Course Description
This course will provide the student with initial instruction in non-invasive vascular diagnosis. Included in course instruction are vascular anatomy, physiology and pathophysiology pertinent to non-invasive vascular diagnosis. The student will learn various forms of instrumentation and techniques used for the assessment of the vascular patient: sonography, plethysmography and transcutaneous monitoring are among the most common.

Through lectures and laboratory workshop training the fundamental non-invasive vascular sonographic and physiologic testing modalities will be introduced as they are applied to the assessment of vascular anatomy, physiology and pathophysiology.

Credits/Modes of Instruction
Non-invasive Vascular Diagnostics I will consist primarily of 48 classroom hours (web enhanced), approximately ½ hour of weekly reading, 16 hours of project preparation time, and 1 hour of weekly laboratory sessions. Other time will be necessary for the student to manage in the preparation and completion of quizzes, examinations, term paper preparation and 1 student presentation. 3 credits will be awarded upon successful completion of course requirements.

Pre/co-requisites
CVXS4000 Cardiovascular Principles. Students matriculated in the Cardiac Sonography Program.

Instructor
Garth Nanni, office 908-889-2468, email nannigs@shp.rutgers.edu
Office hours by appointment

Course Goals and Objectives:
Goals
The goal of this course is to introduce the student to the sonographic and physiologic methods of non-invasive vascular diagnosis. This course will concentrate on the most commonly used examinations to prepare the student for their clinical experiences beginning in the following semester. Students must have sound knowledge of these methods to produce diagnostic quality examination.

Objectives
The general objective of this course is to provide the student with the knowledge necessary to perform comprehensive non-invasive diagnostic examinations. At the conclusion of this course the student will be able to perform/demonstrate the following:

A. Fluid Dynamics
   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

B. Physical and Electrical Principles
   8. Relate the difference between ultrasound energy and power
   9. Describe the types of graphic recording used in noninvasive vascular testing
  10. Explain methods for calibrating sonographic imaging systems and plethysmographic instruments
   11. Define alternating current (AC) versus direct current (DC) coupling, and explain the potential artifacts associated with inappropriate use
   12. Understand the most common units of measure associated with noninvasive vascular testing
   13. Describe the most common tests used for evaluation of tissue mechanics and pressure transmission in the peripheral venous and arterial systems
   14. List the types of plethysmography and pressure assessments used for evaluation of the peripheral arteries and veins
   15. Explain the relationship between Ohm’s Law and hemodynamics

C. Cerebrovascular
   16. Identify the vessels in the extracranial and intracranial cerebrovascular system
   17. Explain the effects of collateral flow on cerebral hemodynamics
   18. List the risk factors and mechanism for cerebrovascular disease
   19. Describe the evolution of atherosclerotic plaque
   20. Define transient ischemic attack (TIA), reversible ischemic neurologic deficit (RIND), stroke and vertebrobasilar insufficiency (VBI)
   21. Describe the capabilities, limitations, protocol/techniques, waveforms and diagnostic criteria for cerebrovascular circulation test procedures
   22. Describe the effects of stenosis and occlusion on flow characteristics in the extracranial cerebrovascular system
   23. Define standard contrast, digital subtraction, computed tomographic arteriography and magnetic resonance arteriography
   24. List the current treatment options for patients with cerebrovascular disease

D. Peripheral Venous
   25. Identify the central, upper and lower extremity deep and superficial veins, and list the major perforating veins in the lower extremity
   26. Describe the function of vein valve leaflets in venous physiology in the normal patient and the patient with venous insufficiency
   27. List the components of Virchow’s Triad, and relate how these impact venous pathophysiology
   28. Describe risk factors for venous thrombosis
   29. Relate the mechanisms of disease associated with acute and chronic deep vein thrombosis, superficial thrombophlebitis, venous insufficiency and
30. Define the clinical signs associated with acute and chronic deep vein thrombosis and superficial thrombophlebitis
31. Describe the role of the calf muscle pump in venous physiology
32. Relate the pathological findings associated with venous stasis and venous insufficiency
33. 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
34. Define correlative imaging technologies
35. List the current treatment options for patients with deep vein thrombosis or superficial thrombophlebitis
36. Describe the CEAP classification for chronic venous insufficiency

Course Requirements
Requirements for Completion

<table>
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<th>Requirements</th>
<th>Weight</th>
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<tr>
<td>Quizzes (cumulative average)</td>
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<td>Mid-term Examination</td>
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<td>Final Examination</td>
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<tr>
<td>Term project*</td>
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<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
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</table>

*The course requires the completion of a term project based on a specific testing modality and its application. The instructor will provide details of the project by the second week of the term. The project is due 2 weeks prior to term end.

Special Enrollment Requirements

The student will need the use of a computer with internet access for web enhanced components (Moodle course management software).

Evaluation, Feedback and Grading

Evaluation/Assessment Methods
The efficacy of this course will be assessed through:
- student evaluation of the course and instructor
- student adaption of material to clinical education
- ongoing analysis of test scores
- certification exam results (as applicable)

Feedback on Progress
The student will received feedback on progress via review of quizzes, examinations and project(s).
**Course Evaluation by Students**

At the conclusion of the course, students will complete the standard SHP course evaluation form available by hardcopy distributed by the instructor or via the Moodle course management system.

The program faculty and staff also monitor national credentialing examinations (offered American Registry of Diagnostic Medical Sonography and Cardiovascular Credentialing International) for graduate pass rates as a measure of course/program effectiveness.

The program also conducts an employer survey post graduation as a further measure of course/program effectiveness.

Any additional suggestions/comments during the semester may be solicited.

**Grade Determination**

A grade of 80% has been established as the satisfactory level for all academic and clinical courses in the Cardiac Sonography program. A final grade below 80% at any time during enrollment in the program may subject a student to dismissal. A student who receives two final grades below 80% will automatically be dismissed from the program.

The grade for this course will be letter grade as noted below.

<table>
<thead>
<tr>
<th>Weighted Average of All Requirements</th>
<th>Final Letter Grade</th>
<th>Grade Quality Description</th>
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<tr>
<td>93-100%</td>
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<td>90-92.9%</td>
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<td>80-82.9%</td>
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<td>73-76.9%</td>
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<td>&lt;63</td>
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*Should the student's final average fall in the range: <80% & ≥75% they will be afforded an opportunity to retake a failed mid-term or final examination to achieve a passing final average. This is with the understanding that the highest final average for grading achievable will be 80%.*
Retake of an examination is at the discretion of the instructor in consultation with the program director taking into consideration the student’s standing in other courses (i.e. a student with multiple failed or failing courses may not be afforded the examination retake opportunity).

**Faculty/Student Honor Code**

(Refer to your SHP Student Handbook at [http://shp.rutgers.edu/current_students/pdf/Handbook.pdf](http://shp.rutgers.edu/current_students/pdf/Handbook.pdf))

The faculty of Rutgers – School of Health Professions believe that students must observe and support high standards of honesty and integrity in all aspects of education, practice, and research. For this reason, all matriculated and non-matriculated students in this course are expected to abide by the School's Faculty/Student Honor Code and accept responsibility to help ensure that these standards are maintained by reporting violations of the Honor Code observed in others. All violations will be considered with gravest concern and may be punishable with sanctions as severe as suspension or dismissal.

**General Learning Resources**

**Required Textbook(s)**

**Other Required Learning Resources**

**Recommended or Supplemental Learning Resources**
None

**Course Units/Schedule**

The course will take place during the Fall I program semester. For additional see program schedule on the group website, Rutgers-SHP internet portal. Instructions for accessing the portal are included in the program student manual and orientation.

**Cerebrovascular**

**Week 1/2**

A. Anatomy review
   1. Aortic arch
      a. Components
      b. Major branches
      c. Origination and termination of vessels
      d. Relational anatomy of vessels
      e. Collateral pathways
   2. Carotid artery (extracranial)
      a. Components
      b. Origination and termination of vessels
      c. Relational anatomy
      d. Collateral pathways
   3. Vertebral artery (Vert)
      a. Segments
      b. Origination and termination
c. Relational anatomy
d. Collateral pathways

B. Intracranial Circulation

1. Components
   a. Circle of Willis and contributing arteries
   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

Week 3/4

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

**Week 5/6**

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
      f. Spectral Doppler interpretation
      g. Color Doppler interpretation
      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
   c. Examination protocol
   d. Imaging and spectral Doppler techniques
   e. Spectral Doppler interpretation
   f. Color Doppler interpretation
   g. Capabilities
   h. Limitations
J. Continuous Wave (CW) Doppler
   1. Patient positioning
   2. Examination protocol/technique
   3. Interpretation
      a. Normal characteristics
      b. Abnormal characteristics
      c. Measurements

Week 7/8
K. Correlative and/or Prior Imaging
   1. Conventional arteriography
      a. Interpretation
      b. Limitations
   2. Digital subtraction arteriography (DSA)
      a. Interpretation
      b. Limitations
   3. Computed tomography arteriography (CTA)
      a. Interpretation
      b. Limitations
   4. Magnetic resonance arteriography (MRA)
      a. Current clinical use
      b. Interpretation
      c. Limitations
L. Treatment
   1. Indications
   2. Medical control and reduction of risk factors
      a. Lifestyle
      b. Pharmacologic control
   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

Peripheral Venous
Week 9/10
M. Anatomy review
   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
   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
         • 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

Week 11/12
N. 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

O. 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)
P. 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)

Week 13/14
Q. 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
      f. Spectral Doppler interpretation
      g. Color Doppler interpretation
      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)
R. Noninvasive Test Procedures for Chronic Venous Insufficiency
   1. Duplex imaging/color flow imaging
      a. Identification of valvular incompetence
      b. Identification of perforator incompetence
      c. Venous obstruction
      d. Assistance during and after radiofrequency/laser ablation procedures
   2. Reflux plethysmography
      a. Photoplethysmography (PPG)
      b. Air plethysmography
S. CEAP Classification
   1. Classification system for reporting and treating the diverse manifestations of chronic venous disorders
      a. Clinical
      b. Etiology
      c. Anatomy
      d. Pathophysiology

Week 15/16
T. Correlative and/or Prior Imaging
   1. Conventional venography
a. Ascending
b. Descending

2. Magnetic resonance venography (MRV)
3. Computed tomography venography (CTV)

U. Other Diagnostic Testing
1. Ventilation perfusion lung scan
2. D-dimer assay
3. CTA

V. 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

Information for Students with Disabilities
Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: http://shp.rutgers.edu/current_students/disability_services/register_ds.html. If the documentation supports your request for reasonable accommodations, your campus’s disability services office will provide you with a Letter of Accommodations. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. To begin this process, please complete the Registration form on the Rutgers Office of Disability Services website at: https://webapps.rutgers.edu/student-ods/forms/registration

Reference