GE Healthcare

TiP-TV™ Training in Partnership Program Supplement and Test for Imaging Professionals

US: Lower Extremity Arterial Segmental Physiologic Evaluation

Publication Date: June 5, 2008

1.0 ASRT-approved Category A CE Credit

imagination at work

TABLE OF CONTENTS

Program Summary

This page provides an overview of the program content and learning objectives. Please refer to the Table of Contents for a detailed list of the topics covered. We encourage you to file a copy of this Program Summary and the Table of Contents with your continuing education certificate. We also recommend that you provide a copy of this information to your manager as a record of your educational achievement.

Program Description

Awareness of peripheral arterial disease (PAD) is growing in the general population. Physiologic segmental pressure studies, as described in this program, are instrumental to the diagnosis of PAD. Join officers of the Society for Vascular Ultrasound (SVU) as they instruct the viewer in techniques necessary to accomplish lower extremity arterial segmental physiologic evaluation.

Program Objectives

By the end of this program, the viewer should be able to:

1. Discuss lower extremity arterial anatomy, physiology, and pathophysiology.
2. Explain the common signs, symptoms, and etiology of lower extremity arterial disease.
3. Identify various spectral waveforms and pulse volume recordings encountered in a lower extremity segmental physiologic examination.
4. Recognize the common pitfalls encountered during a lower extremity arterial physiologic segmental examination.
5. Describe the standard protocol for a lower extremity arterial segmental physiologic evaluation as defined in the Society for Vascular Ultrasound's "Vascular Technology Professional Performance Guidelines."

Target Audience

Course objectives for this program specifically target ultrasound technologists, sonologists, vascular technologists, physicians, and nurses. All other technologists practicing in this field may also benefit.

NOTE: While not limited to this audience group, the technical content is most effective when applied to people with this training. Regardless of your imaging specialty, you may apply for continuing education credit. Refer to the Continuing Education Credit page for additional information.

Continuing Education Credit

1.0 ASRT-approved Category A CE Credit

NOTE: Effective February 1, 2005, the ARDMS accepts credits for ASRT-approved CE activities. ARDMS registrants may claim ASRT-approved Category A credit to meet their CE requirements. For more information, visit: www.ardms.org

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If you have a question or comment on the program content, please send a message to: **PSTIPApps-us2@med.ge.com**

Introduction

Arterial segmental pressure and waveform evaluations are performed to determine the presence, severity, and general location of peripheral arterial occlusive disease, also known as PAOD. This is a non-imaging study performed with continuous wave Doppler ultrasound equipment and it can be confusing to technologists that are new to the vascular lab. This program continues the TiP-TV series on vascular studies, based on the "Vascular Technology Professional Performance Guidelines" developed by the Society for Vascular Ultrasound.

In this program, Mr. Bill Schroedter, a vascular technologist and Vice President and Technical Director of Quality Vascular Imaging in Venice, Florida, presents comprehensive information on performing physiologic testing of the lower extremity.

Physiologic Testing of the Lower Extremity Arterial System

- Anatomy
- Physiology
- Patient history
- Focused physical exam
- “Physiologic” (non-imaging) evaluation

Atherosclerosis

- Atherosclerosis is a systemic disease process.
- Patients with symptomatic PAD will likely have disease elsewhere.
- Survival is significantly less than other age-matched control groups.
- Predicted mortality for patients with symptomatic PAD are approximately:
  - Thirty percent at 5 years.
  - Fifty percent at 10 years.
  - Seventy percent at 15 years.
- Myocardial infarction is the major contributor to outcome.

Affecting the Lower Extremity Arterial Tree

- Affects approximately 10% of the Western population over age 65.
- Exertional leg pain is by far the most common symptom.
- Symptomatic PAD:
  - Commonly affects men over age 50.
  - Affects approximately 2% of the population aged 40 to 60 years.
  - Affects approximately 6% of patients over age 70.
- No racial predilection.

Peripheral Arterial Disease

- Severe limb threatening ischemia and possible amputation is the most feared consequence.
- Amputation is actually fairly uncommon, ranging from 2% to 12% with a 10-year follow-up.
- Exertional leg pain is by far the most common symptom.

The noninvasive vascular laboratory is well-suited for determination of the presence and severity of peripheral arterial disease in the lower extremities, as well as functional impairment. This impact to the patient sets this modality aside from almost any other imaging modality.

Lower Extremity Arterial Anatomy

Abdominal Aorta and Primary Branches

Though physiologic testing does not directly assess the aorta, in-flow disease can be identified. The aorta descends in the abdomen to the level of the umbilicus, where it divides (bifurcates) into the right and left common iliac arteries. The iliac arteries are responsible for supplying blood to both legs. At the level of the mid-pelvis, the iliac arteries give rise to the right and left hypogastric arteries. As the iliac arteries pass the level of the inguinal ligament, they become the common femoral arteries.

Common Femoral Artery

The common femoral artery (CFA) is a fairly short arterial segment. Once past the inguinal ligament, at the groin, it quickly branches into the profunda femoris artery (the primary blood supply to the thigh) and the superficial femoral artery (the primary blood supply to the lower leg).

Popliteal Artery

Following the superficial femoral artery inferior to the level of the adductor canal, the superficial femoral artery becomes the popliteal artery. The popliteal artery courses posterior to the knee at the adductor canal and continues inferior. Just below the knee, the popliteal artery gives rise to the anterior tibial artery and becomes the peroneal trunk. A short distance below the origin of the anterior tibial artery, the peroneal trunk bifurcates to form the peroneal and posterior tibial arteries. The area encompassing the origin of the anterior tibial, peroneal, and posterior tibial arteries is also known as the popliteal trifurcation.

- From a posterior view, the posterior tibial artery is positioned toward the medial aspect of the leg. The peroneal artery is found at midline coursing down the middle of the gastrocnemius muscle.
- From an anterior approach, the anterior tibial artery passes through the interosseous membrane, between the tibia and the fibula, and courses along the anterior-lateral aspect of the leg.

Assessing the Patient

Perform a History and Physical Exam

- Order reads: "Doppler of the legs."
- Indication: "Leg pain."
- Is a clinician available?
- What is causing the patient's symptoms?

Very often the vascular technologist must determine the correct study to perform; orders are often ambiguous. "Doppler of the legs" or "leg pain" are statements that could apply to either arterial or venous studies. Clinicians may not be readily available to facilitate efficient patient treatment. Therefore, vascular technologists must interview the patient to ensure that the correct study is being performed.

The Scope of Practice for the Diagnostic Ultrasound Professional

If a sonographer is to be recognized as a professional, they must perform as a professional. The scope of practice for diagnostic ultrasound professionals defines the limits of how an ultrasound or vascular technologist must practice. The first paragraph of the scope of practice (outlined below) emphasizes the need for ultrasound professionals to perform a history and physical exam.

- Perform patient assessments.
- Acquire and analyze data obtained using ultrasound and related diagnostic technologies.
- Provide a summary of findings to the physician to aid in patient diagnosis and management.
- Use independent judgment and systematic problem-solving methods to produce high quality diagnostic information and optimize patient care.

Requirements

In the United States (U.S.) at present, there is no licensure requirement to perform vascular examinations. However, in most states, in order to bill for and obtain reimbursement under the Medicare system, the person performing the examination is required to be credentialed in vascular technology or be practicing in an accredited facility.

Examples of credentialing organizations and credentials include:

- The American Registry of Diagnostic Medical Sonographers (ARDMS)
  - Registered Vascular Technologist (RVT) credential
- Cardiovascular Credentialing International (CCI)
  - Registered Vascular Specialist (RVS) credential

Examples of accrediting organizations include:

- The Intersociatal Commission for the Accreditation of Vascular Laboratories (ICAVL)
- The American College of Radiology (ACR)

Table 1 Credentialing and Accreditation

Credentialing Organizations	Accreditation Organizations
ARDMS RVT	ICAVL
CCI RVS	ACR

Consumer Assurance of Radiologic Excellence (CARE) Bill – 2007

There is a significant effort currently underway by a large coalition of organizations, including SVU, to create licensure for all medical imaging. This includes all ultrasound testing and technologies. The consumer assurance of radiologic excellence bill is currently before both the U.S. House and Senate. The outcome of this effort is still uncertain.

Patient Communication

Many times when a patient enters the laboratory, they are not exactly sure about what type of procedure they are going to have. It is very important to communicate effectively the exact nature of the exam. This ensures both patient comfort and your ability to obtain a quality test.

- Introduce yourself.
- Explain the procedure to the patient, taking care to ensure that the patient understands the necessity for each aspect of the evaluation.
- Respond to questions and concerns about any aspect of the evaluation.
- Take the opportunity to provide patient education about risk factors for, and symptoms of, peripheral arterial disease.
- Refer specific diagnostic, treatment, or prognosis questions to the patient's physician.

- Allow the patient to talk – "Why are you here?"
  - Then ask more specific questions.
- Ask the patient if they have had any vascular operations. If so, check operation notes.
- Observe the patient to determine their ability to understand and tolerate the procedure.
- Possibly prepare to "customize" the exam.

Risk Factors for PAD – What to Ask and Record

- Family history of coronary artery disease (CAD), PAD, and/or cerebrovascular accident (CVA)?
- Personal history of CAD, myocardial Infarction (MI)?
- Known arterial disease?
- Stroke?
- Diabetes?
- Hypertension?
- Hyperlipidemia?
- Tobacco abuse?
- Medication list? This is important!

Mild Disease

- Possibly asymptomatic.
- Normal or slightly decreased pedal pulses.
- Bruit (abnormal sound heard over a blood vessel).
- With exercise, a decrease in ankle pressure may be experienced.

Moderate Disease

- Asymptomatic at rest.
- Claudication with exercise.

Claudication – "To Limp"

- With exercise, progressive pain in the calf, thigh, buttock, or hip.
- Location dependent upon the location of the offending lesion(s).
- Relieved by rest.
- Very consistent onset and severity.

Medical Rule #1

There will always be a blood pressure drop when a person experiences the pain of true **vasculogenic** claudication!

Severe Disease

- Ischemic rest pain.
- Ulceration.
- Tissue necrosis.
- Gangrene.

Patient History

Symptoms

Claudication:

- Where does it hurt?
- When does it hurt?
- After walking what distance (feet, blocks, miles) does it hurt?
- When were the initial onset of symptoms (SX)?
- Have the symptoms become progressively worse?
- Do you have good days and bad days?
  - This is a very important question to ask. For patients that have other conditions that result in leg pain, the pain is likely to be variable. In contrast, patients with vasculogenic claudication experience the pain every time they walk.

Physical Exam

- Inspect (look).
- Auscultate (listen).
- Palpate (feel).

What to Look for and Palpate

- Hair
- Toe nails
  - Thickened and cracked.
- Dependent rubor (reddish discoloration)
- Ulceration, tissue necrosis, gangrene

- Blue toe – trash foot (history)
  - Microemboli lodged in the toes often after cardiac surgery or aortic aneurysm.
- Capillary refill times
- Cold foot
- Bruits (abdominal, femoral, carotid)
- Reduced pulses
- Common femoral artery (CFA), popliteal artery (POP), posterior tibial artery (PTA), dorsalis pedis artery (DPA)
- Palpable pulses rating: 0 to 3
  - This scale can be equated to: absent, diminished, or easily palpable pulses.
- Bilateral brachial blood pressures

Arterial Pathology

- Atherosclerosis (ASO)
  - Also known as occlusive disease, this it the number one reason to evaluate a patient.
- Thrombosis
  - Preceded by ASO.
  - Sudden onset or increase in symptoms.

Thrombosis is the final event as the artery becomes increasingly more narrow through atherosclerosis.

NOTE: Please review the video portion of this program. Mr. Schroedter presents techniques for physical examination as well as images of dependent rubor, dry scaly skin, ulcerations, and the other physical presentations typically seen in patients with PAD.

Notes:

The 5 P's

- Pain
- Pallor
- Pulselessness
- Parasthesia
- Paralysis

Sixth symptom:

- Poikilothermia

It is common in the field of vascular ultrasound to hear of the "5 P's" when reviewing the symptoms of peripheral vascular disease; however, there is actually a sixth symptom. The sixth "P" listed above, poikilothermia, is defined as cool skin or a cold foot. This condition is a vascular emergency of acute onset and is a symptom of an acute occlusion of a major blood vessel that either severely diminishes or completely occludes the blood flow to the limb.

NOTE: Mr. Schroedter intended to say poikilothermia, not poikiloderma.

Questions to Ask the Patient with a Leg Ulcer

- What started the ulcer?
- How quickly did the ulcer develop?
- At first, what was the appearance of the ulcer?
- What is the patient's family history?
- How painful is the ulcer?
- What drugs has the patient taken?
- Is there a history of other systemic disorders?

Addendum Physical Exam for a Patient with a Leg Ulcer

- All the observations previously mentioned for both arterial and venous disease!
- Where is the ulcer?
- What is the size of the ulcer?
- What is the condition of the surrounding skin?
- Are there signs of other systemic diseases?

Other Arterial Pathology

- Buerger's disease – small vessel thrombosis
- Raynaud's syndrome – small vessel vasospasm
- Arterial venous fistulas (AVF)
- Arteritis
- Popliteal entrapment:
  - Extrinsic compression of popliteal artery in young athletes.

Basis of Physiologic Testing

Hemodynamics

Flow in peripheral arteries is largely regulated by vasoconstriction or vasodilatation in the arterioles. These vessels are lined with vascular smooth muscle that can constrict or dilate. In a normal resting condition, the arterioles are constricted. Upon Doppler examination, vessels at rest yield a high resistance waveform. With exercise, the muscles require more blood, therefore the vessels dilate to facilitate greater blood flow. After exercise, the vessels will display a low resistance waveform upon Doppler examination.

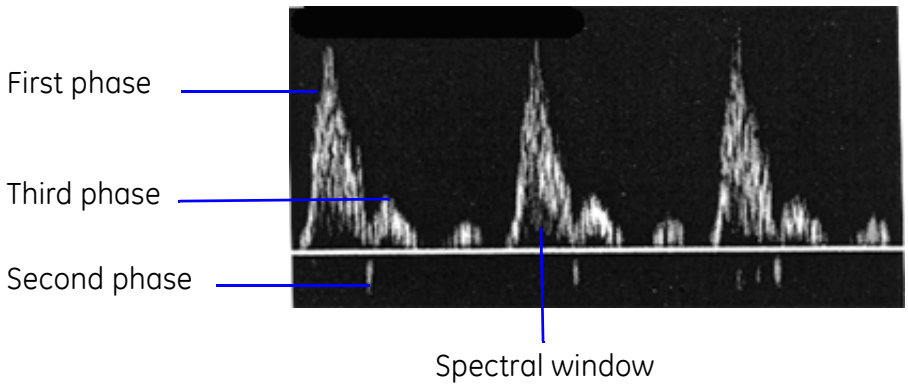
Waveforms

The waveforms obtained upon Doppler examination form the basis of physiologic testing. There is some misunderstanding about a normal triphasic waveform. The phase is defined when the wave crosses the baseline (Figure 1).

- Systole is represented by the sharp upstroke of the first phase.
- Systolic reversal is represented in the second phase.
- Forward flow in diastole is represented in the third phase.
- The spectral window represents the uniformity of the blood flow within the sample volume.

NOTE: In the video segment of this program, Mr. Schroedter mistakenly referred to the "spectral waveform" when indicating the spectral window.

Figure 1 Normal Triphasic Waveform



Normal lower extremity arterial flow typically demonstrates a rapid systolic upstroke in early systole, rapid decleration in mid systole, followed by a hydraulic reflection in late systole (second phase, Figure 1). This is followed by forward flow. The degree of forward flow is dependent upon the elasticity of the blood vessels. Older patients that have some degree of calcification in the blood vessels will lose elasticity.

Stenosis

Bernoulli's principle best illustrates the flow characteristics in stenotic vessels. Flow is equal to the velocity (V) multiplied by the area (A). The effect is that when the area of the lumen is decreased by a stenotic lesion, the velocity of the blood must increase.

Bernoulli's principle:
$$Q = V \times A$$
Flow = velocity x area

After the blood passes the lesion, flow becomes turbulent, as energy is lost through heat in that area. These principles are identified in the study of hydrodynamics. In the study of hemodynamics, additional complexities must be considered, including the elasticity of the vessel, the variables of peripheral resistance, the volume of flow, length of the stenosis, and the geometry of the residual lumen.

- **Borderline hemodynmically significant** – lesions demonstrate some flow acceleration through the stenosis, uniform flow beyond the stenotic area, and little or no vasodilatation in the arterioles.
- **Hemodynamically significant** – refers to lesions that have reduced the lumen of the vessel by greater than 60%. These lesions present quite a different flow pattern. In these lesions, significant increase in the velocity across the lesion and markedly disturbed blood flow down stream from the lesion are observed. However, when the patient is at rest, there is still no significant dilatation of the arterioles. Dilatation can be observed following exercise.
- **Severe disease, or collateralized occlusion** – presents with dilated arterioles distal to the occlusion. The Doppler signal demonstrates flow throughout the cardiac cycle. Additionally, the waveform demonstrates a dampened upstroke during systole, as well as significant flow during diastole. This phenomenon is known as a monophasic waveform.
- **Very severe disease, or poorly collateralized occlusions** – there can be significant vasodilatation coupled with insufficient diastolic pressure to maintain flow. This results in a waveform indicating little or no diastolic flow.

Physiologic Testing

Please enjoy Mr. Schoredter's video discussion of physiology testing. To maintain a manageable file size for downloading purposes, reproduction of the numerous graphics used to explain physiologic testing have been omitted from this document.

Physiologic Testing Perspectives

- Well documented.
- Reproducible.
- Short learning curve.
- Lower equipment cost.
- Quick to interpret.
- Presence of disease.
- Severity of disease.
- Functional impairment:
  - What is causing the symptoms? This test allows you to determine, with a very high degree of certainty, that a lack of blood flow is causing the symptoms.
- Very useful in diabetics.
- Medial calcinosis.
- Digit measurements.
- Healing potential.

Physiologic Tests

- Doppler waveform analysis
- Plethysmography:
  - Pulse volume recording (PVR)
  - Photoplethysmography (PPG)
- Pressure assessment
- Ankle brachial index (ABI) and/or segmental pressures
- Exercise testing

Single Level or Multiple Levels

- Single – generally for the ankle.
  - A quick method to determine presence and relative severity of disease.
- Multiple – two or more levels.
  - Can determine presence and severity of disease.
  - Can determine region of disease.

Continuous Wave (CW) Doppler Analysis

- Advantage:
  - Able to display extremely high velocities.
- Disadvantage:
  - Poor range resolution.
    - Many times arterial and venous signatures can be heard in the same returning signal.

Technique

- Patient resting in basal state.
- Warm room.
- CW Doppler – 4 to 8 megahertz (MHz).
- Angle of insonation – 45 to 60 degrees.
- Obtain waveforms from CFA, superficial femoral artery (SFA), popliteal artery, DPA, and PTA.

Doppler Waveform Analysis

- Normal – triphasic or biphasic.
  - Rapid systolic upstroke.
  - Late systolic flow reversal.
- Abnormal – monophasic.
  - Loss of triphasic waveform.
  - Decrease in amplitude.
  - Dampened upstroke.

Limitations

- Poor quality signals.
  - Limb edema.
  - Obesity.
  - Scar tissue.
  - Occluded artery.
  - Poor technique.

- Venous interference (averaged signal).
- Requires a lot of skill.

Advantages

- Provides information about flow in specific arteries.
- Demonstrates flow changes caused by disease.

Plethysmography

Arterial plethysmography is defined as the measurement of volume changes in a limb or organ.

- Pulse volume recording (PVR)
- Photoplethysmography (PPG)
  - Assessment of digit perfusion.

Pulse Volume Recording (PVR)

- Measures volume changes in limb during systole.
- Air is displaced within a cuff.
- Volume of displaced air is displayed as waveform.

PVR Caveats

- Thigh PVR is primarily related to profunda femoris artery perfusion, and to a much lesser extent, the superficial femoral artery.
- Calf waveforms reflect blood flow in the SFA-popliteal segment.

PVR Advantages

- Easy to learn and to perform.
- Quick to interpret.
- Assessment of global limb perfusion.
- Metatarsal and toe evaluation.
- Not affected by calcified arteries.

PVR Limitations

- Subjective assessment.
- Not quantitative.
- Disease difficult to discern in presence of proximal occlusion.
- Tremor or movement may distort waveforms.

Photoplethysmography (PPG) Assessment

- Light transmission into tissue.
- Reflection dependent upon absorption, which varies with perfusion PPG assessment.
- Beat-to beat variation of reflected light.
- Provides a waveform of digit perfusion.
- Used to detect return of flow for pressure determination.
- Can also provide information about flow state.
- Digits or segmental pressures.

Table 2 Photoplethysmography Waveform Interpretation

Normal	Mild	Moderate	Severe
• Rapid upstroke. • Dicrotic notch.	• Dampened upstroke. • Loss of dicrotic notch.	• Dampened upstroke. • Rounded crest. • No dicrotic notch.	• Flattened.

Pressure Assessment – Ankle Brachial Index (ABI) and/or Segmental Pressures

Principles of Pressure Analysis

- For a normal individual in a supine position, ankle systolic pressure is greater than or equal to brachial.
- Patient must be in a resting, basal state.

The Ankle Brachial Index (ABI)

- Ankle pressure divided by the higher brachial pressure.
- Report either both or the highest ankle pressure for reported ABI.

Doppler Sites for ABI

- Dorsalis pedis
- Posterior tibial

Resting ABI Values

- Greater than 1.0: normal (usually).
- Less than 0.96: abnormal.
  - If borderline, have patient exercise.
- Less than 0.8: probable claudication.
- Less than 0.5: multi-level disease or long segment occlusion.
- Less than 0.3: ischemic rest pain.

ABI Values: Exception for Normals

- Brachial systolic pressure below 100 millimeters of mercury (mmHg) or above 200 mmHg:
  - Ankle pressure may be 25% lower than brachial pressure

Segmental Limb Pressures

- Compare to contralateral limb.
- Compare to adjacent segments.
- A 20 mmHg or greater pressure gradient (drop) is significant in the presence of an **abnormal ABI**.
- Can determine region of disease.

Segmental Pressure Sites

- High thigh
- Low thigh (for 4 cuff)
- Upper calf
- Ankle
- Great toe
- Metatarsals
- All digits

3 Cuff vs. 4 Cuff

- **3 cuff method** – 17 centimeter (cm) thigh cuff; two 10 cm cuffs placed below the knee.
  - If abnormal, cannot differentiate aorta or iliac disease from femoral artery disease.
- **4 cuff method** – two 12 cm thigh cuffs; two 10 cm cuffs placed below the knee.
  - Upper thigh cuff pressure artifact (20 mmHg).
  - Can often differentiate iliac from femoral disease.

Cuff Placement – Especially for Pulse Volume Waveforms

- Evenly spaced.
- Uniformly snug.
- Tapered legs.
- Cuff pressure is approximately 60 mmHg.
- Note cuff volume.
- Rule of thumb: less than 15% difference between cuff volumes.
- Extra time spent in good cuff placement pays dividends in clean artifact-free waveforms.

Pressure Advantages

- Quantitative information on limb perfusion.
- Easy to perform.
- Substantial clinical validation.

Pressure Limitations

- Calcified arteries:
  - Diabetic patients.
  - End stage renal disease (ESRD) patients.
  - Chronic steroid therapy patients.
- Segmental pressures unobtainable or excessively high (ABI greater than 1.2).
  - Calcification of vessels may prevent compression.

Toe Brachial Index (TBI)

- Normal: greater than 0.75.
- Abnormal: less than 0.66.
- Less than 30 mmHg: poor healing potential.

Exercise Stress Testing

- Differentiate true vascular claudication from "pseudo-claudication."
  - Patients with arthritis or neuro-spinal compression may demonstrate exertional leg pain.
- Differentiate borderline normal from abnormal.
- In patients with combined neuropathy and vascular disease, determine which condition limits the ability to walk.

Who Should Be Exercised?

- Intermittent claudicators.
- ABI 0.85 to aproximately 0.4.
- If resting study is normal, but patient is symptomatic, exercise.
- Borderline normal ABI.

Treadmill Exercise Testing

- Treadmill speed: 1.5 or 2 miles per hour (mph).
- Ten percent grade.
- Five minutes is the standard walking time, or until patient is unable to continue.
- Post exercise ankle pressures – as soon as possible and monitor per protocol.

Contraindications for Treadmill Exercise

- Questionable cardiac status.
- Resting ischemia (ABI less than 0.3)
- Ischemic ulceration.
- Poor ambulators.
- If symptoms occur only at rest and resting study is normal.

Vasculogenic Claudication Criteria

- A drop in ankle pressure or a pressure of greater than 20 mmHg confirms vascular etiology for claudication.
- The larger the drop, the longer the return to baseline; corresponds to lesion severity.

Post Occlusive Reactive Hyperemia

- Occlude distal thigh: three minutes.
- Occlusion pressure: 20 mmHg above limb pressure.
- Record post occlusion ankle pressure.
- Painful exam.
- Poor patient acceptance.

Toe Raises

- Toe raises for one minute.
- Note patient symptoms.
- Post exercise pressures.

Ambulation

- Simulates “real world” symptomatology.
- Observe patient (“neurogenic shuffle”).
- Record distance/time and effort.
- Post exercise pressures.

Physiologic Testing Limitations

- Detects only hemodynamically significant disease (greater than 60% stenosis) (i.e., symptomatic disease).
- Usually cannot distinguish stenosis from occlusion.
- Detects region, but not site of disease.

Indirect Test Advantages

- Comparably "easy" to perform.
- Technically reproducible.
- Quantifiable data on the "effect of disease."
- Extensively validated.

Protocols

- Protocols are generally institutional specific.
- Decided on by the lab, based on their specific needs and testing goals.
- Modern instruments are highly programmable.
- Multiple protocols can be programmed.
- Specific protocol based on order and patient presentation.
- Can generally be changed "on the fly."

Suggested Protocol

- Obtain patient history – perform limited physical exam, obtain femoral pulses.
- ABIs with Doppler, using the pedal vessel with strongest signal.
- Perform PVRs at ankle, calves, above knee and thighs bilaterally.
- If study is mildly abnormal or questionable, exercise!
- If study is normal and exercise unwarranted, end exam.

Case Studies

NOTE: Please enjoy case studies presented by Mr. Schroedter.

Notes:

Physiologic Testing Conclusions

- Cost effective, efficient method to assess lower extremity arterial system.
- Determines presence of PAD.
- Determines severity of disease.
- Determines whether patient's symptoms are due to arterial disease or other cause.

SVU Vascular Technology Professional Performance Guidelines

Pages 24 to 29 of this program supplement contain the "Vascular Technology Professional Performance Guidelines – Upper Extremity Arterial Segmental Physiologic Evaluation" article published by the Society for Vascular Ultrasound.

NOTE: The duplication of the guideline is made with the written permission of the Society for Vascular Ultrasound.

SOCIETY FOR VASCULAR ULTRASOUND

VASCULAR TECHNOLOGY
PROFESSIONAL PERFORMANCE GUIDELINES

Upper Extremity Arterial Segmental Physiologic Evaluation

This Guideline was prepared by members of the Society for Vascular Ultrasound (SVU) as a guide to aid the vascular technologist/sonographer and other interested parties. It implies a consensus of those substantially concerned with its scope and provisions. This SVU guideline may be revised or withdrawn at any time. The procedures of SVU require that action be taken to reaffirm, revise, or withdraw this guideline no later than three years from the date of publication. Suggestions for improvement of this guideline are welcome and should be sent to the Executive Director of the Society for Vascular Ultrasound. No part of this guideline may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

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Society for Vascular Ultrasound
4601 Presidents Drive, Suite 260
Lanham, MD 20706-4831
Tel.: 301-459-7550
Fax: 31-459-5651
E-mail: svuinfo@svunet.org
Internet: www.svunet.org

Upper Extremity Arterial Segmental Physiologic Evaluation

PURPOSE

Arterial segmental pressure and waveform evaluations are performed to evaluate the upper extremity arteries to determine the presence, severity, and location of arterial occlusive disease or absence of pathology.

COMMON INDICATIONS

Some of the more common indications for performance of arterial segmental pressures and waveforms include, but are not limited to:

- Arterial insufficiency
- Thoracic Outlet Syndrome (TOS)
- Raynaud's Disease
- Ischemic ulcer
- Limb ischemia

Upper extremity arterial segmental pressure and waveform evaluations are also performed as follow-up of patients with known peripheral artery disease or an arterial intervention of the upper extremity.

CONTRAINDICATIONS AND LIMITATIONS

Functioning dialysis access graft

- Patients with suspected or know acute deep venous thrombosis (DVT).
- Recent surgery, ulcers, casts or bandages on the upper extremity that cannot or should not be compressed by cuff
- Patients with incompressible vessels
- Patients who are post upper extremity interventional procedure, i.e., dialysis access graft, stent, arterial bypass graft, segmental pressures may be contraindicated.

GUIDELINE 1: PATIENT COMMUNICATION AND POSITIONING

1.1 Introduces self and explains why the Upper Extremity Arterial Segmental Physiologic Evaluation is being performed and indicates how long it will take.

1.2 Explains the procedure to the patient, taking care to ensure that the patient understands the necessity for each aspect of the evaluation.

1.3 Responds to questions and concerns about any aspect of the Upper Extremity Arterial Segmental Physiologic Evaluation.

1.4 Educates patients about risk factors for and symptoms of peripheral arterial disease.

1.5 Informs patients about necessary life style changes due to peripheral arterial disease.
Refers specific diagnostic, treatment or prognosis questions to the patient's physician.

1.6 The patient should have rested for at least 15 minutes

1.7 Patients are supine for segmental pressures and Doppler waveforms. Patients are in a seated position with the hands resting on the knees, palm up.

GUIDELINE 2: PATIENT ASSESSMENT

Patient assessment must be performed before the Upper Extremity Arterial Segmental Physiologic Evaluation is performed. This includes assessment of the patient's ability to tolerate the procedure and an evaluation of any contraindications to the procedure.

2.1. Obtains a complete, pertinent history by interview of the patient or patient's representative and review of the patient's medical record. A pertinent history includes:

- a. Current medical status
- b. Previous vascular/cardiovascular surgeries
- c. Current medications or therapies
- d. Presence of any risk factors for arterial disease: diabetes; hypertension; peripheral vascular disease; coronary artery disease; family history of arterial disease, coronary artery, or vascular disease; family history of diabetes or hypertension; age; smoking; job description; sclerodermal condition.
- e. Presence of any symptoms of peripheral arterial disease: limb ischemia; skin changes; bruits.

2.2 When directed, perform adjunctive procedures: auscultation of bruits (carotid, orbital, subclavian); palpation of pulses (brachial, radial, carotid, facial); Allen's Test.

2.3 Verify that the requested procedure correlates with the patient's clinical presentation.

GUIDELINE 3: EXAMINATION GUIDELINES

Throughout each exam, characteristics of normal and abnormal waveform and segmental pressures must be observed so that the testing technique can be adjusted as necessary. The patient's physical and mental status is assessed and monitored during the examination, with modifications made to the procedure plan according to changes in the patient's clinical status during the procedure. Also, segmental pressure and waveform findings are analyzed throughout the course of the examination to ensure that sufficient data is provided to the physician to direct patient management and render a final diagnosis.

3.1 Use appropriate instrumentation, which includes a display of the Doppler or plethysmographic waveforms and segmental pressure measurements:
   a. Waveform output and display capabilities
   b. Doppler carrier frequency of at least 5.0 MHz
   c. Doppler carrier frequency of at least 8.0 MHz
   d. Hardcopy paper, film or digital storage capabilities

3.2 Follow a standard exam protocol for each upper extremity. Physiological waveform analysis is typically Doppler or air plethysmography in origin. Segmental waveform and pressure information is used to identify the presence, absence, location and the severity of disease.
   a. Doppler Waveforms: At least three representative Doppler waveforms are recorded in the brachial, radial and ulnar arteries. All Doppler waveforms must be performed at a 45-degree angle to the skin or area being insonated. At least three representative waveforms should be obtained at all levels. Gain settings should be standardized.
      1. Audio interpretation of the signals should attempt to classify the signals as triphasic, biphasic, or monophasic.
   b. Air Plethysmography Waveforms: At least three representative air plethysmography waveforms must be obtained at the upper arm and forearm. Standardized inflation pressures must be used in all pulse volume cuffs. Gain settings should be standardized.
   c. Systolic segmental pressures should be recorded at the brachial, radial and ulnar arteries, bilaterally. The radial or ulnar with the greatest pressure is used to take the arm pressure measurements.

3.3 Additional waveform and/or pressure analyses may include the palmer arches, subclavian, axillary and digital arteries. Gain settings should be standardized.

3.4 When testing for Thoracic Outlet Syndrome (TOS), a photophethysmography (PPG) cell is attached to the index fingers bilaterally and an Adson's, Costoclavicular and Hyperabduction maneuver(s) is performed, bilaterally. Gain settings and chart speed should be standardized.

3.5 When testing for Vasospastic Disease, PPG waveforms and/or digital surface temperatures are obtained from all (1-5) digits, bilaterally at room temperature and following digital immersion in iced water for two minutes. PPG gain settings and chart speed should be standardized.

3.6 To determine any change in follow-up studies, review previous exam documentation so that the current evaluation can document a change in status. The examination protocol may need to be modified to address previous findings and current physical needs.

GUIDELINE 4: REVIEW OF THE DIAGNOSTIC EXAM FINDINGS

4.1 Review data acquired during the Upper Extremity Arterial Segmental Physiologic Evaluation to ensure that a complete and comprehensive evaluation has been performed and documented.

4.2 Explain and document any exceptions to the routine Upper Extremity Arterial Segmental Physiologic Evaluation protocol (i.e., study limitations, omissions or revisions).

4.3 Record all technical findings required to complete the final diagnosis on a worksheet, logbook or other appropriate form so that the measurements can be classified according to the laboratory diagnostic criteria (based on published or internally validated data).

4.4 Document exam date, clinical indication(s), technologist performing the evaluation and exam summary in a laboratory logbook or other appropriate method, i.e. computer

software.

4.5 Alert the vascular laboratory Medical Director or appropriate health care provider when immediate medical attention is indicated based on the Upper Extremity Arterial Segmental Physiologic Evaluation findings.

GUIDELINE 5: PRESENTATION OF EXAM FINDINGS

5.1 Provides preliminary results when necessary as provided for by internal guidelines based on the Upper Extremity Arterial Physiologic Evaluation findings.

5.2 Presents record of data, explanations, and technical worksheet to the interpreting physician for use in rendering a diagnosis and for archival purposes.

GUIDELINE 6: EXAM TIME RECOMMENDATIONS

High quality and accurate results are fundamental elements of the Upper Extremity Arterial Segmental Physiologic Evaluation. A combination of indirect and direct exam components is the foundation for maximizing exam quality and accuracy.

6.1 Indirect exam components include pre-exam procedures: obtaining previous exam data; completing pre-exam paperwork; exam room and equipment preparatory activities; patient assessment and positioning (Guideline 1 & 2); patient communication (Guideline 2); post-exam activities: exam room cleanup; compiling, reviewing and processing exam data for preliminary and/or formal interpretation (Guidelines 4-5); and, patient charge and billing activities. Recommended time allotment is 30 minutes.

6.2 Direct exam components include equipment optimization and the actual hands-on, examination process (Guideline 3). Recommended time allotment is 35-45 minutes.

GUIDELINE 7: CONTINUING PROFESSIONAL EDUCATION

Certification is considered the standard of practice in vascular technology. It demonstrates an individual's competence to perform vascular technology at the entry level. After achieving certification, all Registered Vascular Technologists (RVTs) must keep current with:

7.1 Advances in diagnosis and treatment of peripheral arterial disease.

7.2 Changes in Upper Extremity Arterial Segmental Physiologic Evaluation protocols or published laboratory diagnostic criteria.

7.3 Advances in ultrasound technology used for the Peripheral Arterial Evaluation.

7.4 Advances in other technology used for the Peripheral Arterial Evaluation.

APPENDIX

It is recommended that published or internally generated diagnostic criteria should be validated for each ultrasound system used. When validating ultrasound diagnostic criteria, it is important to realize that equipment, operator and interpretation variability is inherent to this process.

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5. Zwiebel, William J. *Introduction to Vascular Ultrasonography, 3rd Edition*. Philadelphia: W.B. Saunders, 1992

Appendix A: Presenters

Joe Morton, MBA, R.T. (R), RDMS
Ultrasound TiP-TV Program Manager
Ultrasound/MR TiP-TV Program Manager
GE Healthcare

William B. Schroedter, B.S., RVT, FSVU
Vice President/Technical Director
Quality Vascular Imaging, Inc.
Venice, Florida

Appendix B: Resources

Electronic Resources

American College of Radiology: http://www.acr.org

American Heart Association: http://www.americanheart.org

American Institute of Ultrasound in Medicine: http://www.aium.org/

American Registry of Diagnostic Medical Sonographers: http://www.ardms.org

American Society of Radiologic Technologists: http://www.asrt.org

Medcyclopaedia: http://www.medcyclopaedia.com

National Institutes of Health: http://www.nih.gov

Radiological Society of North America: http://www.rsna.org

Society for Vascular Ultrasound: http://www.svunet.org

NOTE: The Internet is an ever-evolving environment and links are subject to change without notice.

Appendix C: Post-Test

LMS Course Number: 3325

To be eligible for CE credit, you MUST view the video presentation first. Then complete the post-test on the GE Healthcare Learning System **(hls.gehealthcare.com)** by the due date listed online.

1. Predicted mortality for patients with symptomatic PAD are approximately _____% at 10 years.
   a. 40
   b. 50
   c. 60
   d. 70
2. PAD affects aproximately _____% of the Western population older than 65 years.
   a. 5
   b. 7
   c. 10
   d. 12
3. The aorta descends in the abdomen to the level of the umbilicus, where it divides (bifurcates) into the right and left _____ arteries.
   a. hypogastric
   b. brachial
   c. common femoral
   d. common iliac
4. The profunda femoris artery is the primary blood supply to the _____.
   a. thigh
   b. lower leg
   c. abdominal viscera
   d. groin
5. Which of the following is NOT considered a risk factor for PAD?
   a. stroke
   b. arthritis
   c. smoking
   d. diabetes
6. Patients with mild or moderate PAD may present which symptom?
   a. ulceration
   b. ischemic rest pain
   c. asymptomatic at rest
   d. gangrene
7. Palpable pulses can be rated on a scale of _____ to _____.
   a. 1; 8
   b. 1; 4
   c. 0; 5
   d. 0; 3

8. _____ is a symptom of an acute occlusion of a major blood vessel that either severely diminishes or completely occludes the blood flow to the limb.
   a. Poikilothermia
   b. Pallor
   c. Pain
   d. Pulselessness
9. The waveforms obtained upon Doppler examination form the basis of _____ testing.
   a. Doppler
   b. physiologic
   c. radiologic
   d. sonographic
10. What additional complexities do NOT need to be considered when studying the hemodynamics of blood flow through a stenotic region?
    a. Elasticity of the vessel.
    b. Variables of peripheral resistance.
    c. Age of the patient.
    d. Length of the stenosis.
11. The advantages of continuous wave Doppler include _____.
    a. ability to locate the lesion
    b. excellent range resolution
    c. ability to display high velocities
    d. direct imaging capabilities
12. Arterial plethysmography is defined as the measurement of a(n) _____ change in a limb or organ.
    a. electrostatic
    b. arthritic
    c. capacity
    d. volume
13. _____ uses the principle of light transmission into tissue.
    a. Photoplethysmography
    b. Segmental pressure study
    c. Pulse volume recording
    d. Continuous wave Doppler
14. A patient with an ankle brachial index of less than 0.8 will also present with probable _____.
    a. ischemic rest pain
    b. claudication
    c. multi-level disease
    d. long segment occlusion
15. All of the following conditions may present with calcified arteries, EXCEPT_____.
    a. diabetes
    b. end stage renal disease (ESRD)
    c. long history of oral contraceptive usage
    d. chronic steroid therapy

16. A suggested protocol for treadmill exercise testing includes a _____ minute walking time, or until patient is unable to continue.
    a. 20
    b. 15
    c. 10
    d. 5
17. In order to properly perform initial pressure analysis studies, the patient must be _____.
    a. in a resting, basal state
    b. post exercise
    c. sedated
    d. asked to do toe lifts
18. Ambulation rather than treadmill testing _____.
    a. causes the patient greater discomfort
    b. simulates real world symptomatology
    c. takes much longer to perform
    d. always induces claudication
19. A toe brachial index of greater than _____ is generally considered normal.
    a. 0.30
    b. 0.55
    c. 0.65
    d. 0.75
20. Post occlusive reactive hyperemia is _____.
    a. a painful exam
    b. a method of choice for claudicators
    c. widely used
    d. highly accepted by the patient population