DP ABI</td>
<td>0.29/0.31</td>
<td>22 (14/63)</td>
<td>36 (5/14)</td>
</tr>
<tr>
<td>Absent PT and DP ABI</td>
<td>0.00/0.00</td>
<td>40 (25/63)</td>
<td>100 (25/25)</td>
</tr>
</tbody>
</table>

ABI, ankle-brachial index; CLI, critical-limb ischemia; DP, dorsalis pedis; PT, posterior tibial.

**Table 1**

<table>
<thead>
<tr>
<th>Digital PPG Waveforms Patients and Limbs Diagnosed with CLI</th>
</tr>
</thead>
<tbody>
<tr>
<td>95 Patients, 107 Extremities</td>
</tr>
<tr>
<td>Group 1</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Location CLI diagnosis</td>
</tr>
<tr>
<td>In-hospital</td>
</tr>
<tr>
<td>Outpatient</td>
</tr>
<tr>
<td>Affected CLI extremity</td>
</tr>
<tr>
<td>Right leg</td>
</tr>
<tr>
<td>Left leg</td>
</tr>
<tr>
<td>Average PT ABI</td>
</tr>
<tr>
<td>Average DP ABI</td>
</tr>
</tbody>
</table>

ABI, ankle-brachial index; CLI, critical-limb ischemia; DP, dorsalis pedis; PPG, photoplethysmography; PT, posterior tibial.

Patient’s Deserve a Full Arterial Study
Technical Review

What’s *REALLY* in a PVR Report,
-and the-
The Diabetic Patient
What’s in a Report

1. Waveform Analysis**

* Very Technology Dependent
Doppler and PVR Waveform Comparative Analysis

Pre Exercise Waveforms

Post Exercise Waveforms
*Inclusion Criteria*

DIABETIC’S WITH NORMAL RESTING ABI’s

CASE ONE
CASE TWO

SEGMENTAL PRESSURE AND PVR STUDY

Brachial
RIGHT LEFT

<table>
<thead>
<tr>
<th>Location</th>
<th>PVR</th>
<th>Vol.</th>
<th>Right High Thigh</th>
<th>Left High Thigh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Below Knee</td>
<td>62</td>
<td>177cc</td>
<td>81 mmHg 9cc 90cc</td>
<td>81 mmHg 9cc 90cc</td>
</tr>
<tr>
<td>Right Ankle</td>
<td>64</td>
<td>104cc</td>
<td>81 mmHg 9cc 90cc</td>
<td>81 mmHg 9cc 90cc</td>
</tr>
<tr>
<td>Right Metatarsal</td>
<td>64</td>
<td>104cc</td>
<td>81 mmHg 9cc 90cc</td>
<td>81 mmHg 9cc 90cc</td>
</tr>
</tbody>
</table>
CASE 2 Duplex Findings

- Rt FA Aneurysm
- Lt FA Aneurysm
Fun Fact -
Aortoiliac Aneurysm’s

- 60% of aneurysms are asymptomatic, generally discovered *incidentally* during imaging scans and physical examinations.

**NOTE**

THE PHYSICAL EXAM IS ONLY 58% SENSITIVE AND 75% SPECIFIC FOR AAA > 3CM

Zweibel & Pellerito, 2004 Introduction to vascular ultrasound
LT FEM ART OCCLUSION
CASE FIVE
CASE SIX
SEGMENTAL PRESSURE AND PVR STUDY

Brachial
RIGHT LEFT
134 137

PVR 67mmHg 676cc RIGHT High Thigh
Gain: 6 Spd:25 Amp:18

PVR 63mmHg 545cc LEFT High Thigh
Gain: 6 Spd:25 Amp:16

0.96
1.13

0.84
1.01

0.72
1.01

0.61
0.80

RIGHT LEFT

PVR 64mmHg 194cc RIGHT Below Knee
Gain: 6 Spd:25 Amp:12

PVR 50mmHg 115cc LEFT Below Knee
Gain: 6 Spd:25 Amp:26

ABI: 0.77
TBI: 0.61

ABI: 1.01
TBI: 0.80

PVR 60mmHg 84cc RIGHT Ankle
Gain: 6 Spd:25 Amp:08

PVR 53mmHg 89cc LEFT Ankle
Gain: 6 Spd:25 Amp:10

RIGHT POST EXERCISE

Min BRA, ANK, ABI
Res 137 105 0.77
Imm 169 66 0.39

LEFT POST EXERCISE

Min BRA, ANK, ABI
Res 137 136 1.01
Imm 169 93 0.55

Dop 8MHz RIGHT Posterior Tibial
Gain: 8 Speed:25

Dop 8MHz RIGHT Dorsalis Pedis
Gain: 8 Speed:25

Dop 8MHz LEFT Posterior Tibial
Gain: 8 Speed:25

Dop 8MHz LEFT Dorsalis Pedis
Gain: 8 Speed:25
What’s the Solution?

- Physiologic Testing
  1. Patients that are non-compressible need to be exercised. All need to be exercised.
  2. Patients with ABI of <1.0

- Arterial Duplex
  1. Stents
  2. Grafts
  3. Aneurysms
  4. Known Interventions
  5. Patient Who Cannot be Exercised
Question ???

HOW CAN YOU FIND THE SOURCE OF CLAUDICATION IF YOU DO NOT EXERCISE THE PATIENT ????????????