

**National Education Curriculum**  
**Specialty Curricula**

*Vascular Technology*

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# Vascular Technology

## **Section I: Fluid Dynamics**

**Rationale:** Accurate, appropriate, noninvasive vascular examinations require knowledge of sonography physical principles and instrumentation, hemodynamics and the pathophysiology and treatment of vascular disease. The application of this knowledge to standardized diagnostic test protocols, correlation of test data with other recognized imaging modalities, and an ongoing quality assurance program is requisite to quality patient care.

1. Define power, work, and energy
  2. Describe the differences between potential and kinetic energy
  3. Explain the importance of hydrostatic pressure in the human circulatory system
  4. Describe the relationship between volumetric flow and blood flow velocity
  5. Define capacitance and compliance
  6. Explain the impact of variations in fluid viscosity on blood flow
  7. Describe the components of Poiseuille's law and Bernoulli's principle
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### **I. Fluid Dynamics**

#### **A. General Description**

1. Flow and related terms
2. Power, work and energy
3. Potential and kinetic energy
4. Hydrostatic pressure
5. Volumetric flow
6. Velocity
7. Capacitance
8. Compliance
9. Fluid viscosity

#### **B. Derivation of Equations**

1. Describe
  - a. Resistance equation
  - b. Volumetric flow equation (continuity equation)
  - c. Simplified law of hemodynamics
  - d. Pressure/flow relationships
    - i) Poiseuille's law
    - ii) Bernoulli's principle
      - Conservation of energy
      - Bernoulli's equation
        - Equation with hydrostatic pressure term
        - Equation with heat term
    - iii) Reynold's number
  - e. Relationship of equation components to each other

#### **C. Description of Steady Flow**

1. Rigid tube
2. Curved tube

## **Section II: Physiology and Hemodynamics**

1. Explain the relationship between pressure, flow and resistance
  2. Define and describe high resistance and low resistance flow profiles
  3. Relate the difference between steady and pulsatile flow
  4. Describe the changes in pulsatility of flow that occur with vasoconstriction and vasodilation
  5. Describe normal and abnormal flow profiles that occur in the arterial and venous systems
  6. Correlate flow profiles to pressure, flow and resistance
  7. Define systemic versus autoregulatory control of peripheral resistance
- 

### **II. Physiology and Hemodynamics (Pulmonary versus Systemic)**

#### **A. Pressure and Flow Resistance**

1. Left heart
  - a. Stroke volume
  - b. Cardiac output
    - i) Ejection fraction
    - ii) Pre-load and after-load
  - c. Cardiac cycle
  - d. Electrical conductivity
    - i) Relation to waveform morphology
2. Peripheral arterial system
  - a. Vessel sizes
  - b. Arterial resistance
    - i) High resistance
    - ii) Low resistance
  - c. Volume flow changes
    - i) Effects of vessel diameter
    - ii) Anatomy
    - iii) Pathology
    - iv) End-organ perfusion
  - d. Effective resistance in peripheral arterial system
    - i) Arteries
    - ii) Arterioles
    - iii) Capillaries
3. Peripheral venous system
  - a. Vessel diameter
  - b. Anatomy
  - c. Pathology
  - d. Effective resistance in the peripheral venous system

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- i) Vena cava
  - ii) Peripheral veins
  - iii) Venules
- 4. Right and left heart
  - a. Effects on peripheral flow patterns
  - b. Pulmonary hemodynamics
- 5. Cardiovascular system
  - a. Velocity versus cross-sectional area
  - b. Pressure changes in arterial system
    - i) Arteriolar regulation
    - ii) Change in pulsatility waveforms
    - iii) Vasoconstriction/vasodilation
  - c. Pressure changes in venous system
    - i) Venous pressure
    - ii) Venous capacitance and static filling pressure
    - iii) Hydrostatic pressure
    - iv) Calf muscle pump
    - v) Respiratory related changes
    - vi) Venous resistance and transmural pressure
    - vii) Venous hypertension and edema
- B. Arterial Hemodynamics
  - 1. Total energy
    - a. Potential
      - i) Hydrostatic
      - ii) Gravitational
    - b. Kinetic
    - c. Conservation of energy
  - 2. Energy gradient
    - a. Definition
    - b. Effects on flow
    - c. Effects of cardiac output and peripheral resistance
  - 3. Resistance
    - a. Effects of viscosity, friction, inertia
    - b. Blood in a non-Newtonian fluid
    - c. Autoregulatory versus sympathetic
  - 4. Application of pressure/flow relationship
    - a. Poiseuille's law
      - i) Vessel length
      - ii) Vessel radius
    - b. Reynolds number
  - 5. Application of flow/pressure/velocity relationship

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- a. Bernoulli's principle
  6. Steady versus pulsatile flow
  7. Doppler flow profiles
    - a. Flow patterns
      - i) Laminar
        - Plug
        - Parabolic
      - ii) Disturbed
      - iii) Turbulent
    - b. Waveform morphology
      - i) Triphasic
      - ii) Monophasic
      - iii) Systolic upstroke
      - iv) Systolic deceleration
      - v) Diastolic component
    - c. Pressure pulse distortion
  8. Effects of stenosis/occlusion on flow characteristics
    - a. Definition of hemodynamic significant stenosis
      - i) Flow versus pressure gradient
    - b. Direction of flow, turbulence, disturbed flow
    - c. Velocity acceleration/deceleration
    - d. Entrance/exit effects
    - e. Diameter reduction
    - f. Peripheral resistance
    - g. Collateral effects
    - h. Effects of exercise
    - i. Effects of occlusion
- C. Venous Hemodynamics
1. Total energy
    - a. Potential
      - i) Hydrostatic
      - ii) Gravitational
    - b. Kinetic
    - c. Conservation of energy
  2. Venous resistance
  3. Pressure/volume relationships
    - a. Pressure gradient
    - b. Respirophasicity
    - c. Effects of calf muscle pump mechanism
      - i) Rest

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- ii) Contraction
    - iii) Relaxation
  - d. Obstruction/resistance
  - e. Venous insufficiency
    - i) Duration of reflux
    - ii) Venous hypertension
  - f. Cardiac cycle
- 4. Effects of edema
- 5. Doppler flow profiles
  - a. Continuous/non-phasic
  - b. Phasic
    - i) Respiration
    - ii) Heartbeat
  - c. Pulsatility

## **Section III: Physical and Electrical Principles**

1. Relate the difference between ultrasound energy and power
  2. Describe the types of graphic recording used in noninvasive vascular testing
  3. Explain methods for calibrating sonographic imaging systems and plethysmographic instruments
  4. Define alternating current (AC) versus direct current (DC) coupling, and explain the potential artifacts associated with inappropriate use
  5. Understand the most common units of measure associated with noninvasive vascular testing
  6. Describe the most common tests used for evaluation of tissue mechanics and pressure transmission in the peripheral venous and arterial systems
  7. List the types of plethysmography and pressure assessments used for evaluation of the peripheral arteries and veins
  8. Explain the relationship between Ohm's Law and hemodynamics
- 

### **III. Physical and Electrical Principles**

#### **A. General**

1. Energy
2. Power
  - a. Relationship to flow dynamics
3. Ohm's Law
  - a. Description
  - b. Relationship to flow dynamics
4. Graphical recording
  - a. Sweep speed
5. Calibration and optimization
  - a. Spectral Analysis
  - b. Continuous wave Doppler
  - c. Plethysmographs
  - d. Strip chart
6. Zero-crossing detector
  - a. AC/DC coupling
7. Information displays
  - a. Monitors
  - b. Strip chart
8. Picture archiving communication system (PACS)
  - a. Digital imaging and communications in medicine (DICOM)

#### **B. Units of Measure**

1. Peak-systolic velocity (PSV)
2. End-diastolic velocity (EDV)
3. Pulsatility index (PI)



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4. Resistive index (RI)
  5. Frequency (kilo Hertz, mega Hertz)
  6. Centimeters or meters per second
  7. Distance
  8. Ratios
  9. Flow volume
- C. Tissue Mechanics/Pressure Transmission
1. Venous occlusion by limb positioning
  2. Superficial venous occlusion by tourniquets
  3. Volume changes by inflow/outflow
  4. Arterial occlusion by cuffs
- D. Plethysmography
1. Volume displacement (pneumatic cuff)
  2. Photoplethysmography (PPG)
    - a. Venous
    - b. Arterial
- E. Pressure Measurements
1. Palpatory
  2. Auscultatory
  3. Continuous Wave (CW)-Doppler (flow meter)
  4. Segmental pressure measurements
    - a. Cuff size artifact
- F. Other
1. Skin temperature
  2. Transcutaneous oximetry (TCPO<sub>2</sub>)
  3. Laser Doppler
- G. Oculopneumoplethysmography (historical)
1. OPG-Gee

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## **Section IV: Cerebrovascular**

1. Identify the vessels in the extracranial and intracranial cerebrovascular system
  2. Explain the effects of collateral flow on cerebral hemodynamics
  3. List the risk factors and mechanism for cerebrovascular disease
  4. Describe the evolution of atherosclerotic plaque
  5. Define transient ischemic attack (TIA), reversible ischemic neurologic deficit (RIND), stroke and vertebrobasilar insufficiency (VBI)
  6. Describe the capabilities, limitations, protocol/techniques, waveforms and diagnostic criteria for cerebrovascular circulation test procedures
  7. Describe the effects of stenosis and occlusion on flow characteristics in the extracranial cerebrovascular system
  8. Define standard contrast, digital subtraction, computed tomographic arteriography and magnetic resonance arteriography
  9. List the current treatment options for patients with cerebrovascular disease
- 

### **IV. Cerebrovascular**

#### **A. Anatomy**

1. Aortic arch
  - a. Components
    - i) Ascending
    - ii) Transverse
    - iii) Descending
  - b. Major branches
    - i) Innominate artery (brachiocephalic)
    - ii) Left common carotid artery
    - iii) Left subclavian artery
  - c. Origination and termination of vessels
  - d. Relational anatomy of vessels
    - i) Principal arch anomalies
  - e. Collateral pathways
2. Carotid artery (extracranial)
  - a. Components
    - i) Common carotid artery (CCA)
    - ii) Carotid bulb
    - iii) Internal carotid artery (ICA)
      - Carotid siphon
      - Ophthalmic artery - 1st intracranial branch
    - iv) External carotid artery (ECA)
      - Superior thyroid artery

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- Ascending pharyngeal
  - Lingual
  - Occipital
  - Facial
  - Posterior auricular
  - Maxillary
  - Superficial temporal
- b. Origination and termination of vessels
  - c. Relational anatomy
  - d. Collateral pathways
3. Vertebral artery (Vert)
    - a. Segments
      - i) Pre-vertebral
      - ii) Cervical
      - iii) Horizontal (Atlantic)
      - iv) Intracranial
    - b. Origination and termination
    - c. Relational anatomy
    - d. Collateral pathways
- B. Intracranial Circulation
1. Components
    - a. Circle of Willis and contributing arteries
      - i) Terminal ICA
      - ii) Middle cerebral artery (MCA)
      - iii) Anterior cerebral artery (ACA)
      - iv) Anterior communicating artery (ACoA)
      - v) Posterior communicating arteries (PCoA)
      - vi) Posterior cerebral arteries (PCA)
      - vii) Basilar artery (Bas)
    - b. Terminal vertebral artery
    - c. Ophthalmic artery
  2. Origination and termination
  3. Relational anatomy
  4. Collateral pathways
- C. Congenital Variants
- D. Risk factors
1. Controllable
    - a. Diabetes
    - b. Hyperlipidemia
    - c. Hypertension

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- d. Smoking
- 2. Uncontrollable
  - a. Age
  - b. Gender
  - c. Family history
- 3. Hypercoagulopathy
- E. Mechanisms of Disease
  - 1. Atherosclerosis
    - a. Definition/characteristics
    - b. Common locations
    - c. Plaque evolution
    - d. Endothelial injury
    - e. Sub-endothelial deposit of lipids
    - f. Inflammatory response; smooth muscle cell proliferation
    - g. Plaque formation
    - h. Hemorrhage
    - i. Necrosis
    - j. Ulceration
    - k. Embolization/thrombosis
  - 2. Aneurysm
    - a. Definition/characteristics
    - b. True aneurysm
    - c. Fusiform
    - d. Saccular
    - e. Dissecting (arterial)
    - f. Pseudoaneurysm
    - g. Common location
  - 3. Thromboembolic events
    - a. Definition/characteristics
  - 4. Carotid body tumor
    - a. Definition/characteristics
  - 5. Fibromuscular dysplasia (FMD)
    - a. Definition/characteristics
    - b. Common locations
  - 6. Subclavian (vertebral) steal
    - a. Definition/characteristics
  - 7. Neointimal hyperplasia
    - a. Definition/characteristics
    - b. Common locations
- F. Types of Stroke
  - 1. Hemorrhagic

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2. Ischemic
3. Lacunar
- G. Signs and Symptoms
  1. Transient symptoms
    - a. Transient ischemic attack (TIA)
    - b. Reversible ischemic neurological deficit (RIND)
    - c. Vertebrobasilar insufficiency (VBI)
  2. Non-localizing (non-focal) symptoms
  3. Stroke
    - a. Minor
    - b. Major
- H. Physical Examination
  1. Palpation of pulses
    - a. Locations
  2. Relevance
  3. Auscultation – bruits
    - a. Definition
    - b. Location
    - c. Relevance
  4. Bilateral brachial systolic pressure measurements
    - a. Indication
    - b. Relevance
- I. Noninvasive Test Procedures
  1. Indirect testing (historical and physiologic interest)
    - a. Periorbital Doppler examination
    - b. Oculopneumoplethysmography (OPG)
  2. Direct testing/Duplex sonography
    - a. Patient positioning
    - b. Choice of instrumentation/transducer frequencies
    - c. Examination protocol
    - d. Imaging and spectral Doppler techniques
    - e. 2-D interpretation
      - i) Normal characteristics
      - ii) Abnormal characteristics
      - iii) Measurements
        - Diameter versus area
        - Intimal medial thickness (IMT)
        - Aneurysm size
    - f. Spectral Doppler interpretation
      - i) Normal characteristics

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- ii) Abnormal characteristics
- iii) Measurements
  - Peak systolic velocity
  - ICA/CCA ratio
  - End diastolic velocity
  - Pitfalls of measurements
  - Current diagnostic criteria
- g. Color Doppler interpretation
  - i) Presence/absence of flow
  - ii) Direction of flow
  - iii) Flow characteristics
    - Aliasing
    - Bruit
    - High and low resistive signal
  - h. Capabilities
  - i. Limitations
- 3. Intraoperative duplex sonography
  - a. Indications
  - b. Monitoring
  - c. Limitations
- 4. Transcranial Doppler (TCD)/Transcranial imaging (TCI) examination
  - a. Patient positioning
  - b. Choice of instrumentation/transducer frequency
    - i) Imaging
    - ii) Non-imaging
  - c. Examination protocol
    - i) Acoustic windows
    - ii) Vessel depth
    - iii) Signal traceability
    - iv) Sample volume size
    - v) Transmit frequency/power
  - d. Imaging and spectral Doppler techniques
  - e. Spectral Doppler interpretation
    - i) Normal characteristics
      - Flow direction
      - Flow pattern
      - Velocity ranges
    - ii) Abnormal characteristics
    - iii) Measurements
      - Maximum of the Mean velocity

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- Peak systolic velocity
  - End diastolic velocity
  - ICA/MCA ratio
  - Pulsatility index
  - Pitfalls of measurements
  - Embolic showers
- f. Color Doppler interpretation
    - i) Presence/absence of flow
    - ii) Direction of flow
    - iii) Flow characteristics
  - g. Capabilities
    - i) Current clinical use
    - ii) Monitoring
  - h. Limitations
- J. Continuous Wave (CW) Doppler
- 1. Patient positioning
  - 2. Examination protocol/technique
  - 3. Interpretation
    - a. Normal characteristics
    - b. Abnormal characteristics
    - c. Measurements
- K. Correlative and/or Prior Imaging
- 1. Conventional arteriography
    - a. Interpretation
      - i) Stenosis
      - ii) Occlusion
      - iii) Collaterals/intracranial cross-filling
    - b. Limitations
  - 2. Digital subtraction arteriography (DSA)
    - a. Interpretation
      - i) Stenosis
      - ii) Occlusion
      - iii) Collaterals/intracranial cross-filling
    - b. Limitations
  - 3. Computed tomography arteriography (CTA)
    - a. Interpretation
      - i) Stenosis
      - ii) Occlusion
      - iii) Collaterals/intracranial cross-filling
    - b. Limitations

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4. Magnetic resonance arteriography (MRA)
  - a. Current clinical use
  - b. Interpretation
    - i) Stenosis
    - ii) Occlusion
    - iii) Collaterals/intracranial cross-filling
  - c. Limitations
- L. Treatment
  1. Indications
  2. Medical control and reduction of risk factors
    - a. Lifestyle
    - b. Pharmacologic control
      - i) Hypertension
      - ii) Cholesterol
      - iii) Clotting factors
  3. Endovascular
    - a. Thrombolytic therapy
    - b. Percutaneous transluminal angioplasty (PTA)
    - c. Carotid angioplasty and stenting (CAS)
  4. Surgical
    - a. Endarterectomy
    - b. Bypass graft
  5. Acute thrombolytic therapy



# Vascular Technology

## **Section V: Peripheral Venous**

1. Identify the central, upper and lower extremity deep and superficial veins, and list the major perforating veins in the lower extremity
  2. Describe the function of vein valve leaflets in venous physiology in the normal patient and the patient with venous insufficiency
  3. List the components of Virchow's Triad, and relate how these impact venous pathophysiology
  4. Describe risk factors for venous thrombosis
  5. Relate the mechanisms of disease associated with acute and chronic deep vein thrombosis, superficial thrombophlebitis, venous insufficiency and pulmonary embolism
  6. Define the clinical signs associated with acute and chronic deep vein thrombosis and superficial thrombophlebitis
  7. Describe the role of the calf muscle pump in venous physiology
  8. Relate the pathological findings associated with venous stasis and venous insufficiency
  9. Describe the capabilities, limitations, patient positioning, protocol/techniques and diagnostic criteria for the following venous examinations: duplex sonography, color flow imaging and venous refill plethysmography
  10. Define correlative imaging technologies
  11. List the current treatment options for patients with deep vein thrombosis or superficial thrombophlebitis
  12. Describe the CEAP classification for chronic venous insufficiency
- 

### **V. Peripheral Venous**

#### **A. Anatomy**

1. Upper extremity deep veins
  - a. Components
    - i) Deep digital and deep palmar
    - ii) Radial and ulnar
    - iii) Brachial
    - iv) Axillary
    - v) Subclavian
      - Significance of thoracic outlet anatomy
    - vi) Brachiocephalic (innominate)
    - vii) Superior Vena Cava (SVC)
    - viii) Neck – Internal jugular, external jugular
  - b. Origination and termination of vessels
  - c. Anatomic anomalies
  - d. Relational anatomy of vessels
  - e. Collateral pathways
2. Upper extremity superficial veins
  - a. Components
    - i) Cephalic
    - ii) Basilic

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- iii) Median cubital
- b. Origination and termination of vessels
- c. Anatomic anomalies
- d. Relational anatomy of vessels
- e. Collateral pathways
- 3. Lower extremity deep veins
  - a. Components
    - i) Deep digital and metatarsal
    - ii) Calf veins
      - Soleal veins
      - Gastrocnemius (sural) veins
      - Tibial
      - Peroneal
      - Posterior tibial
      - Anterior tibial
    - iii) Popliteal
    - iv) Femoral (FV)
    - v) Deep femoral (profunda femoris)
    - vi) Common femoral (CFV)
    - vii) External and internal iliac (hypogastric)
    - viii) Common iliac
    - ix) Inferior vena cava (IVC)
  - b. Origination and termination of vessels
  - c. Anatomic anomalies
  - d. Relational anatomy of vessels
    - i) Significance of left common iliac vein location
  - e. Collateral pathways
- 4. Lower extremity superficial veins
  - a. Components
    - i) Great saphenous
    - ii) Small saphenous
  - b. Origination and termination of vessels
  - c. Anatomic anomalies
  - d. Relational anatomy of vessels
  - e. Collateral pathways
- 5. Lower extremity perforating veins
  - a. Origination and termination of vessels
- 6. Central venous system
  - a. Components
    - i) Vena cava

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- Superior vena cava (SVC)
  - Inferior vena cava (IVC)
  - ii) Portal, hepatic, renal and mesenteric
  - b. Origination and termination of vessels
  - c. Anatomic anomalies
  - d. Relational anatomy of vessels
  - e. Collateral pathways
  - 7. Vein walls and valve leaflets
    - a. Intima
    - b. Media
    - c. Adventitia
    - d. Valve leaflets
      - i) Location and number of valves
      - ii) Relationship with pathophysiology of DVT
- B. Risk Factors
1. Pre-disposing
    - a. Age
    - b. Cancer
    - c. Prolonged bed rest or inactivity
    - d. Prior episode of DVT
    - e. Trauma
    - f. Hormones
    - g. Paraplegia
    - h. Surgery
    - i. Pregnancy
    - j. Thrombophilias
  2. Virchow's triad
    - a. Stasis
    - b. Hypercoagulability
    - c. Vessel wall injury
- C. Mechanisms of Disease
1. Acute deep venous thrombosis
  2. Chronic deep venous thrombosis
    - a. Post-thrombotic syndrome
  3. Chronic venous insufficiency
    - a. Valvular incompetence
    - b. Outflow obstruction
    - c. May Thurner Syndrome
    - d. Stasis ulceration
    - e. Ambulatory venous hypertension

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4. Varicose veins
    - a. Primary venous insufficiency
    - b. Secondary venous insufficiency
  5. Congenital
    - a. Absence of valves
    - b. Hypercoagulability
  6. Pulmonary embolism (PE)
- D. Signs and Symptoms
1. Acute deep venous thrombosis
    - a. Phlegmasia alba dolens
    - b. Phlegmasia cerula dolens
  2. Chronic deep venous thrombosis
  3. Venous ulceration/stasis ulcers
    - a. Chronic venous insufficiency (CVI)
      - i) Clinical etiologic anatomic pathologic classification (CEAP)
        - Venous ulcer, venous stasis
- E. Noninvasive Test Procedures for Upper and Lower Extremities Venous Thrombosis
1. Duplex imaging
    - a. Patient positioning
    - b. Choice of instrument/transducer frequencies
    - c. Examination protocol
    - d. Imaging and spectral Doppler techniques
    - e. 2-D interpretation
      - i) Thrombus characteristics
        - Acute
        - Chronic
      - ii) Normal characteristics
      - iii) Abnormal characteristics
    - f. Spectral Doppler interpretation
      - i) Normal characteristics
      - ii) Abnormal characteristics
      - iii) Flow characteristics
    - g. Color Doppler interpretation
      - i) Presence/absence of flow
      - ii) Direction of flow
      - iii) Flow characteristics
      - iv) Recanalization
      - v) Collateralization
    - h. Capabilities
    - i. Limitations

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2. Non-imaging (historical interest)
  - a. CW Doppler venous examination
  - b. Strain gauge plethysmography (SPG)
  - c. Impedance plethysmography (IPG)
  - d. CW Doppler (historical)
- F. Noninvasive Test Procedures for Chronic Venous Insufficiency
  1. Duplex imaging/color flow imaging
    - a. Identification of valvular incompetence
      - i) Spectral Doppler
      - ii) Color Doppler
      - iii) Duration of retrograde flow
      - iv) Deep versus superficial venous incompetence
    - b. Identification of perforator incompetence
      - i) Spectral Doppler
      - ii) Color Doppler
    - c. Venous obstruction
    - d. Assistance during and after radiofrequency/laser ablation procedures
  2. Reflux plethysmography
    - a. Photoplethysmography (PPG)
      - i) Venous refill time (VRT)
        - Tourniquet application/location
    - b. Air plethysmography
- G. CEAP Classification
  1. Classification system for reporting and treating the diverse manifestations of chronic venous disorders
    - a. Clinical
      - i) Visual changes seen on the extremity
    - b. Etiology
      - i) Congenital
      - ii) Primary
      - iii) Secondary
    - c. Anatomy
      - i) Superficial veins
      - ii) Deep veins
      - iii) Perforating veins
    - d. Pathophysiology
      - i) Reflux
      - ii) Obstruction
- H. Correlative and/or Prior Imaging
  1. Conventional venography
    - a. Ascending

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- b. Descending
- 2. Magnetic resonance venography (MRV)
- 3. Computed tomography venography (CTV)
- I. Other Diagnostic Testing
  - 1. Ventilation perfusion lung scan
  - 2. D-dimer assay
  - 3. CTA
- J. Treatment
  - 1. Indications for treatment
  - 2. Anticoagulation
  - 3. Thrombolytic therapy
    - a. Systemic
    - b. Catheter-directed
  - 4. Vena caval filters
  - 5. Compression stockings
  - 6. Surgery
    - a. Ligation of perforating veins
    - b. Stripping or local excision of varicosities/phlebectomy
    - c. Sclerotherapy
  - 7. Radiofrequency/laser ablation of incompetent saphenous veins
    - a. Sonography guidance for and/or endovenous laser ablation procedures for incompetent saphenous veins
  - 8. Vein mapping for arterial and AV fistula procedures
    - a. Upper extremity
    - b. Lower extremity
    - c. Endoscopic vein surgery

## **Section VI: Peripheral Arterial**

1. Identify the major arteries of the upper and lower extremities and the branches of the abdominal aorta
  2. Differentiate between arterial and venous wall anatomy at the microscopic level
  3. List the risk factors and mechanisms for arterial disease
  4. List the most common sites for arterial disease in the peripheral arterial system
  5. Differentiate fusiform, saccular, and dissecting aneurysms
  6. List common nonatherosclerotic vascular disorders
  7. Differentiate the symptoms of acute arterial occlusion and chronic arterial occlusive disease
  8. Relate the difference between primary and secondary Raynaud's syndrome
  9. Describe the capabilities, limitations, protocols/techniques and diagnostic criteria for noninvasive peripheral arterial test procedures
  10. Define correlative imaging techniques
  11. Describe the current treatment options for patients with peripheral arterial disease
- 

### **VI. Peripheral Arterial**

#### A. Anatomy

1. Upper extremity arteries
  - a. Components
    - i) Innominate (Brachiocephalic)
    - ii) Subclavian
    - iii) Axillary
    - iv) Brachial
    - v) Radial
    - vi) Ulnar
    - vii) Interosseous
    - viii) Palmar (volar) arches
      - Deep
      - Superficial
    - ix) Digital
2. Abdominal aorta
  - a. Functional division
    - i) Supra-renal
    - ii) Infra-renal
  - b. Branches
    - i) Phrenic
    - ii) Celiac
    - iii) Superior mesenteric (SMA)
    - iv) Renal
    - v) Gonadal

# Vascular Technology

- vi) Inferior mesenteric (IMA)
  - vii) Lumbar
  - 3. Lower extremity arteries
    - a. Components
      - i) Common iliac
      - ii) External iliac
      - iii) Internal iliac (hypogastric)
      - iv) Common femoral (CFA)
      - v) Superficial femoral (SFA)
      - vi) Deep femoral (profunda femoris)
      - vii) Popliteal
      - viii) Tibioperoneal trunk
      - ix) Anterior tibial
      - x) Posterior tibial
      - xi) Peroneal
      - xii) Plantar arteries
  - 4. Microscopic anatomy of the arterial wall, capillaries, arterioles
- B. Risk Factors
- 1. Controllable risk factors
    - a. Diabetes
    - b. Hypertension
    - c. Hyperlipidemia
    - d. Smoking
  - 2. Uncontrollable risk factors
    - a. Age
    - b. Gender
    - c. Family history
    - d. Thrombophilia
- C. Mechanisms of Disease
- 1. Atherosclerosis
    - a. Plaque evolution
  - 2. Embolization
  - 3. Aneurysm
    - a. Fusiform
    - b. Saccular
    - c. Dissecting (arterial)
    - d. Pseudoaneurysm
  - 4. Nonatherosclerotic lesions
    - a. Arteritis
      - i) Types
      - ii) Common locations



# Vascular Technology

- b. Vasospastic disorders
  - i) Raynaud's syndrome
    - Primary – Raynaud's disease
    - Secondary – Raynaud's phenomenon
  - c. Aortic coarctation
    - i) Etiology and characteristics
  - d. Entrapment syndromes
    - i) Popliteal artery entrapment
    - ii) Thoracic outlet compression syndrome (TOS)
  - e. Popliteal adventitial cystic disease
- D. Signs and Symptoms
  - 1. Chronic occlusive disease
    - a. Claudication
    - b. Ischemic rest pain
    - c. Trophic changes
      - i) Gangrene
      - ii) Ulcers
  - 2. Acute arterial occlusion
    - a. Embolic
    - b. Thrombotic
    - c. Trauma
    - d. Six P's
      - i) Pain
      - ii) Pallor
      - iii) Pulselessness
      - iv) Paresthesia
      - v) Paralysis
      - vi) Poikilothermia
  - 3. Vasospastic disorders
    - a. Digital cold sensitivity
  - 4. Physical examination
    - a. Skin (dermal) changes
      - i) Color
      - ii) Temperature
      - iii) Thickened nails; scaly, thin, transparent-appearing skin; loss of hair
    - b. Palpation of pulses
    - c. Auscultation of pulses
- E. Noninvasive Test Procedures
  - 1. Indirect (physiologic) testing
    - a. Segmental systolic pressure measurements

# Vascular Technology

- i) Rationale
  - ii) Cuff sizes
  - iii) Extremity
    - 3-cuff versus 4-cuff techniques
    - Advantages and disadvantages
  - iv) Digital
  - v) Penile
  - vi) Examination protocols
  - vii) Interpretation criteria of pressures
  - viii) Normal pressure gradients
  - ix) Abnormal pressure gradients
  - x) Capabilities
  - xi) Limitations
- b. Constant-load treadmill exercise testing
- i) Rationale
  - ii) Examination protocol
    - Placement of blood pressure cuffs
    - Walking speed and elevation
    - Claudication distance
  - iii) Interpretation of post-exercise ankle pressure response
    - Normal
    - Abnormal
      - Duration of reduced pressures (time to reconstitution of pressure)
- c. Reactive hyperemia
- i) Rationale
  - ii) Examination protocol
    - Cuff sizes
    - Placement of pressure cuffs
    - Cuff pressure
    - Duration of cuff inflation
  - iii) Interpretation of post-inflation pressure response
    - Normal
    - Abnormal
      - Duration of reduced pressure (time to reconstitution of pressure)
  - iv) Capabilities
  - v) Limitations
- d. Plethysmography
- i) Pulse volume recording
    - Rationale
    - Patient positioning

# Vascular Technology

- Examination protocol
    - Cuff sizes and placement
    - Pressure and volume calibration
  - Interpretation of plethysmographic waveforms
    - Normal
    - Abnormal
  - Capabilities
    - Location of segmental flow-reducing obstruction
    - Assessment of collateral flow
  - Limitations (potential sources of error)
    - Inappropriate cuff size/calibration
    - Obesity
    - Edema
    - Resting muscle tremors (waveform artifact)
- ii) Photoplethysmography
- Rationale
  - Clinical uses
    - Digital pressures and waveforms
    - Assessment of skin perfusion (wound healing potential)
    - Digital cold sensitivity testing
  - Examination protocol
    - Sensor placement
  - Interpretation of PPG waveforms
    - Normal
    - Abnormal
  - Capabilities
    - Arterial pressures
    - Assessment of skin perfusion
  - Limitations
    - Qualitative assessment only
    - Temperature
    - Vasodilation/vasoconstriction
2. Direct testing
- a. Continuous wave (CW) Doppler evaluation
- i) Analogue waveforms
- Qualitative interpretation
  - Quantitative interpretation
    - Pulsatility index
    - Acceleration time
- ii) Zero crossing detector

# Vascular Technology

- b. Duplex imaging/color flow imaging
  - i) Patient positioning
  - ii) Choice of instrumentation/transducer frequencies
  - iii) Examination protocol
  - iv) Imaging and spectral Doppler techniques
  - v) 2-D Interpretation
    - Normal characteristics
    - Abnormal characteristics
    - Measurements
      - Diameter versus area
      - Lesion length
  - vi) Spectral Doppler interpretation
    - Normal flow characteristics
      - Native arteries
      - Bypass grafts/stents
    - Abnormal flow characteristics
      - Stenosis
      - Occlusion
      - Bypass grafts/stents
      - Aneurysms
      - Pseudoaneurysms
      - Trauma
    - Qualitative interpretation
      - Phasicity
      - Spectral broadening
      - Turbulence
    - Quantitative interpretation
      - Peak systolic velocity
      - End-diastolic velocity
      - Velocity ratio
      - Pulsatility index
      - Resistive index
      - Acceleration time
    - Pitfalls of measurements
  - vii) Color Doppler interpretation
    - Presence/absence of flow
    - Direction of flow
    - Flow characteristics
  - viii) Capabilities
  - ix) Limitations

# Vascular Technology

## F. Correlative and/or Prior Imaging

1. Conventional arteriography
  - a. Interpretation
  - b. Stenosis
  - c. Occlusion
  - d. Collaterals/intracranial cross-filling
  - e. Limitations
2. Digital subtraction angiography
3. Interpretation
4. Stenosis
5. Occlusion
6. Collaterals/intracranial cross-filling
7. Limitations
8. Computed tomographic arteriography
9. Interpretation
10. Stenosis
11. Occlusion
12. Collaterals/intracranial cross-filling
13. Limitations
14. Magnetic resonance angiography
15. Current clinical use
16. Interpretation
17. Stenosis
18. Occlusion
19. Collaterals/intracranial cross-filling
20. Limitations

## G. Treatment

1. Indications for treatment
2. Medical
3. Control and reduction of risk factors
4. Exercise
5. Pharmacologic
6. Blood pressure
7. Cholesterol
8. Clotting factors
9. Drug therapy
10. Surgical
11. Thrombectomy
12. Embolectomy
13. Endarterectomy
14. Bypass graft

## Vascular Technology

15. In situ saphenous
16. Reversed saphenous
17. Non-reversed transposed saphenous
18. Prosthetic
19. Cryo-preserved grafts
20. Anastomoses
21. End-to-side
22. End-to-end
23. Interposition graft
24. Side-to-side
25. Amputation
26. Fasciotomy
27. Split-thickness skin grafts
28. Endovascular
29. Percutaneous transluminal angioplasty (PTA)
30. Stent
31. Endograft (covered stent)
32. Atherectomy
33. Compression/thrombin injection
34. Pseudoaneurysm repair

## **Section VII: Abdominal/Visceral**

1. Identify the arteries and veins of the abdomen and list the major branches of the abdominal aorta
  2. List the common risk factors for abdominal arterial and venous disorders
  3. Describe the mechanisms of disease for renovascular hypertension, renal fibromuscular dysplasia, abdominal aortic aneurysm, portal hypertension and acute and chronic mesenteric ischemia
  4. Describe the variations in vascular resistance in the mesenteric arterial system during fasting and post-prandial states
  5. Relate the clinical presentation of patients with abdominal aortic aneurysm, portal hypertension, and chronic mesenteric ischemia
  6. Describe the capabilities, limitations, patient positioning, protocols/techniques, and current diagnostic criteria for duplex sonography of the abdominal aorta, renal and mesenteric arteries and the hepatoportal system
  7. Differentiate normal and abnormal Doppler spectral waveforms from the hepatic and portal veins and the inferior vena cava
  8. Describe the correlating imaging modalities used for confirmation of abdominal vascular disease
  9. Describe the current treatment options for patients with renovascular hypertension, mesenteric ischemia, abdominal aortic aneurysm and portal hypertension
- 

### **VII. Abdominal/Visceral**

#### A. Anatomy

1. Abdominal pelvic arterial
  - a. Components
    - i) Aorta
    - ii) Celiac artery (trunk, axis)
      - Hepatic arteries
      - Splenic artery
      - Left gastric
    - iii) Superior mesenteric artery (SMA)
    - iv) Renal arteries
    - v) Inferior mesenteric artery (IMA)
    - vi) Gonadal arteries
    - vii) Iliac arteries
2. Abdominal pelvic venous
  - a. Components
    - i) Iliac veins
    - ii) Gonadal veins
    - iii) Inferior mesenteric vein (IMV)
    - iv) Renal veins
    - v) Splenic vein
    - vi) Superior mesenteric vein (SMV)

# Vascular Technology

- vii) Portal vein tributaries
  - Superior mesenteric vein
  - Splenic vein
    - ~ Inferior mesenteric vein
  - Hepatic veins
  - Inferior vena cava (IVC)

## B. Congenital Variants

## C. Risk Factors

### 1. Arterial

- a. Diabetes
- b. Hypertension
- c. Hyperlipidemia
- d. Smoking
- e. Atrial fibrillation

### 2. Venous

- a. Prior thrombosis
- b. Malignancy
- c. Liver disease

## D. Mechanisms of Disease

### 1. Renovascular hypertension

- a. Consistent clinical features
  - i) Hypertension
  - ii) Renal artery stenosis/occlusion/fibromuscular dysplasia
  - iii) Renal ischemia
- b. Etiology
  - i) Atherosclerosis
  - ii) Fibromuscular dysplasia
  - iii) Arteritis
  - iv) Post-irradiation fibrosis
  - v) Neurofibromatosis
  - vi) Thrombosis/embolism

### 2. Mesenteric angina/ischemia

- a. Chronic celiac, SMA, IMA stenosis or occlusion
  - i) Consistent clinical features
    - Post prandial pain
    - “Fear of food” syndrome
    - Weight loss
  - ii) Etiology



# Vascular Technology

- Atherosclerosis
- Thrombosis/embolism
- b. Acute mesenteric ischemia
  - i) Consistent clinical features
    - Insidious onset acute, severe abdominal pain out of proportion to physical findings.
    - Result of delayed diagnosis
      - Potential for catastrophic gastrointestinal ischemia
      - Extremely high mortality rate, even with treatment
  - ii) Etiology
    - Embolism
    - Thrombosis
- 3. Portal hypertension
  - a. Portal splenic vein thrombosis
  - b. Cirrhosis
  - c. Budd-Chiari syndrome
- 4. Abdominal aortic aneurysm
  - a. Size
  - b. Location
  - c. Classification
    - i) Fusiform
    - ii) Saccular
    - iii) Dissecting
    - iv) Mycotic
  - d. Etiology
    - i) Atherosclerosis
    - ii) Aging
    - iii) Infection (mycotic)
    - iv) Inflammatory aneurysm: distinct clinical scenario
    - v) Trauma
    - vi) Congenital anomalies
      - Ehler-Danlos syndrome
      - Marfan's syndrome
      - Others
    - vii) Medial degeneration
    - viii) Arteritis

## E. Signs and Symptoms

### 1. Arterial

# Vascular Technology

- a. Acute mesenteric ischemia
  - i) Abrupt onset of severe abdominal pain
  - ii) Gastrointestinal tissue injury
- b. Chronic mesenteric ischemia
  - i) Triad of symptoms
- c. Renal
  - i) Renovascular hypertension
  - ii) Renal artery stenosis/occlusion
  - iii) Renal ischemia
- d. Aneurysm
  - i) Incidental finding
  - ii) "Pulsatile abdominal mass"
  - iii) Abdominal or back pain
  - iv) Embolization/blue toe syndrome
    - Digital arteries
    - End-arterial occlusion
  - v) Rupture
    - Contained retroperitoneal
    - Free rupture

## 2. Venous

- a. Portal
  - i) Portal hypertension
    - Cirrhosis
    - GI bleed
    - Ascites
    - Jaundice
- b. Hepatic
  - i) Budd-Chiari syndrome
    - hypertension Hepatomegaly
    - Ascites
    - Abdominal pain
    - Portal
- c. IVC
  - i) Lower extremity edema
    - Venous claudication
    - Stasis ulceration

## F. Noninvasive Test Procedures

### 1. Direct-duplex imaging/color flow imaging

# Vascular Technology

- a. Patient positioning
- b. Examination protocol
- c. Imaging and spectral Doppler techniques
  - i) Aorta
  - ii) Celiac, splenic, and hepatic arteries
  - iii) Mesenteric arteries
  - iv) Renal arteries
  - v) IVC
  - vi) Hepatic veins
  - vii) Portal, splenic, and mesenteric veins
  - viii) Renal veins
- d. 2-D interpretation
  - i) Normal characteristics
  - ii) Abnormal characteristics
  - iii) Measurements
    - Diameter versus area reduction
- e. Spectral Doppler interpretation
  - i) Normal characteristics
  - ii) Abnormal characteristics
  - iii) Measurements
    - Peak systolic velocity
    - End diastolic velocity
    - Velocity ratio
    - Pulsatility index
    - Resistive index
    - Pitfalls of measurements
- f. Waveform analysis
  - i) Triphasic
  - ii) Biphasic
  - iii) Monophasic
  - iv) Continuous, non-phasic
  - v) Pulsatile
- g. Color Doppler interpretation
  - i) Presence/absence of flow
  - ii) Direction of flow
  - iii) Flow characteristics
- h. Capabilities
- i. Limitations

# Vascular Technology

## G. Correlative and/or Prior Imaging

1. Conventional arteriography
  - a. Interpretation
    - i) Stenosis
    - ii) Occlusion
    - iii) Collaterals/intracranial cross-filling
  - b. Limitations
2. Digital subtraction arteriography
  - a. Interpretation
    - i) Stenosis
    - ii) Occlusion
    - iii) Collaterals/intracranial cross-filling
  - b. Limitations
3. Computed tomographic arteriography
  - a. Interpretation
    - i) Stenosis
    - ii) Occlusion
    - iii) Collaterals/intracranial cross-filling
  - b. Limitations
4. Magnetic resonance arteriography (MRA)
  - a. Current clinical use
  - b. Interpretation
    - i) Stenosis
    - ii) Occlusion
    - iii) Collaterals/intracranial cross-filling
  - c. Limitations

## H. Treatment

1. Indications for treatment
2. Medical
  - a. Antihypertensives; beta blockade
  - b. Anticoagulation
3. Surgical
  - a. Bypass graft
  - b. Endarterectomy
4. Endovascular
  - a. Endovascular Aneurysm Repair Aortic endograft (EVAR or stent graft)
  - b. Angioplasty/stent
  - c. IVC interruption device (filter)

## Vascular Technology

- d. Transjugular intrahepatic porto-systemic shunt (TIPS)

### **Section VIII: Miscellaneous Conditions/Tests**

1. Describe the protocols and techniques used for preoperative mapping of the extremity veins, and the radial, internal mammary and epigastric arteries
  2. Differentiate the anatomy and blood flow patterns of pseudoaneurysms and arteriovenous fistulae
  3. Relate the technical protocols for assessment of dialysis access grafts and fistulae
  4. Detail the sonographic evaluation of liver, pancreas, and renal transplants
  5. Describe the tests procedures and modalities used for evaluation of vasculogenic impotence
  6. Relate the noninvasive vascular test procedures and provocative maneuvers used for detection of thoracic outlet syndrome
  7. Describe the capabilities and limitations of duplex sonography for identification of temporal arteritis
  8. Define the test procedures used for evaluation of arterial injury
  9. Differentiate the signs and symptoms of congenital and acquired lymphedema and deep vein thrombosis
- 

#### **VIII. Miscellaneous Conditions/Tests**

- A. Preoperative Venous and Arterial Mapping
  1. Potential vessels for use as bypass conduits
    - a. Saphenous veins, cephalic and basilic veins
    - b. Radial artery
    - c. Internal mammary artery
    - d. Epigastric artery
  2. Patient positioning
  3. Examination protocols
  4. Imaging and spectral Doppler techniques
  5. 2-D interpretation
    - a. Normal characteristics
    - b. Abnormal characteristics
    - c. Measurements
      - i) Diameter
      - ii) Length
  6. Spectral Doppler interpretation

# Vascular Technology

- a. Normal characteristics
  - b. Abnormal characteristics
  - c. Measurements/waveform analysis
    - i) Venous
      - Phasic versus non-phasic
    - ii) Arterial
      - Triphasic/biphasic/monophasic
      - Peak systolic velocity
      - End-diastolic velocity
      - Velocity ratios
  - d. Pitfalls of measurements
7. Color Doppler interpretation
- a. Presence/absence of flow
  - b. Direction of flow
  - c. Flow characteristics
8. Capabilities
9. Limitations
- B. Pseudoaneurysm/Arteriovenous Fistula
1. Pseudoaneurysm
    - a. Direct-duplex scanning and color flow imaging
      - i) Patient positioning
      - ii) Examination protocols
      - iii) Imaging and spectral Doppler techniques
        - Sonography-guided probe compression repair
        - Sonography-guided thrombin injection repair
      - iv) 2-D interpretation
        - Normal characteristics
        - Abnormal characteristics
          - Multilobar
          - Concomitant arteriovenous fistula
        - Measurements
          - Pseudoaneurysm diameter
          - Neck length and diameter
      - v) Spectral Doppler interpretation
        - Characteristics of flow
        - Measurements/waveform analysis
          - Characteristic to-fro Doppler signal
          - Proximal and distal arterial flow signals

# Vascular Technology

- Pitfalls of measurements
  - vi) Color Doppler interpretation
    - Presence/absence of flow
    - Direction of flow
    - Flow characteristics
  - vii) Capabilities
  - viii) Limitations
2. Arteriovenous fistula
- a. Classification
    - i) Traumatic
    - ii) Congenital
  - b. Noninvasive test procedure
    - i) Direct-duplex scanning and color flow imaging
  - c. Patient positioning
  - d. Examination protocols
  - e. Imaging and spectral Doppler techniques
  - f. 2-D interpretation
    - i) Characteristics
    - ii) Measurements
      - Location
      - Diameter/length
  - g. Spectral Doppler interpretation
    - i) Normal characteristics
    - ii) Abnormal characteristics
    - iii) Measurements/waveform analysis
      - Characteristic low resistance Doppler signal
      - Proximal and distal venous flow signals
  - h. Pitfalls of measurements
  - i. Color Doppler interpretation
    - i) Presence/absence of flow
    - ii) Direction of flow
    - iii) Flow characteristics
  - j. Capabilities
  - k. Limitations
3. Dialysis access
- a. Noninvasive test procedure
    - i) Duplex scanning and color flow imaging
      - Patient positioning

# Vascular Technology

- Examination protocols
  - Pre-operative mapping of inflow and outflow vessels
  - Dialysis fistulae
    - ~ Brescia Cimino
    - ~ Brachiocephalic fistulae
    - ~ Basilic transposition fistulae
  - Dialysis grafts
    - ~ Straight
    - ~ Looped
  - Catheters
    - ~ Short-term access
- Imaging and spectral Doppler techniques
- 2-D interpretation
  - Normal characteristics
  - Abnormal characteristics
  - Measurements
- Spectral Doppler interpretation
  - Normal characteristics
  - Abnormal characteristics
  - Measurements/waveform analysis
    - ~ Peak systolic velocity
    - ~ End diastolic velocity
    - ~ Velocity ratios
    - ~ Flow volume
- Pitfalls of measurements
- Color Doppler interpretation
  - Presence/absence of flow
  - Direction of flow
  - Flow characteristics
- Capabilities
- Limitations

## C. Organ Transplants

1. Types
  - a. Kidney
  - b. Liver
  - c. Pancreas
2. Noninvasive test procedures
  - a. Patient positioning



# Vascular Technology

- b. Examination protocols
  - c. Imaging and spectral Doppler techniques
  - d. 2-D interpretation
    - i) Normal characteristics
    - ii) Abnormal characteristics
    - iii) Measurements
      - Length
      - Width
  - e. Spectral Doppler interpretation
    - i) Normal characteristics
    - ii) Abnormal characteristics
    - iii) Measurements
      - Peak systolic velocity
      - End diastolic velocity
      - Velocity ratios
      - Resistive index
      - Pulsatility index
      - Pitfalls of measurements
  - f. Color Doppler interpretation
    - i) Presence/absence of flow
    - ii) Direction of flow
    - iii) Flow characteristics
  - g. Capabilities
  - h. Limitations
- D. Impotence Testing
- 1. Noninvasive test procedures
    - a. Indirect
      - i) Pressures
        - Penile-brachial index
    - b. Direct - Duplex sonography and color flow imaging
      - i) Patient positioning
      - ii) Examination protocols
      - iii) Imaging and spectral Doppler techniques
        - Techniques for cavernosal artery injection
        - Papaverine
        - Prostaglandin
      - iv) 2-D interpretation
        - Normal characteristics

## Vascular Technology

- Abnormal characteristics
  - Measurements
    - Pre and post-injection
    - Anterior-posterior dimensions
      - ~ Cavernosal arteries
      - ~ Deep dorsal vein
  - v) Spectral Doppler interpretation
    - Normal characteristics
    - Abnormal characteristics
    - Measurements
      - Post-injection timing
      - Peak systolic velocity
        - ~ Pre-injection
        - ~ Post-injection
      - End diastolic velocity
        - ~ Pre-injection
        - ~ Post-injection
      - Duration of erection
      - Pitfalls of measurements
  - c. Color Doppler interpretation
    - i) Presence/absence of flow
    - ii) Direction of flow
    - iii) Flow characteristics
  - d. Capabilities
  - e. Limitations
- E. Thoracic Outlet Syndrome Evaluation
1. Noninvasive test procedures
    - a. Indirect
      - i) Plethysmography
        - Pulse volume recording
        - Digital photoplethysmography
      - ii) Upper extremity systolic pressures
      - iii) Patient positioning
      - iv) Examination protocol
        - Provocative maneuvers
      - v) Techniques for indirect assessment
        - Arterial inflow
        - Arterial outflow

# Vascular Technology

- vi) Interpretation of waveforms and pressures
  - Normal characteristics
  - Abnormal characteristics
  - Measurements
    - Qualitative
    - Quantitative
- b. Direct-duplex sonography with color flow imaging
  - i) Patient positioning
  - ii) Examination protocols
  - iii) Imaging and spectral Doppler techniques
  - iv) 2-D interpretation
    - Normal characteristics
    - Abnormal characteristics
    - Measurements
      - Arterial/venous diameter proximal to thoracic outlet
      - Arterial/venous diameter distal to thoracic outlet
  - v) Spectral Doppler interpretation
    - Normal characteristics
    - Abnormal characteristics
    - Measurements
      - Peak systolic velocity
      - End diastolic velocity
      - Velocity ratio
      - Pitfalls of measurements
    - Color Doppler interpretation
      - Presence/absence of flow
      - Direction of flow
      - Flow characteristics
    - Capabilities
    - Limitations
- F. Giant Cell Arteritis
  - 1. Classification
    - a. Temporal arteritis
    - b. Takayasu's arteritis
  - 2. Noninvasive test procedures
    - a. Duplex sonography with color flow imaging
      - i) Patient positioning
      - ii) Examination protocol

## Vascular Technology

- iii) Imaging and spectral Doppler techniques
- iv) 2-D Interpretation
  - Normal characteristics
  - Abnormal characteristics
    - Halo sign
    - Macaroni sign
  - Measurements
    - Anterior-posterior diameter
    - Transverse diameter
    - Residual lumen diameter
- v) Spectral Doppler interpretation
  - Normal characteristics
  - Abnormal characteristics
  - Measurements
    - Peak systolic velocity
    - End diastolic velocity
    - Velocity ratio
    - Pitfalls of measurements
- vi) Color Doppler interpretation
  - Presence/absence of flow
  - Direction of flow
  - Flow characteristics
- vii) Capabilities
- viii) Limitations

### G. Trauma/Arterial Injury

- 1. Noninvasive test procedures
  - a. Indirect testing
    - i) CW Doppler
    - ii) Plethysmography
  - b. Direct testing - Duplex sonography with color flow imaging
    - i) Patient positioning
    - ii) Choice of instrumentation and transducer frequencies
    - iii) Examination protocol
    - iv) Imaging and spectral Doppler techniques
    - v) 2-D Interpretation
      - Normal characteristics
      - Abnormal characteristics
      - Measurements

# Vascular Technology

- Diameter
  - Length
  - vi) Spectral Doppler interpretation
    - Normal characteristics
    - Abnormal characteristics
    - Measurements
      - Peak systolic velocity
      - End diastolic velocity
      - Velocity ratio
      - Pitfalls of measurements
  - vii) Color Doppler interpretation
    - Presence/absence of flow
    - Direction of flow
    - Flow characteristics
  - viii) Capabilities
  - ix) Limitations
- H. Lymphedema
1. Definition
  2. Classification
    - a. Congenital/primary
    - b. Acquired/secondary
  3. Treatment
- I. Sonographic-Guided Procedures
1. Venous ablation
  2. Dialysis access intervention
  3. Pseudo aneurysm treatment
  4. Endovascular arterial interventions
  5. Intravascular ultrasound (IVUS)

### **Section IX: Quality Measurements**

1. Explain importance of test validation
  2. Define sensitivity, specificity, positive and negative predictive values, accuracy and disease prevalence
  3. State the statistical equations to calculate sensitivity, specificity, positive and negative predictive values, accuracy and disease prevalence
  4. Describe the methods used to measure diameter and area reduction
  5. Relate the difference between the angiographic measurements used in the North American Symptomatic Carotid Endarterectomy Trial (NASCET) and European Carotid Surgery Trial (ECST)
- 

#### **IX. Quality Measurements**

##### A. Statistics

1. Chi square
2. Sensitivity
3. Specificity
4. Positive predictive value
5. Negative predictive value
6. Overall accuracy
7. Prevalence

##### B. Measurement of Stenosis

1. Diameter versus area reduction
  - a. Diameter reduction
  - b. Area reduction
2. Angiographic determination of severity
  - a. NASCET
  - b. ECST

## **Section X: Sonography Safety**

1. Evaluate sonographic image and Doppler spectral quality, and recognize the importance of preventive maintenance of the sonographic system
  2. Define and discuss the biological effects associated with the use of medical sonography
  3. Relate the As Low As Reasonably Achievable (ALARA) principle
- 

### **X. Sonography Safety**

#### **A. Instrument Performance**

1. Evaluation of image quality
2. Evaluation of Doppler quality
3. Preventive maintenance

#### **B. Biological Effects**

1. Minimizing exposure time
  - a. ALARA principle/Prudent use statement
2. Mechanisms of production
  - a. Mechanical index
  - b. Thermal index
3. Cavitation effects
4. Scientific data
5. Preventing electrical hazards

## Abbreviations

### A

AC	Alternating Current
ACA	Anterior Cerebral Artery
ACoA	Anterior Communicating Artery
AV	Arteriovenous

### B

Bas	Basilar Artery
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### C

CCA	Common Carotid Artery
CEAP	Clinical Etiologic Anatomic Pathologic Classification
CFA	Common Femoral Artery
CFV	Common Femoral Vein
CRT	Cathode Ray Tube
CTA	Computed Tomographic Angiography
CTV	Computed Tomographic Venography
CVA	Cerebrovascular Accident
CVI	Chronic Venous Insufficiency
CW	Continuous Wave Doppler

### D

DC	Direct Current
DICOM	Digital Imaging and Communications in Medicine
DSA	Digital Subtraction Angiography

### E

ECA	External Carotid Artery
ECST	European Carotid Surgery Trial
EDV	End-Diastolic Velocity

### F

FMD	Fibromuscular Dysplasia
FV	Femoral Vein

### I

ICA	Internal Carotid Artery
IMA	Inferior Mesenteric Artery; Internal Mammary Artery
IMT	Intimal Medial Thickness
IMV	Inferior Mesenteric Vein
IVC	Inferior Vena Cava

### M

MCA	Middle Cerebral Artery
MRA	Magnetic Resonance Arteriography
MRV	Magnetic Resonance Venography

### N

NASCET	North American Symptomatic Carotid Endarterectomy Trial
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### O

OPG-Gee	Oculopneumoplethysmography-Gee
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# Vascular Technology

## **P**

PACS	Picture Archiving Communication System
PCA	Posterior Cerebral Artery
PCoA	Posterior Communicating Artery
PE	Pulmonary Embolism
PI	Pulsatility Index
PPG	Photoplethysmography
PSV	Peak Systolic Velocity
PTA	Percutaneous Transluminal Angioplasty
PW	Pulsed Wave Doppler

## **R**

RI	Resistive Index
RIND	Reversible Ischemic Neurologic Deficit

## **S**

SFA	Superficial Femoral Artery
SMA	Superior Mesenteric Artery

## **T**

TCD	Transcranial Doppler
TCI	Transcranial Imaging
TCPO <sub>2</sub>	Transcutaneous Oxygen
TGC	Time Gain Compensation
TIA	Transient Ischemic Attack
TOS	Thoracic Outlet Syndrome

## **V**

VBI	Vertebrobasilar Insufficiency
VRT	Venous Refill Time

# Vascular Technology

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