National Education Curriculum
Specialty Curricula

Vascular Technology
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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

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
               o Equation with hydrostatic pressure term
               o 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
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)
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. Ausculatory
   3. Continuous Wave (CW)-Doppler (flow meter)
   4. Segmental pressure measurements
      a. Cuff size artifact

F. Other
   1. Skin temperature
   2. Transcutaneous oximetry (TCPO2)
   3. Laser Doppler

G. Oculopneumoplethysmography (historical)
   1. OPG-Gee
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
3. Vertebral artery (Vert)
   a. Segments
      i) Pre-vertebral
      ii) Cervical
      iii) Horizontal (Atlantic)
      iv) Intracranial
   b. Origination and termination of vessels
   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
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
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
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
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 thrombotic therapy
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
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
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
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
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
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
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
      o 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
      o 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
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
          o Diameter versus area
          o Lesion length
   vi) Spectral Doppler interpretation
       • Normal flow characteristics
          o Native arteries
          o Bypass grafts/stents
       • Abnormal flow characteristics
          o Stenosis
          o Occlusion
          o Bypass grafts/stents
          o Aneurysms
          o Pseudoaneurysms
          o Trauma
       • Qualitative interpretation
          o Phasicity
          o Spectral broadening
          o Turbulence
       • Quantitative interpretation
          o Peak systolic velocity
          o End-diastolic velocity
          o Velocity ratio
          o Pulsatility index
          o Resistive index
          o Acceleration time
       • Pitfalls of measurements
   vii) Color Doppler interpretation
       • Presence/absence of flow
       • Direction of flow
       • Flow characteristics
   viii) Capabilities
   ix) Limitations
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
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 hepatopancreatic 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)
vii) Portal vein tributaries
   o Superior mesenteric vein
   o 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
b. Acute mesenteric ischemia
   i) Consistent clinical features
      • Insidious onset acute, severe abdominal pain out of proportion to physical findings.
      • Result of delayed diagnosis
         o Potential for catastrophic gastrointestinal ischemia
         o 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
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
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
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)
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
               o Multilobar
               o Concomitant arteriovenous fistula
            • Measurements
               o Pseudoaneurysm diameter
               o Neck length and diameter
      v) Spectral Doppler interpretation
         • Characteristics of flow
         • Measurements/waveform analysis
            o Characteristic to-fro Doppler signal
            o Proximal and distal atrial 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
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
Abnormal characteristics

Measurements
  o Pre and post-injection
  o Anterior-posterior dimensions
    ~ cavernosal arteries
    ~ deep dorsal vein

v) Spectral Doppler interpretation

Normal characteristics

Abnormal characteristics

Measurements
  o Post-injection timing
  o Peak systolic velocity
    ~ Pre-injection
    ~ Post-injection
  o End diastolic velocity
    ~ Pre-injection
    ~ Post-injection
  o Duration of erection
  o 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
vi) Interpretation of waveforms and pressures
   • Normal characteristics
   • Abnormal characteristics
   • Measurements
     o Qualitative
     o 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
       o Arterial/venous diameter proximal to thoracic outlet
       o Arterial/venous diameter distal to thoracic outlet

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

<table>
<thead>
<tr>
<th>A</th>
<th>Alternating Current</th>
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<tbody>
<tr>
<td>ACA</td>
<td>Anterior Cerebral Artery</td>
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<tr>
<td>ACoA</td>
<td>Anterior Communicating Artery</td>
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<tr>
<td>AV</td>
<td>Arteriovenous</td>
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<tr>
<td>B</td>
<td>Basilar Artery</td>
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<tr>
<td>C</td>
<td>Common Carotid Artery</td>
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<tr>
<td>CEAP</td>
<td>Clinical Etiologic Anatomic Pathologic Classification</td>
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<tr>
<td>CFA</td>
<td>Common Femoral Artery</td>
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<td>CFV</td>
<td>Common Femoral Vein</td>
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<tr>
<td>CRT</td>
<td>Cathode Ray Tube</td>
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<tr>
<td>CTA</td>
<td>Computed Tomographic Angiography</td>
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<td>CTV</td>
<td>Computed Tomographic Venography</td>
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<td>CVA</td>
<td>Cerebrovascular Accident</td>
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<td>CVI</td>
<td>Chronic Venous Insufficiency</td>
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<td>CW</td>
<td>Continuous Wave Doppler</td>
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<td>D</td>
<td>Direct Current</td>
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<tr>
<td>DICOM</td>
<td>Digital Imaging and Communications in Medicine</td>
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<td>DSA</td>
<td>Digital Subtraction Angiography</td>
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<td>E</td>
<td>External Carotid Artery</td>
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<td>ECST</td>
<td>European Carotid Surgery Trial</td>
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<td>EDV</td>
<td>End-Diastolic Velocity</td>
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<td>Fibromuscular Dysplasia</td>
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<td>Femoral Vein</td>
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<td>I</td>
<td>Internal Carotid Artery</td>
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<tr>
<td>IMA</td>
<td>Inferior Mesenteric Artery; Internal Mammary Artery</td>
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<tr>
<td>IMT</td>
<td>Intimal Medial Thickness</td>
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<td>Inferior Vena Cava</td>
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<td>M</td>
<td>Middle Cerebral Artery</td>
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<td>MRA</td>
<td>Magnetic Resonance Arteriography</td>
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<td>Posterior Communicating Artery</td>
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<td>Pulsatility Index</td>
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<td>Peak Systolic Velocity</td>
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<td>Percutaneous Transluminal Angioplasty</td>
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<td>Pulsed Wave Doppler</td>
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Utilized References