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**VASCULAR TECHNOLOGY  
PROFESSIONAL PERFORMANCE GUIDELINES**

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# Upper Extremity Arterial Physiologic Evaluations

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## PURPOSE

Segmental pressures, pulse volume recordings and Doppler waveform analysis are performed to evaluate upper extremity arteries to determine the presence, severity and location of arterial occlusive disease.

## COMMON INDICATIONS

Common indications for performance of arterial segmental pressures and waveforms include, but are not limited to:

- Bruit
- Arterial insufficiency
- Post-operative thoracic endograft repair with aortic debranching.
- Upper extremity revascularization procedures
- Thoracic Outlet Syndrome (TOS)
- Vasospastic Disease
- Ischemic ulcer
- Limb ischemia/ Digital ischemia
- Raynaud's Syndrome
- Abnormal vertebral artery waveform is found when assessing for extracranial cerebrovascular disease.
- Pre-operative assessment for hemodialysis access or radial artery harvest for coronary artery bypass graft (CABG)

## CONTRAINDICATIONS AND LIMITATIONS

- Functioning dialysis access graft (no pressure assessment)
- Suspected or known acute deep venous thrombosis (DVT)
- Recent surgery, ulcers, casts or bandages of the upper extremity that cannot be removed for the exam.
- Non-compressible vessels
- Post-operative upper extremity interventional procedure, i.e., dialysis access graft, stent, arterial bypass graft and segmental pressures may be contraindicated
- Patient's inability to cooperate with the examination

## PATIENT COMMUNICATION

Prior to beginning the exam, the sonographer or examiner should:

- Introduce themselves, explain why the examination is being performed and indicate how much time the examination will take.
- Verify the patient's name and date of birth or utilize facility-specific patient identifiers.

- Explain procedure, taking into consideration the age and mental status of the patient and ensure that the necessity for each portion of the evaluation is understood.
- Respond to questions and concerns about any aspect of the evaluation.
- Educate the patient about risk factors for and symptoms of peripheral arterial disease.
- Refer specific diagnostic, treatment or prognosis questions to the patient's physician.
- The patient should have rested for at least 15 minutes before beginning exam.

## **PATIENT ASSESSMENT**

A patient assessment must be performed before the evaluation. This includes an assessment of the patient's ability to tolerate the procedure, an evaluation of any contraindications to the procedure and a physical assessment of bilateral arms, hands, and fingers. The sonographer or examiner should obtain a complete, pertinent history and a review of the patient's medical record, if available. A pertinent history includes:

- Previous vascular/cardiovascular surgeries
- Current medications or therapies
- Risk factors for arterial disease:
  - Diabetes,
  - Hypertension
  - Hyperlipidemia
  - Coronary artery disease
  - Age
  - Smoking history
  - Connective Tissue Disease such as Scleroderma, Systemic Lupus Erythematosus, and CREST syndrome.
- Type of job/hobby (especially if the examination is for TOS or arm/hand trauma).
- Results of previous vascular studies
- Physical assessment of arms, hands, and fingers for symptoms of limb ischemia, skin changes (including duration, location, and whether it is persistent or episodic) and ulcers.

A complete assessment should guide the sonographer to:

- Verify that the procedure ordered correlates with the patient's clinical presentation.
- Determine if supplemental procedures are necessary: positional stress test or cold challenge
- Perform adjunctive procedures according to the laboratory-specific protocol: auscultation of bruits, palpation of pulses and/or Allen's test.

## **PATIENT POSITIONING/PREPARATION**

The optimal position and preparation for performing an upper extremity arterial segmental physiologic evaluation includes the following:

- The extremities positioned at approximately the same level as the heart. The exam is typically performed with the patient in supine position. Position can be altered when performing supplemental procedures.
- The examiner should be as close to the examined extremity as possible to allow for proper ergonomics.
- Performed in a warm room to reduce vasoconstriction.

## INSTRUMENTATION

Non-invasive physiologic studies require separate and distinct equipment from the Duplex ultrasound scanner. Instrumentation must allow the display and permanent recording of pressures with bi-directional Doppler analysis of blood flow, plethysmography and/or oxygen tension measurements.

- Continuous wave (CW) Doppler must provide:
  - Doppler frequencies appropriate for vessels examined
    - Typically range from 4 to 10 MHz
  - Direction sensitive Doppler blood flow meter
  - Doppler waveform display with bi-directional flow capabilities
  - Audible output and permanent recording of Doppler waveforms
- Segmental limb plethysmography must provide:
  - Equipment capable of measuring small segmental volume changes and making permanent recordings of blood pressure measurements
  - Blood pressure cuffs of various sizes for each limb segment and digit evaluated
    - The recommended size is 20% wider than the limb diameter
- Pulse volume plethysmography (PVR) must provide:
  - Equipment capable of measuring small limb volume changes and saving permanent PVR waveforms
  - Capability to be calibrated before each exam
  - Blood pressure cuffs of various sizes for each limb segment and digit evaluated
- Photoplethysmography (PPG) must provide:
  - Electrical sensor for signal display
  - Capable of providing a permanent recording of PPG waveforms

## EXAM PROTOCOL

Sonographers should follow a standard exam protocol for each upper extremity examination. A complete examination includes bilateral non-invasive physiologic studies (segmental pressures, bi-directional Doppler waveforms, and/or segmental volume plethysmography) of 3 or more levels. A

limited bilateral noninvasive physiologic study (segmental pressures, bi-directional Doppler waveforms, and/or segmental volume plethysmography) consist of 1-2 levels.

Throughout each examination, the sonographer should:

- Assess and monitor the patient's physical and mental status, allowing modifications to the procedure plan according to the patient's clinical status
- Analyze segmental pressure and waveform findings to ensure that sufficient data is provided to the physician to direct patient management and render a final diagnosis
- Analyze sonographic findings to ensure that sufficient data is provided to the physician to direct patient management and render a final diagnosis

***Continuous wave (CW) Doppler signals:***

- At least three representative CW Doppler waveforms are recorded from the brachial, radial and ulnar arteries, at an angle which optimizes the visual and audible signal.
  - When waveforms from the brachial level are abnormal, Doppler waveforms from the subclavian and axillary artery are recommended.
- Gain settings are optimized to display waveform characteristics
- Audio interpretation of the CW Doppler signals should attempt to classify the signals as triphasic, biphasic (unidirectional or bidirectional), or monophasic.

***Pulse Volume Recordings (PVR):***

- Blood pressure cuffs are placed at the mid portion of the arm and forearm and standardized inflation pressure is used in all pulse volume cuffs.
- Three representative waveforms are obtained at both levels
- Gain settings are optimized for appropriate amplitude

***Segmental Pressures:***

- Blood pressure cuffs are placed at the mid portion of the arm, wrist and/or forearm.
- CW Doppler is used to obtain segmental pressures at each level using the brachial, radial, and ulnar arteries respectively.
- A **wrist brachial index (WBI)** is calculated by dividing the highest wrist pressure from each limb by the highest brachial pressure.

***Digit waveforms and pressures:***

Additional information may be obtained to differentiate between large and small vessel disease.

- Digit waveforms and pressures are obtained using photoplethysmography sensors (PPG) and digit cuffs. PPG sensor is placed on the pad of each finger being evaluated.
- At least three representative waveforms should be obtained.
- Gain settings and chart speed should be optimized.
- Additional digit pressures and waveforms may be obtained based on patient's

clinical presentation or per laboratory specific protocol.

### ***Thoracic Outlet Test Method:***

- The examination can be performed using CW Doppler tracings from the radial or ulnar arteries, PVR of the arms, or a PPG sensor attached to a finger. When symptoms include the hand or digits, evaluation of these segments may be necessary.
- A resting baseline study followed by provocative maneuvers is performed according to laboratory-specific protocol.
- The protocol may be tailored according to position-related symptoms if not covered by laboratory-specific protocol.

### ***Cold Immersion Test:***

- Examination is performed using PPG sensors or VPR (volume pulse recording)
- A baseline study is performed prior to cold immersion. PPG/VPR waveforms and digit pressures are obtained from all digits bilaterally.
  - If the baseline is abnormal, cold immersion may not be necessary. Instead, warming of the affected hands may differentiate between vasospastic disease and occlusive arterial disease.
- Sonographers should follow laboratory-specific protocol in regards to:
  - The length of time for hand immersion
  - The time intervals at which waveform tracings are obtained post-cold immersion. Post-immersion digital pressure measurements may also be obtained in addition to waveforms.
- Waveform tracings and recovery time are monitored following cold immersion.
- Monitoring should continue for a minimum of 10 minutes (or longer per laboratory-specific protocol) for recovery times longer than 5 minutes.

## **REVIEW OF DIAGNOSTIC EXAM FINDINGS**

The sonographer or examiner should:

- Review data acquired during the upper extremity arterial physiologic evaluation to ensure a complete evaluation has been performed and documented.
- Explain and document any exceptions to the routine protocol (i.e., study limitations, omissions or revisions).
- To determine any change in follow-up studies, review previous exam documentation to document any change in status; and/or duplicate prior imaging and Doppler parameters.
- Record all technical findings required to complete the final diagnosis in the patient's medical record.
- Document exam date, clinical indications, sonographer performing the evaluation and exam summary in the patients' medical record.

## PRESENTATION OF EXAM FINDINGS

The sonographer or examiner should:

- Provide preliminary results when necessary as provided for by laboratory specific guidelines.
- Present record of diagnostic images, data, explanations, and technical worksheet to the interpreting physician. Interpretation must be available within two business days.
- The sonographer's and interpreting physician's names must appear on the final report. The finalized/signed report should be available within four business days.
- Alert the vascular laboratory medical director or appropriate healthcare provider when immediate medical attention is indicated based on departmental guidelines and procedures.

## EXAMINATION TIME RECOMMENDATIONS

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

- Indirect exam components include:
  - Pre-exam activities: obtaining previous exam data, initiating exam worksheet and paperwork, equipment and exam room preparation, patient assessment and positioning, and patient communication
  - Post-exam activities: exam room cleanup, compiling and processing exam data for preliminary and/or formal interpretation, and exam billing activities.
- Direct exam components include:
  - Equipment optimization and the actual hands-on, examination process
- While study times may vary depending on testing protocols, patient condition, and clinical complexity of the evaluation being performed, these are the times necessary to provide a quality diagnostic evaluation. Listed are the recommended examination times for performing each CPT related to this guideline, which were derived from the direct time inputs from the Resource Based Relative Value Scale (RBRVS).
  - 93922            39 minutes
  - 93923            59 minutes

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