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**VASCULAR TECHNOLOGY
PROFESSIONAL PERFORMANCE GUIDELINES**

Radial Artery Assessment for Coronary Artery Bypass

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PURPOSE

Radial artery evaluations are performed to assess the patency of the palmar arch and suitability of the radial artery for use as a conduit for coronary artery bypass. Evaluations include duplex evaluation of the radial artery and physiologic assessment of upper extremity arterial perfusion, including digital perfusion.

COMMON INDICATIONS

- Assessment of upper extremity and digital perfusion
- A quantitative documentation of patency of the palmar arch
- Duplex evaluation of the radial artery to evaluate for:
 - Anatomic variants
 - Vessel size
 - Stenosis
 - Sclerosis (calcification)

CONTRAINDICATIONS AND LIMITATIONS

Contraindications and limitations may include the following:

- Non-compressible vessels
- Presence of hemodialysis access
- Presence of ulcers, casts, staples or bandages
- Incomplete palmar arch
- Ischemic digits
- Raynaud's syndrome
- IV or catheters that limit access /visualization of arterial structures
- Patients' inability to cooperate with or tolerate 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 the 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.

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 arms, hands, and fingers. The sonographer or examiner should obtain a complete, pertinent history and review 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.
- History of Raynaud's Syndrome
- Prior cannulation of the radial artery
- Prior trauma to the extremity
- Results of previous vascular studies
- Physical assessment of arms, hands, and fingers for symptoms of upper extremity arterial disease

A complete assessment should guide the sonographer to:

- Verify that the procedure ordered correlates with the patient's clinical presentation.
- Perform adjunctive procedures according to the laboratory-specific protocol: auscultation of bruits and/or palpation of pulses.

PATIENT POSITIONING

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

- The exam is typically performed with the patient in supine position, head slightly elevated, and arm externally rotated. The arm can be placed on a pillow for patient

comfort.

- Examiner should be as close to the examined extremity as possible to allow for proper ergonomics.
- The non-dominant arm is the first choice, unless testing reveals abnormalities.

INSTRUMENTATION

Duplex

Utilize the appropriate duplex instrumentation with the appropriate frequencies for the vessels being examined.

- Typically, this is a high-frequency linear transducer with frequency ranging from 8-15 MHz.
- Display of both two-dimensional structure and motion in real-time
 - Doppler ultrasonic signal documentation
 - Spectral analysis with or without color Doppler imaging
- Digital storage of static images or cineloop is required.

Physiologic

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 4-10MHz
 - 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 imaging protocol. Studies are often unilateral (evaluating the non-dominant arm) but may be bilateral if the radial artery is inadequate, if the palmar arch is incomplete, or by physician request. Additional physiologic testing can evaluate digital perfusion with radial artery compression.

Throughout each examination, the sonographer or examiner should:

- Observe the sonographic characteristics of normal and abnormal tissues, structures, and blood flow to allow the necessary adjustment to optimize exam quality
- Analyze segmental pressure and waveform findings to ensure that sufficient data is provided to the physician
- Assess and monitor the patient's physical and mental status, allowing modifications to the procedure plan according to the patient's clinical status
- Analyze sonographic and physiologic findings to ensure that sufficient data is provided to the physician to direct patient management and render a final diagnosis

Duplex Imaging Protocol:

B-Mode and color Doppler imaging of the upper extremity arteries should be performed. Diameter measurements of the radial artery should be taken in a transverse plane. Longitudinal grayscale and color Doppler images should be documented for each arterial segment and in areas of stenosis or other abnormality. Color Doppler is used to localize areas of flow disturbance and stenosis. Power Doppler is useful to confirm possible vessel occlusion or low flow states.

Transverse **B-Mode** images must include **diameter measurements** from the:

- Proximal, mid and distal radial artery

Longitudinal **B-mode and/or color Doppler images** should include the following:

- Brachial artery

- Radial and Ulnar arteries
 - Early takeoff of the radial artery in the upper arm and/or other anatomical variants should be noted.
 - Identify areas of stenosis or calcification.
 - A normal ulnar artery is essential if the radial artery is to be harvested.

Doppler spectral analysis is used to quantify disease severity. Spectral Doppler waveforms should be obtained in a longitudinal plane at an angle of 60° and parallel to the direction of the blood flow/vessel walls. Maintain Doppler angles between 45° and 60° whenever possible. Angles greater than 60° must be avoided.

Peak systolic velocities should be documented for each normal arterial segment and in areas of stenosis, previous intervention or other abnormality. Spectral Doppler waveforms and velocity measurements should be obtained 1- 4cm proximal to, at, and distal to sites of suspected stenosis, obstruction or in areas of previous intervention.

Spectral Doppler waveforms and velocity measures should include:

- Brachial artery
- Radial and Ulnar arteries
 - Ulnar artery with and without radial artery compression
 - Palmar arch artery with and without radial artery compression

Physiologic Testing Protocol:

Physiologic evaluation involves the use of photoplethysmography waveforms/pulse volume recording, continuous wave (CW) Doppler and segmental pressures of the upper extremities and digits to detect significant upper extremity arterial disease.

Continuous wave (CW) Doppler and segmental pressures of upper extremities:

- At least three representative CW Doppler waveforms are recorded from the brachial, radial and ulnar arteries at an angle that optimizes the visual and audible signal.
 - 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.
- Blood pressure cuffs are placed at the upper arm, mid forearm and wrist. 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 PVR/ PPG Waveforms and Pressures:

Evaluation of digit perfusion can be obtained with volume pulse recording (VPR) or photoplethysmography (PPG) based on laboratory's protocol.

- PVR waveforms are obtained by placing the pressure cuff on the digit and inflating it to a predetermined pressure to evaluate changes in blood volume.
 - At least three representative waveforms are recorded.
- PPG waveforms and pressures are obtained by placing the PPG sensor and digital pressure cuff at the base of the thumb/index finger and fifth digit.
 - At least 3 PPG waveforms are recorded.
 - The cuff is inflated to a supra-systolic pressure and then deflated slowly until the waveform re-appears. Obtain and record the systolic pressure.
 - A **digit brachial index (DBI)** is obtained by taking the digit pressure divided by the highest brachial pressure.

Allen Test

The Allen Test is performed to assess the patency of the palmar arch and evaluate digital perfusion in the hand. This can be performed with physiologic testing or duplex imaging.

Physiologic Evaluation

- Use a slow speed and adjust the PPG scale and gain controls at similar amplitudes.
- Resting PPG waveforms are obtained at the 1st, 2nd and 5th digit.
 - At least 3 PPG waveforms are recorded.
- The radial artery is compressed and tracings are captured. Next, the ulnar artery is compressed and tracings are captured.
 - Little or no change in PPG waveforms when either artery is compressed indicates a complete palmar arch.
 - Obliteration of PPG waveforms when either artery is compressed indicates incomplete palmar arch.
- Perform compression maneuvers for each digit examined.
- If the palmar arch is incomplete, assess the other extremity.

Duplex Evaluation

- Obtain spectral Doppler waveforms in the ulnar artery with and without radial artery compression
 - Normally, a >20% increase in ulnar PSV with radial compression
- Obtain spectral Doppler waveforms within the palmar arch artery/terminal radial artery with and without radial artery compression
 - Normally, a reversal of flow with radial artery compression

REVIEW OF THE DIAGNOSTIC EXAM FINDINGS

The sonographer or examiner should:

- Review data acquired during the radial artery mapping evaluation to ensure that a complete and comprehensive evaluation has been performed and documented.
- Explain and document any exceptions to the routine radial artery mapping protocol (i.e., study omissions or revisions).
- Record all technical findings required to complete the final interpretation in the patient's medical record.
- Document exam date, clinical indication(s), technologist performing the evaluation and exam summary in the patients' medical record.
- Alert the medical director or other responsible physician when immediate attention is indicated, according to departmental protocol.

PRESENTATION OF 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 name 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.

EXAM TIME RECOMMENDATIONS

High quality, accurate results are fundamental elements of the radial artery duplex and physiologic evaluation. A combination of indirect and direct examination components is the foundation for maximizing exam quality and accuracy.

- Indirect examination components include:
 - Pre-examination activities
 - Initiating examination and paperwork
 - Equipment and examination room preparation
 - Patient communication
 - Patient assessment
 - Patient positioning
 - Post-examination activities
 - Examination room clean-up
 - Review of the diagnostic examination findings
 - Processing of the examination data for preliminary reporting and/or final interpretation
 - Examination billing activities
- Direct examination components include:
 - Equipment optimization and 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).
 - 93930 76 minutes
 - 93931 51 minutes
 - 93922 39 minutes
 - 93923 59 minutes

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