Differential Diagnosis of Leg Pain: Could It Be Vascular?

Combined Sections Meeting 2014
Las Vegas, Nevada, February 3 – 6, 2014

Miriam Cortez-Cooper, PT, PhD
Department of Physical Therapy, Georgia Regents University
Danielle Frischmann, RN, BSN
Cardiac Catheterization Laboratory, Georgia Regents Medical Center

Disclosures

• No relevant financial relationship exists for either speakers
• Some of the slides are borrowed from the core curriculum slide set titled, “The Peripheral Arterial Disease Guideline: Evidence-Based Management of Patients With PAD”

The Peripheral Arterial Disease Guideline:
Evidence-Based Management of Patients With PAD

Core Curriculum Slide Set
A Collaborative Product Co-Developed by:
American College of Cardiology; American Heart Association;
American Association of Cardiovascular and Pulmonary Rehabilitation;
National Heart, Lung and Blood Institute; Peripheral Arterial Disease Coalition;
Society for Cardiovascular Angiography and Interventions;
Society of Interventional Radiology; Society for Vascular Nursing;
TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation.

Applying Classification of Recommendations and Level of Evidence

<table>
<thead>
<tr>
<th>Class I</th>
<th>Benefit &gt;&gt; Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure/Treatment SHOULD be performed/administered</td>
<td></td>
</tr>
<tr>
<td>IT IS REASONABLE to perform procedure/administer treatment</td>
<td></td>
</tr>
<tr>
<td>Level A</td>
<td>Multiple (3-5) population risk strata evaluated</td>
</tr>
<tr>
<td>General consistency of direction and magnitude of effect</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class IIa</th>
<th>Benefit &gt;&gt; Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure/Treatment needed</td>
<td></td>
</tr>
<tr>
<td>Additional registry data would be helpful</td>
<td></td>
</tr>
<tr>
<td>Level B</td>
<td>Limited (2-3) population risk strata evaluated</td>
</tr>
<tr>
<td>Procedure/Treatment MAY BE CONSIDERED</td>
<td></td>
</tr>
<tr>
<td>IT IS REASONABLE to perform procedure/administer treatment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class IIb</th>
<th>Benefit ≥ Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure/Treatment MAY BE CONSIDERED</td>
<td></td>
</tr>
<tr>
<td>Additional registry data would be helpful</td>
<td></td>
</tr>
<tr>
<td>Additional studies with broad objectives needed; Additional registry data would be helpful</td>
<td></td>
</tr>
<tr>
<td>Level C</td>
<td>Very limited (1-2) population risk strata evaluated</td>
</tr>
<tr>
<td>Procedure/Treatment SHOULD NOT be performed/administered</td>
<td></td>
</tr>
<tr>
<td>Level D</td>
<td>No additional studies needed</td>
</tr>
<tr>
<td>Risk ≥ Benefit</td>
<td></td>
</tr>
<tr>
<td>Procedure/Treatment should NOT be performed/administered</td>
<td></td>
</tr>
<tr>
<td>Since it is NOT helpful and MAY be harmful</td>
<td></td>
</tr>
</tbody>
</table>

Learning Objectives

Course participants will:
• Determine when screening for PAD is indicated given a patient’s medical history and chief complaints.
• Identify patients needing further testing based on vascular exam findings.
• Explain why exercise improves vascular function and walking distance in patients with PAD
• Prescribe exercise to improve walking distance in patients with PAD

Content

• Pathophysiology & Epidemiology of PAD
• Clinical Presentations of PAD
• Vascular Examination
• Diagnostic Testing
• Exercise Prescription for PAD

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author
Leg Pain: Could It Be Vascular?

2/5/13

Learning Objective 1
Determine when screening for PAD is indicated given a patient's medical history and chief complaints.

CASE 1 - Medical History
A 53 year old African American male presents with low back and left lower leg pain x 2 months. He weighs 152 lbs and is 68 in tall. He works as a welder at a rural foundry and has smoked 1 pack per day for 35 years.

What Medical History information would make you consider a vascular cause of his leg pain?
A. Age - 53 years
B. Weight - 152 lbs
C. Sex - Male
D. Race - African American
E. Smoking - 35 pack year history
F. Occupation - Welder at a foundry

What descriptors of his left lower leg pain would make you consider a vascular cause?
A. Pain that subsides within 10 min of stopping walking
B. Pain that remains constant or decreases as walking distance increases
C. Pain described as burning or tingling
D. Pain described as cramping or tightness
E. Buttock or thigh pain in addition to lower leg pain

Claudication vs. Pseudoclaudication

<table>
<thead>
<tr>
<th>Characteristic of discomfort</th>
<th>Claudication</th>
<th>Pseudoclaudication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of discomfort</td>
<td>Buttock, hip, thigh, calf, foot</td>
<td>Same as claudication</td>
</tr>
<tr>
<td>Exercise-induced</td>
<td>Yes</td>
<td>Variable</td>
</tr>
<tr>
<td>Distance</td>
<td>Consistent</td>
<td>Variable</td>
</tr>
<tr>
<td>Occurs with standing</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Action for relief</td>
<td>Stand</td>
<td>Sit, change position</td>
</tr>
<tr>
<td>Time to relief</td>
<td>&lt;5 minutes</td>
<td>≤30 minutes</td>
</tr>
</tbody>
</table>

Differential diagnosis
- Arthritis
- Anemia
- Spinal stenosis – narrowing of the spinal canal causing leg or lower back pain
- Thrombophlebitis – blood clots in the deep veins of the legs
- Peripheral neuropathy -- nerve damage in the legs and feet, usually in people with diabetes
- Night cramps in older people that are not due to problems in blood vessels
- Muscle entrapment of the arteries or kinks in the arteries in the leg – typically occurs in young athletes

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author
Walking Impairment Questionnaire

WIQ
- PAD-specific, self-administered questionnaire that measures patient-perceived difficulty climbing stairs and walking specific distances and speeds.

Assessment
- How far can you walk?
- Do you ever need to stop and rest when walking? Why?
- Do you participate in any form of exercise or physical activity, such as mowing the lawn or grocery shopping?
- Do you have any wounds or sores on your legs or feet?
- Have you slowed down or do you feel less active than one year ago?
- Would you have any difficulty walking one block, climbing one flight of stairs or walking faster?

Clinical Presentations of PAD

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.

Comparison of Walking Distance and Daily Physical Activity

- Patients classified according to the San Diego Claudication Questionnaire
  - Leg pain on exertion and sometimes at rest (n = 103)
  - Atypical leg pain causing them to stop (n = 125)
  - Atypical leg pain but able to continue (n = 81)
  - Classic intermittent claudication (n = 406)
- Fontaine stage II PAD
  - ABI <0.9: pain limited ambulation

Learning Objective 2
Identify patients needing further testing based on vascular exam findings.

This guideline recognizes that:

Individuals With PAD Present in Clinical Practice 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.

Comparison of Walking Distance and Daily Physical Activity

- Patients classified according to the San Diego Claudication Questionnaire
  - Leg pain on exertion and sometimes at rest (n = 103)
  - Atypical leg pain causing them to stop (n = 125)
  - Atypical leg pain but able to continue (n = 81)
  - Classic intermittent claudication (n = 406)
- Fontaine stage II PAD
  - ABI <0.9: pain limited ambulation

Learning Objective 2
Identify patients needing further testing based on vascular exam findings.

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author.
Leg Pain: Could It Be Vascular?

VASCULAR EXAMINATION

Comprehensive Vascular Examination

Key components of the vascular physical examination include:

- Bilateral arm blood pressure (BP)
- Cardiac examination
- Palpation of the abdomen for aneurysmal disease
- Auscultation for bruits
- Examination of legs and feet
- Pulse Examination
  - Carotid
  - Radial/ulnar
  - Femoral
  - Popliteal
  - Dorsalis pedis
  - Posterior tibial
- Scale:
  - 0=Absent
  - 1=Dimplished
  - 2=Normal
  - 3=Bounding (aneurysm or AI)

The Vascular Review of Symptoms:
An Essential Component of the Vascular History

Key components of the vascular review of symptoms (not usually included in the review of systems of the extremities) and family history include the following:

- Any exertional limitation of the lower extremity muscles or any history of walking impairment. The characteristics of this limitation may be described as fatigue, aching, numbness, or pain. The primary site(s) of discomfort in the buttock, thigh, calf, or foot should be recorded, along with the relation of such discomfort to rest or exertion.
- Any poorly healing or nonhealing wounds of the legs or feet.
- Any pain at rest localized to the lower leg or foot and its association with the upright or recumbent positions.
- Post-prandial abdominal pain that reproducibly is provoked by eating and is associated with weight loss.
- Family history of a first-degree relative with an abdominal aortic aneurysm.

The First Tool to Establish the PAD Diagnosis:
A Standardized Physical Examination

Pulse intensity should be assessed and should be recorded numerically as follows:

- 0, absent
- 1, diminished
- 2, normal
- 3, bounding

If pulse exam is abnormal, obtain an ABI

ABI Procedure

Arm SBP

Ankle SBP

How to Perform an ABI Exam

- Performed with the patient resting in the supine position
- All pressures are measured with an arterial Doppler and appropriately sized blood pressure cuff (edge 1-2 inches above the pulse; cuff width should be 40% of limb circumference).
- Systolic pressures will be measured in the right and left brachial arteries followed by the right and left ankle arteries.

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author
Leg Pain: Could It Be Vascular?

ABI Procedure

• **Step 1:** Apply the appropriately sized blood pressure cuff on the arm above the elbow (either arm).
• **Step 2:** Apply Doppler gel to skin surface.
• **Step 3:** Turn on the Doppler and place the probe in the area of the pulse at a 45-60° angle to the surface of the skin, pointing to the shoulder.
• **Step 4:** Move the probe around until the clearest arterial signal is heard.
• **Step 5:** Inflate the blood pressure cuff to approximately 20 mmHg above the point where systolic sounds are no longer heard.
• **Step 6:** Gradually deflate until the arterial signal returns. Record the pressure reading.
• **Step 7:** Repeat the procedure for the right and left posterior tibial and dorsalis pedis arteries. Place the probe on the pulse and angle the probe at 45° toward the knee.
• **Step 8:** Record the systolic blood pressure of the contralateral arm.

Understanding the ABI

The ratio of the higher brachial systolic pressure and the higher ankle systolic pressure for each leg:

\[
\text{ABI} = \frac{\text{Ankle systolic pressure}}{\text{ Higher brachial artery systolic pressure}}
\]

Calculate the ABI

1. For the left side, divide the left ankle pressure by the highest brachial pressure and record the result.
2. Repeat the steps for the right side.
3. Record the ABIs and place the results in the medical record.

Interpreting the Ankle-Brachial Index

\[
\text{ABI} = \frac{\text{Lower extremity systolic pressure}}{\text{Brachial artery systolic pressure}}
\]

- The ankle-brachial index is 95% sensitive and 99% specific for PAD
- Establishes the PAD diagnosis
- Identifies a population at high risk of CV ischemic events
- The “population at risk” can be clinically and epidemiologically defined:
  - Age less than 50 years with diabetes, and one additional risk factor
  - Age 50 to 60 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
- Toe-brachial index (TBI) useful in individuals with non-compressible pedal pulses

Interpretation of the ABI

<table>
<thead>
<tr>
<th>ABI</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00–1.29</td>
<td>Normal</td>
</tr>
<tr>
<td>0.91–0.99</td>
<td>Borderline</td>
</tr>
<tr>
<td>0.41–0.90</td>
<td>Mild-to-moderate disease</td>
</tr>
<tr>
<td>≤0.40</td>
<td>Severe</td>
</tr>
<tr>
<td>≥1.30</td>
<td>Noncompressible</td>
</tr>
</tbody>
</table>
Leg Pain: Could It Be Vascular?

Using the ABI: An Example

<table>
<thead>
<tr>
<th>Right ABI</th>
<th>Left ABI</th>
<th>ABI (Normal &gt;0.90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80/160=0.50</td>
<td>120/160=0.75</td>
<td></td>
</tr>
</tbody>
</table>

- Brachial SBP 150 mm Hg
- Highest brachial SBP
- PT SBP 40 mm Hg
- DP SBP 80 mm Hg
- Highest of PT or DP SBP

ABI Limitations

- Incompressible arteries (elderly patients, patients with diabetes, renal failure, etc.)
- Resting ABI may be insensitive for detecting mild aorto-iliac occlusive disease
- Not designed to define degree of functional limitation
- Normal resting values in symptomatic patients may become abnormal after exercise
- Note: “Non-compressible” pedal arteries is a physiologic term and such arteries need not be “calcified”

Toe-Brachial Index Measurement

- The toe-brachial index (TBI) is calculated by dividing the toe pressure by the higher of the two brachial pressures.
- TBI values remain accurate when ABI values are not possible due to non-compressible pedal pulses.
- TBI values ≤ 0.7 are usually considered diagnostic for lower extremity PAD.

Exercise ABI Testing

- Confirms the PAD diagnosis
- Assesses the functional severity of claudication
- May “unmask” PAD when resting the ABI is normal
- Aids differentiation of intermittent claudication vs. pseudoclaudication diagnoses

Exercise ABI Testing: Treadmill

- Indicated when the ABI is normal or borderline but symptoms are consistent with claudication;
- An ABI fall post-exercise supports a PAD diagnosis;
- Assesses functional capacity (patient symptoms may be discordant with objective exercise capacity).

The Plantar Flexion Exercise ABI

- Benefits:
  - Reproduces treadmill-derived fall in ABI
  - Can be performed anywhere
  - Inexpensive
- Limitation:
  - Does not measure functional capacity

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author
**Individuals “At Risk” for Lower Extremity PAD**

Based on the epidemiologic evidence base, an “at risk” population for PAD can be objectively defined by:

- Age less than 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

**Diagnostic tools**

- ABI
- ABI/PVR with or without exercise
- Arterial duplex
- CT angiography
- Aortofemoral runoff/invasive angiography

**Segmental Pressures (mm Hg)**

<table>
<thead>
<tr>
<th>Segment</th>
<th>Pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brachial</td>
<td>150</td>
</tr>
<tr>
<td>ABI</td>
<td>150</td>
</tr>
<tr>
<td>ABI</td>
<td>150</td>
</tr>
<tr>
<td>110</td>
<td>146</td>
</tr>
<tr>
<td>108</td>
<td>84</td>
</tr>
<tr>
<td>62</td>
<td>0.44</td>
</tr>
<tr>
<td>0.54</td>
<td>0.44</td>
</tr>
</tbody>
</table>

**Pulse Volume Recordings**

**Color Duplex Ultrasonography**
Leg Pain: Could It Be Vascular?

Arterial Duplex Ultrasound Testing

- Duplex ultrasound of the extremities is useful to diagnose anatomic location and degree of stenosis of peripheral arterial disease.
- Duplex ultrasound is useful to provide surveillance following femoral-popliteal bypass using venous conduit (but not prosthetic grafts).
- Duplex ultrasound of the extremities can be used to select candidates for:
  (a) endovascular intervention
  (b) surgical bypass, and
  (c) to select the sites of surgical anastomosis.

However, the data that might support use of duplex ultrasound to assess long-term patency of PTA is not robust.

Magnetic Resonance Angiography (MRA)

- MRA has virtually replaced contrast arteriography for PAD diagnosis
- Excellent arterial picture
- No ionizing radiation
- Noniodine-based intravenous contrast medium rarely causes renal insufficiency or allergic reaction
- ~10% of patients cannot utilize MRA because of:
  - Claustrophobia
  - Pacemaker/implantable cardioverter-defibrillator
  - Obesity
- Gadolinium use in individuals with an eGFR <60 mL/min has been associated with nephrogenic systemic fibrosis (NSF)/nephrogenic fibrosing dermopathy

Computed Tomographic Angiography (CTA)

- Requires iodinated contrast
- Requires ionizing radiation
- Produces an excellent arterial picture

Computed Tomographic Angiography (CTA)

- Requires iodinated contrast
- Requires ionizing radiation
- Produces an excellent arterial picture

Case study 1

- 59 year old African American male with a past medical history significant for: HTN, HLD, known prior PAD. He presents with left foot pain, particularly of the lateral aspect, which is worse at night.
- No ulcerations or gangrene.
- Nonpalpable left pedal pulse.
- Weak doppler signal for left DP.
- Absent doppler signal for left PT.
- Severely depressed ABI (0.11) on left (vs right side 1.01)

Diagnosis?

ABI/PVR study

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author
Leg Pain: Could It Be Vascular?

**Case Study 2**
- 50 year old caucasian male.
- Past medical hx significant for: prior MVA 20 years prior with cervical spine injury and right femur fracture, hx lumbar spine injury, obstructive sleep apnea, hypertension, and hyperlipidemia.
- 2.5 to 3 pack per day smoker
- Presents for evaluation of right lower extremity pain.

**Symptoms**
- With mild exertion, he complains of “severe” RLE pain.
- Legs feel “numb” and “paralyzed.” R>L
- Sometimes symptoms are positional, other times exertional.
- Occurring over 1 year, worsening over past 6 months.
- Can “barely walk short distances” without symptoms.
- Describes “pain and burning” starting in his hip, back of his thigh and going down his leg. “Drags” his right leg behind him.
- Some relief with rest.
- He has been sedentary secondary to his lower extremity symptoms

What should we do next?

**Pulse exam**
- Femoral pulses are 1+ on the right side and 2+ on the left side.
- Popliteal pulses are 1+ on the right side and 2+ on the left side.
- Pedal pulses are diminished on the right side, but palpable. Posterior tibial pulses are 1+ bilaterally

In office ABI’s were obtained.....
Leg Pain: Could It Be Vascular?

ABI

- Ankle brachial indices revealed a right ABI of 0.77 and left ABI of 0.96.

Because symptoms were likely multifactorial, noninvasive vascular evaluation was ordered.

ABI/PVR study cont’d.

- Based on the results of the noninvasive vascular study, a CTA was ordered and obtained to delineate anatomy and prepare for angiography.
- CTA revealed:
  1. Mild proximal 30% bilateral common iliac artery stenosis
  2. Focal right 90% mid common iliac artery stenosis.
  3. 50 to 70% ostial hypogastric artery stenoses bilaterally
  4. Widely patent runoff from the external iliac artery down bilaterally

Angiogram

Learning Objective 3

Explain why exercise improves vascular function and walking distance in patients with PAD

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author
Exercise improves walking performance in patients with PAD by:

A. Causing regression of plaque formation
B. Increasing the dilation capacity of the artery
C. Increasing the internal diameter of the artery
D. Increasing angiogenesis to by-pass blocked arteries
E. Improving the metabolic properties of skeletal muscle

Learning Objective 4
Prescribe exercise to improve walking distance in patients with PAD

Key Functional Outcome Measures

- Pain-free walking distance (PFWD): Distance that can be walked before the onset of pain/claudication
- Maximal walking distance (MWD): Distance that patients can walk before pain forces them to stop
- Treadmill based test requiring patients to walk at 2 mph, 0% grade with 2% increase every 2 min
- Note: ABI is NOT used to demonstrate efficacy of training!

Which of the following types of exercise has been shown to improve maximal walking distance?

A. Treadmill training- Intermittent
B. Arm ergometry training- Continuous
C. Resistance training for the lower extremities
D. Unsupervised walking at home

Treadmill Training

- Frequency: 3 – 5 d/wk
- Intensity: “3” on a 4 point claudication pain scale (near maximal pain). Select treadmill speed and grade used to elicit the onset of leg pain. Stop until leg pain subsides completely. Repeat exercise/rest bouts
- Duration: Total exercise time, including rest periods, should equal at 50 min/d. May begin with 30 min/d
- Training should continue for at least 6 months but minimum is 12 wks

The PAD Exercise Training Prescription

<table>
<thead>
<tr>
<th>Warm-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Warm-up: Approximately 5 minutes</td>
</tr>
<tr>
<td>Repeated exercise periods: End at moderate claudication level</td>
</tr>
<tr>
<td>Rest Periods: Until claudication abates</td>
</tr>
</tbody>
</table>

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author
Leg Pain: Could It Be Vascular?

Arm Ergometry Training

- RCT of comparative effectiveness for arm ergometry, TM walking, combination training, and no exercise control
- ABI ≤ 0.90 at rest or fall in ABI (≥ 10%) after exercise
- 10–12 subjects per group
- 12 wk of training
- 12 wk of follow up
- Main outcome measures of PFWD & MWD

Resistance Training

- RCT of comparative effectiveness for LE resistance training & TM walking, and nutrition education control
- ABI ≤ 0.95 at rest; asymptomatic or intermittent claudication
- 51–53 subjects per group
- 24 wks of training; 3x/wk
- Main outcome measures: 6 min walk distance, short physical performance battery (4 m walking velocity, timed 5 sit to stands, standing balance)
- Secondary measures: Endothelial function (brachial artery FMD), physical activity (accelerometer)
- Exploratory: MWD time, PFWD time

Resistence Training

- Class IIB recommendation by the ACC & AHA.
- Efficacy limited by patients’ willingness to exercise at the needed intensity

Unsupervised Home Exercise

- 2011 RCT (Gardner et al.)
  - Step activity monitors
  - 12 weeks
  - 3d/wk at self-selected pace to near-maximal claudication pain
  - Began with 20 min and added 5 min bi-weekly for a total of 45 min by end of 10 weeks
  - Checked in with research staff for 15 min every 2 wks

Effects of Treadmill Training on Claudication

- Meta analysis of 21 Studies
- Exercise Training vs. Control
- Change in Treadmill Walking Time (min) for maximal walking distance (m)

Arm Ergometry Study

PROTOCOL
- Exercise at 10 watts below maximal work rate
- 2 min exercise + 2 min rest for 60 min
- Increase 1 min of exercise every 2–3 wks and decrease rest period to 1 min for maximum of 5 min exercise + 1 min rest for 60 min (50 min of actual exercise).
- Work rate increased to maximal rate by week 3

RESULTS (12 Weeks)

- Change in Treadmill Walking Distance
- MWD vs. PFWD

Resistance Training

RESISTANCE PROTOCOL
- 3 Sets of 8 reps
  - Knee extension
  - Leg press
  - Leg curl
- Begun at 50% of 1 RM
- Weight increased during 1st 5 wks to achieve 80% of 1 RM
- 3 Sets of 8 reps
  - Squats
  - Heel raises

RESULTS - Main Outcomes

- Change in Walking Distance
- MWD vs. PFWD

No within or between group changes for the SPPB

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author.
PARTNERS: Prevalence of PAD and Other CVD in Primary Care Practices

29% of Patients in a Target Population Were Diagnosed With PAD Using An Office-Based ABI

29% 44% 56%

Patients diagnosed with PAD
PAD only
PAD and CVD

Mortality According to ABI and Diabetes: Strong Heart Study

Home Safety Considerations

Supervised Exercise Rehabilitation

A program of supervised exercise training is recommended as an initial treatment modality for patients with intermittent claudication.

Supervised exercise training should be performed for a minimum of 30 to 45 minutes, in sessions performed at least three times per week for a minimum of 12 weeks.

Key Elements of an Effective PAD Therapeutic Claudication Exercise Program (1)

Exercise Guidelines for Claudication:
- Warm-up and cool-down period: 5 to 10 minutes each
- Types of exercise:
  - Treadmill and track walking are the most effective exercise for claudication
  - Resistance training has conferred benefit to individuals with other forms of cardiovascular disease, and its use, as tolerated, for general fitness is complementary to but not a substitute for walking
- Intensity:
  - The initial workload of the treadmill is set to a speed and grade that elicit claudication symptoms within 3 to 5 minutes
  - Patients walk at this workload until they achieve claudication of moderate severity, which is then followed by a brief period of standing or sitting rest to permit symptoms to resolve

Property of Cortez-Cooper, not to be copied or otherwise used without express permission of the author
Key Elements of an Effective PAD Therapeutic Claudication Exercise Program (2)

Exercise Guidelines for Claudication:

- **Duration:**
  - The exercise-rest-exercise pattern should be repeated throughout the exercise session.
  - The initial duration will usually include 35 minutes of intermittent walking and should be increased by 5 minutes each session until 50 minutes of intermittent walking can be accomplished.

- **Frequency:**
  - Treadmill or track walking 3 to 5 times per week.

References


Key Elements of an Effective PAD Therapeutic Claudication Exercise Program (3)

Role of Direct Supervision:

- As patients improve their walking ability, the exercise workload should be increased by modifying the treadmill grade or speed (or both) to ensure that there is always the stimulus of claudication pain during the workout.
- As patients increase their walking ability, there is the possibility that cardiac signs and symptoms may appear (e.g., dysrhythmia, angina, or ST-segment depression). These events should prompt physician re-evaluation.
- These general guidelines should be individualized and based on the results of treadmill stress testing and the clinical status of the patient. A full discussion of the exercise precautions for persons with concomitant diseases can be found elsewhere for diabetes.*

Prevalence of PAD by age and gender, adults 40 years and older, United States, 1999–2000 (n=23174).

Weight As A Risk Factor?

- Overweight/obesity is associated with diabetes.
- Diabetes is associated with a higher risk for PAD.
- Waist-to-hip ratio associated with 1.7 fold increase in risk when controlling for all other factors.
- BMI not associated with PAD risk.

Ethnicity and PAD: The San Diego Population Study
Leg Pain: Could It Be Vascular?

Risk Factors for PAD

<table>
<thead>
<tr>
<th>Smoking</th>
<th>Diabetes</th>
<th>Hypertension</th>
<th>Hypercholesterolemia</th>
<th>Hyperhomocysteinemia</th>
<th>C-Reactive Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced</td>
<td>Increased</td>
<td>Reduced</td>
<td>Reduced</td>
<td>Reduced</td>
<td>Reduced</td>
</tr>
</tbody>
</table>

Relative Risk

Blood lead and cadmium levels are associated with a higher prevalence of PAD

Greater occupational physical activity is associated with a lower prevalence of PAD

Regression of Plaque Formation

- Evidence for regression of plaque with statin therapy in non-peripheral vessels
- Some support for plaque regression in the coronary arteries with >1 year of training but difficult to separate out the effects of all interventions

Increased Dilation Capacity

- Impaired endothelial vasodilation measured in the BRACHIAL artery (FMD) found in patients with PAD
- Increase in arterial dilation capacity seen in the brachial artery of patients with cardiac disease after 12 weeks of endurance exercise
- Daily physical activity is associated with greater FMD in patients with PAD
- One study reported a small increase in dilation capacity after treadmill training

Increased Internal Arterial Diameter

- Improvement in walking distance not associated with improvement in ABI
- Calf blood flow not associated change in walking time after 3 months of exercise

Increased Angiogenesis

- Tissue ischemia stimulates the release of growth factors → angiogenesis
- Animal models of PAD supportive of angiogenesis or collateralization
- Maximal blood flow in humans not associated with improvements in walking distance
- Limitations with how we measure blood flow in humans?
Increased Skeletal Muscle Metabolism

- Patients with PAD have smaller and fewer numbers muscle fibers (type I), decreased capillary density and increased fat content. They also have mitochondrial dysfunction.
- Although endurance exercise is known to improve all of the above parameters in healthy adults, information regarding the association between mitochondrial energy production and muscle structure in patients with PAD is limited.