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49 **Description of the Profession**  
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51 The profession of advanced cardiovascular sonography includes advanced cardiac sonographers (ACS) and  
52 advanced vascular sonographers (AVS) who: 1) assist staff sonographers to assess cases that require 2D,  
53 Doppler, advanced measurements, and advanced imaging/non-imaging techniques; 2) review studies that have  
54 been performed by the staff sonographer in preparation for review by the supervising physician; 3) provide in-  
55 service education for staff sonographers of new methods that are to be incorporated in the examination; 4)  
56 ensure that the necessary data is obtained based on the clinical history and presentation; and 5) establish  
57 quality assurance measures to maintain the highest standard of care of a laboratory by closely monitoring  
58 sonographer performance and identifying training needs.  
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60 The ACS or AVS is a highly skilled professional qualified by education, experience and certification to provide the  
61 above services. The ACS or AVS works under physician supervision, applying clinical knowledge to the exam to  
62 ensure that all information is obtained from the exam to answer the clinical question.

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64 **I. Sponsorship**  
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66 **A. Program Sponsor**

67 A program sponsor must be at least one of the following

- 68 1. A post-secondary academic institution accredited by an institutional accrediting agency that is  
69 recognized by the U.S. Department of Education and must be authorized under applicable law or  
70 other acceptable authority to provide a post-secondary program, which awards a minimum of a  
71 certificate at the completion of the program.  
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- 73 2. A hospital, clinic or medical center accredited by a healthcare accrediting agency that is recognized  
74 by the U.S. Department of Health and Human Services, and authorized under applicable law to  
75 provide healthcare, and authorized under applicable law to provide the post-secondary program,  
76 which awards a minimum of a certificate at the completion of the program.  
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- 78 3. A branch of the United States Armed Forces, or a federal or state governmental agency, which  
79 awards a minimum of a certificate at the completion of the program.  
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81 **B. Responsibilities of Program Sponsor**

82 The program sponsor must

- 83 1. Ensure that the program meets the Standards.  
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- 85 2. Award academic credit for the program or have an articulation agreement with an accredited post-  
86 secondary institution;  
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- 88 3. Have a preparedness plan in place that assures continuity of education services in the event of an  
89 unanticipated interruption; and  
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91 *Examples of unanticipated interruptions may include unexpected departure of key personnel, natural*  
92 *disaster, public health crisis, fire, flood, power failure, failure of information technology services, or*  
93 *other events that may lead to inaccessibility of educational services.*  
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- 95 4. Ensure that the graduates of the program have obtained or will obtain a minimum of a bachelor's  
96 degree upon completion of the program.

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*The student entering the program should hold an entry-level technical credential in sonography.*

## 100 II. Program Goals

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### A. Program Goals and Minimum Expectations

The program must have the following minimum expectations statement: “To prepare advanced cardiac sonographer and/or advanced vascular sonographers who are competent in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains to enter the profession for the following concentration(s) it offers:

- Advanced cardiac sonography
- Advanced vascular sonography.”

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Programs that adopt educational goals beyond the minimum expectations statement must provide evidence that all students have achieved those goals prior to entry into the advanced cardiovascular sonography field.

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Program goals must be compatible with the mission of the sponsoring institution(s), the expectations of the communities of interest, and accepted standards of roles and functions of an advanced cardiovascular sonographer. Goals are based upon the substantiated needs of health care providers and employers, and the educational needs of the students served by the educational program. Program goals must be written referencing one or more of the learning domains.

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The program must assess its goals at least annually and respond to the changes in the needs and expectations of its communities of interest.

### 123 B. Program Advisory Committee

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The program advisory committee must include at least one representative of each community of interest and must meet annually. Communities of interest served by the program include, but are not limited to students, graduates, faculty members, sponsor administrators, employers, physicians, and the public.

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The program advisory committee advises the program regarding revisions to curriculum and program goals based on the changing needs and expectations of the program’s communities of interest, and an assessment of program effectiveness, including the outcomes specified in these Standards.

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*Program advisory committee meetings may be conducted using synchronous electronic means.*

## 136 III. Resources

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### A. Type and Amount

Program resources must be sufficient to ensure the achievement of the program’s goals and outcomes. Resources must include, but are not limited to

1. Faculty;
2. Administrative and support staff;
3. Curriculum;
4. Finances;
5. Faculty and staff workspace;
6. Space for confidential interactions;

- 147 7. Classroom and laboratory (physical or virtual);  
148 8. Ancillary student facilities;  
149 9. Clinical affiliates;  
150 10. Equipment;  
151 11. Supplies;  
152 12. Information technology;  
153 13. Instructional materials; and  
154 14. Support for faculty professional development.

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156 **B. Personnel**

157 The sponsor must appoint sufficient faculty and staff with the necessary qualifications to perform the  
158 functions identified in documented job descriptions and to achieve the program’s stated goals and  
159 outcomes.

160 At a minimum, the following positions are required.

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163 **1. Program Director**

164 **a. Responsibilities**

165 The program director must be responsible for all aspects of the program, including but not  
166 limited to

- 167 1) Administration, organization, and supervision of the program;  
168 2) Continuous quality review and improvement of the program;  
169 3) Academic oversight, including curriculum planning and development; and  
170 4) Ensuring achievement of the program’s goals and outcomes.

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172 **b. Qualifications**

- 173 1) The program director for the advanced cardiac sonography concentration must  
174 a) Have documented education or experience in instructional methodology; and  
175 b) Meet at least one of the following  
176 1. Possess a minimum of a bachelor’s degree and an advanced cardiac credential  
177 offered by an organization accredited by the National Commission for Certifying  
178 Agencies (NCCA), by the American National Standards Institute (ANSI), or under  
179 International Organization for Standardization (ISO); or  
180 2. Possess a minimum of a master’s degree and a cardiac credential offered by an  
181 organization accredited by the National Commission for Certifying Agencies (NCCA),  
182 by the American National Standards Institute (ANSI), or under International  
183 Organization for Standardization (ISO); or  
184 3. Be a physician board-certified in the cardiac discipline.

185 *The ACS credential fulfills the advanced cardiac credential.*

186 *Examples of cardiac credentials are RDCS and RCS credentials.*

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190 2) The program director for the advanced vascular sonography concentration must  
191 a) Have documented education or experience in instructional methodology; and  
192 b) Meet at least one of the following  
193 1. Possess a minimum of a bachelor’s degree, vascular credential offered by an  
194 organization accredited by the National Commission for Certifying Agencies (NCCA),  
195 by the American National Standards Institute (ANSI), or under International  
196 Organization for Standardization (ISO), and 3 years of experience; or  
197 2. Possess a master’s degree and vascular credential offered by an organization

198 accredited by the National Commission for Certifying Agencies (NCCA), by the  
 199 American National Standards Institute (ANSI), or under International Organization  
 200 for Standardization (ISO); or  
 201 3. Be a physician board certification in the vascular discipline.  
 202  
 203 *Examples of vascular credentials are RVT, RVS, or RT(VS) credentials.*  
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 205 *One individual may serve as program director for both concentrations provided the qualifications*  
 206 *of each position are met.*  
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 208 **2. Medical Advisor**  
 209 **a. Responsibilities**  
 210 The medical advisor(s) must  
 211 1) Provide the input necessary to ensure that the medical components of the curriculum, both  
 212 didactic and supervised practice, meets current standards of medical practice; and  
 213 2) Engage in cooperative involvement with the program director.  
 214  
 215 **b. Qualifications**  
 216 The medical advisor(s) must  
 217 1) Be a physician (MD or DO) currently licensed and board certified in the discipline(s) offered;  
 218 2) Have the requisite knowledge and skills to advise the program leadership about the  
 219 clinical/academic aspects of the program; and  
 220 3) Be knowledgeable in teaching the subjects assigned, when applicable.  
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 222 **3. Faculty/Instructional Staff**  
 223 **a. Responsibilities**  
 224 For all didactic, laboratory, and clinical instruction to which a student is assigned, there must be  
 225 a qualified individual(s) clearly designated by the program to provide instruction, supervision,  
 226 and timely assessment of the student’s progress in meeting program requirements.  
 227  
 228 **b. Qualifications**  
 229 Faculty/instructional staff must be effective in teaching and knowledgeable in subject matter as  
 230 documented by appropriate professional credential(s)/certification(s), education, and  
 231 experience in the designated content area.  
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 233 *The ACS credential fulfills the advanced cardiac credential.*  
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 235 *Examples of cardiac credentials are RDCS and RCS credentials.*  
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 237 *Examples of vascular credentials are RVT, RVS, or RT(VS) credentials.*  
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 239 **C. Curriculum**  
 240 The curriculum content must ensure that the program goals are achieved. Instruction must be based on  
 241 clearly written course syllabi that include course description, course objectives, methods of evaluation,  
 242 topic outline, and competencies required for graduation. Instruction must be delivered in an appropriate  
 243 sequence of classroom, laboratory, and clinical activities.  
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 245 The program must demonstrate that the curriculum offered meets or exceeds the content listed in  
 246 Appendix B of these **Standards**.  
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 248 *CAAHEP supports and encourages innovation in the development and delivery of the curriculum.*  
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**D. Resource Assessment**

The program must, at least annually, assess the appropriateness and effectiveness of the resources described in these **Standards**. The results of resource assessment must be the basis for ongoing planning and change. An action plan must be developed when needed improvements are identified in the program resources. Implementation of the action plan must be documented, and results measured by ongoing resource assessment.

**IV. Student and Graduate Evaluation/Assessment**

**A. Student Evaluation**

**1. Frequency and purpose**

Evaluation of students must be conducted on a recurrent basis and with sufficient frequency to provide both the students and program faculty with valid and timely indications of the students' progress toward and achievement of the curriculum competencies in the required learning domains.

*Validity means that the evaluation methods chosen are consistent with the learning and performance objectives being tested.*

**2. Documentation**

Student evaluations must be maintained in sufficient detail to document learning progress and achievements.

**B. Outcomes**

The program must meet the established outcomes thresholds.

**1. Assessment**

The program must periodically assess its effectiveness in achieving established outcomes. The results of this assessment must be reflected in the review and timely revision of the program.

Outcomes assessments for programs offering the advanced cardiac sonography concentration must include but are not limited to national credentialing examination(s) performance, programmatic retention, graduate satisfaction, employer satisfaction, and placement in full or part-time employment in the profession or in a related profession.

Outcomes assessments for programs offering the advanced vascular sonography concentration must include but are not limited to programmatic retention, graduate satisfaction, employer satisfaction, and placement in full or part-time employment in the profession or in a related profession.

A related profession is one in which the individual is using cognitive, psychomotor, and affective competencies acquired in the educational program.

Graduates pursuing academic education related to progressing in health professions or serving in the military are counted as placed.

*A national certification examination program should be accredited by the National Commission for Certifying Agencies (NCCA), American National Standards Institute (ANSI), or under International Organization for Standardization (ISO).*

300 *Results from an alternative examination may be accepted as an outcome, if designated as equivalent*  
301 *by the organization whose credentialing examination is so accredited.*

## 302 303 **2. Reporting**

304 At least annually, the program must periodically submit to the CoA-ACS the program goal(s),  
305 outcomes assessment results, and an analysis of the results.

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307 If established outcomes thresholds are not met, the program must participate in a dialogue with and  
308 submit an action plan to the CoA-ACS that responds to the identified deficiency(ies). The action plan  
309 must include an analysis of any deficiencies, corrective steps, and timeline for implementation. The  
310 program must assess the effectiveness of the corrective steps.

## 311 312 313 **V. Fair Practices**

### 314 315 **A. Publications and Disclosure**

316 **1.** Announcements, catalogs, publications, advertising, and websites must accurately reflect the  
317 program offered.

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319 **2.** At least the following must be made known to all applicants and students

- 320 **a.** Sponsor's institutional and programmatic accreditation status;
- 321 **b.** Name and website address of CAAHEP;
- 322 **c.** Admissions policies and practices;
- 323 **d.** Technical standards
- 324 **e.** Occupational risks;
- 325 **f.** Policies on advanced placement, transfer of credits, and credits for experiential learning;
- 326 **g.** Number of credits required for completion of the program;
- 327 **h.** Availability of articulation agreements for transfer of credits;
- 328 **i.** Tuition/fees and other costs required to complete the program;
- 329 **j.** Policies and processes for withdrawal and for refunds of tuition/fees; and
- 330 **k.** Policies and processes for assignment of clinical experiences.

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332 **3.** At least the following must be made known to all students

- 333 **a.** Academic calendar;
- 334 **b.** Student grievance procedure;
- 335 **c.** Appeals process;
- 336 **d.** Criteria for successful completion of each segment of the curriculum and for graduation; and
- 337 **e.** Policies by which students may perform clinical work while enrolled in the program.

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339 **4.** The sponsor must maintain and make accessible to the public on its website a current and  
340 consistent summary of student/graduate achievement that includes one or more of these program  
341 outcomes: national credentialing examination(s), programmatic retention, and placement in full or  
342 part-time employment in the profession or a related profession as established by the CoA-ACS.

### 343 344 **B. Lawful and Non-discriminatory Practices**

345 All activities associated with the program, including student and faculty recruitment, student admission,  
346 and faculty employment practices, must be non-discriminatory and in accord with federal and state  
347 statutes, rules, and regulations. There must be a faculty grievance procedure made known to all paid  
348 faculty.

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**C. Safeguards**

The health and safety of patients/clients, students, faculty, and other participants associated with the educational activities of the students must be adequately safeguarded. Advanced cardiovascular sonography students must be readily identifiable as students.

All activities required in the program must be educational and students must not be substituted for staff.

The program must ensure voluntary and prudent use of students or other human subjects for nonclinical scanning. Students' grades and evaluations must not be affected by participation or nonparticipation. If non-incidental findings are found, the student must be instructed to seek care with a medical provider without disclosing the suspected finding.

**D. Student Records**

Grades and credits for courses must be recorded on the student transcript and permanently maintained by the program sponsor in an accessible and secure location. Students and graduates must be given direction on how to access their records. Records must be maintained for admission, advisement, and counseling while the student is enrolled in the program.

**E. Substantive Change**

The sponsor must report substantive change(s) as described in Appendix A to CAAHEP/CoA in a timely manner.

**F. Agreements**

There must be a formal affiliation agreement or memorandum of understanding between the program sponsor and all other entities that participate in the education of the students describing the relationship, roles, and responsibilities of the program sponsor and that entity.

## APPENDIX B

### Curriculum Competencies for Educational Programs in Advanced Cardiovascular Sonography

Appendix B includes learning competencies common to both concentrations and specific to each concentration.

#### 1. Learning competencies common to both concentrations

##### a. Physics and Instrumentation (Cognitive)

Demonstrate the role each of the following physics concepts and instrumentation plays in performing a cardiovascular sonography procedure.

- 1) Waves and sound waves
- 2) Hemodynamics
- 3) Principles of Doppler Techniques
- 4) Interaction of sound waves and media
- 5) System Functionality and Operation
- 6) Transducers
- 7) Image Acquisition and Storage
- 8) Artifacts
- 9) Contrast and harmonics
- 10) Bioeffects
- 11) Quality assurance
- 12) Image optimization
- 13) New and emerging technologies

##### b. Introduction to Clinical Trials Research and IRB Requirements (Cognitive)

Explain how principles of clinical trials and IRB requirements are applied to research in advanced cardiovascular sonography.

- 1) Responsibilities and Organization
- 2) Specific Clinical Trials Design
- 3) Clinical Trial Study Protocols
- 4) Clinical Sites
- 5) Statistical Analysis
- 6) Data Handling and Management
- 7) Quality Assurance
- 8) Regulatory Considerations
- 9) IRB Application Process
- 10) Subjects Training

##### c. Research Methods and Biostatistics (Cognitive)

Demonstrate knowledge of types of research methods and application of biostatistics to determine research results.

- 1) Research Methods
  - a) Population Surveys
  - b) Hypothesis Testing
  - c) Outcomes Research
  - d) Randomized versus Nonrandomized
  - e) Blinded versus Nonblinded (single, double, triple)
  - f) Simulations

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Standards initially adopted in 2012; revised in 2016, 2020, xxxx.

- 426 g) Qualitative Data Collection
- 427 h) Qualitative Data Analysis
- 428 i) Mixed Methods
- 429 2) Biostatistics
- 430 a) Probability
- 431 b) Data Distribution Types
- 432 c) Concepts of Inference
- 433 d) Inference for Single Samples
- 434 e) Inference for Two Samples
- 435 f) Inference for Proportions
- 436 g) Regression and Correlation
- 437 h) Analysis of Variance (ANOVA)
- 438 i) Nonparametric Statistical Methods

**d. Instructional Techniques for the Adult Learner (Cognitive and Affective)**

**Apply knowledge in the types of learning models to effectively teach, communicate and collaborate in the healthcare environment.**

- 443 1) Adult Learning Modules
- 444 2) Behaviorism
- 445 3) Cognitivism
- 446 4) Social Learning Theory
- 447 5) Motivation to learn
- 448 a) Learners' beliefs and values
- 449 b) Setting and pursuing meaningful goals
- 450 c) Fostering self-regulated and continual learning
- 451 6) Social and emotional influences on learning
- 452 a) Optimal learning environments
- 453 b) Belongingness
- 454 c) Interpersonal relationships
- 455 d) Sense of agency and purpose
- 456 e) Teamwork and collaboration
- 457 7) Providing effective feedback
- 458 8) Recognizing and responding to individual differences and needs
- 459 9) Building on existing knowledge and skills

**e. Accreditation Preparedness (Cognitive)**

**Demonstrate knowledge of a quality control and improvement program.**

- 463 1) Equipment Information
- 464 2) Procedure Volumes
- 465 3) Training/Experience Qualification for Physicians and Technologists
- 466 4) Credential Information
- 467 5) Continuing Medical Education
- 468 6) Policies
- 469 a) Primary Source Verification Policy
- 470 b) Patient Complaint Policy
- 471 c) Personnel Safety Policy (Ergonomics)
- 472 d) Patient Safety Policy
- 473 e) Patient Confidentiality Policy
- 474 f) Quality Improvement (QI) Policy

- 475 7) Quality Improvement
- 476 a) Program
- 477 b) Oversight
- 478 c) Measures
- 479 d) Meetings
- 480 e) Documentation
- 481 8) Examination Protocols
- 482 9) Case Studies
- 483 10) Ergonomics
- 484

## 2. Learning competencies for the advanced cardiac sonography concentration

### a. Cardiac Hemodynamics/Pathophysiology (Cognitive)

**Demonstrate knowledge of normal and abnormal cardiac pathophysiology and hemodynamics with application in the echocardiographic laboratory.**

- 489 1) Cardiac Cycle
  - 490 a) Generation of action potentials
  - 491 b) Electrical activation of the heart
  - 492 c) Mechanical sequence of events
    - 493 i. Pressure curves for ventricles, atria and great arteries
    - 494 ii. Left ventricular volume curve
    - 495 iii. Valve movements and heart sounds
    - 496 iv. Pressure-Volume loops: normal
- 497 2) Determinants of Ventricular Function
  - 498 a) Stroke volume, cardiac index and ejection fraction
  - 499 b) Ventricular strain
  - 500 c) Control of myocardial contractile performance
    - 501 i. Preload and Starling's curves
    - 502 ii. Afterload and Afterload-Velocity curves
    - 503 iii. Contractility
    - 504 iv. Pressure-Volume loops: altered preload, afterload and contractility
  - 505 d) Diastolic Function
    - 506 i. Relaxation
    - 507 ii. Compliance/Stiffness
- 508 3) Autonomic Nervous System
  - 509 a) Anatomy of the sympathetic and parasympathetic systems
  - 510 b) Distribution and properties of autonomic receptors
  - 511 c) Cardiovascular responses evoked by agonists and antagonists of the autonomic nervous system
- 512 4) Reflex and Humoral Control of the Circulation
  - 513 a) Baroreceptor reflexes
  - 514 b) Renin-Angiotensin-Aldosterone
  - 515 c) Anti-Diuretic Hormone
  - 516 d) Cardiac Natriuretic Peptides
- 517 5) Vascular Flow, Including Coronary Blood Flow
  - 518 a) Relationship between blood viscosity and hematocrit
  - 519 b) Relationship between blood viscosity and flow rate (shear stress)
  - 520 c) Turbulence; Reynolds Number
  - 521 d) Flow, pressure, resistance relationship and Poiseuille's Law
    - 522 i. Autoregulation
    - 523 ii. Mechanical factors
    - 524 iii. Metabolic factors (myocardial oxygen demand)
    - 525 iv. Neural factors
    - 526 v. Pharmacologic agents

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- 527 vi. Coronary flow reserve
- 528 6) Valvular HeartDisease
- 529 a) Pathophysiology of aortic and mitral stenosis
- 530 i. Geometric valve area and effective orifice area
- 531 ii. Blood velocity and pressure gradient
- 532 iii. Pressure curves
- 533 iv. Effects on chambers
- 534 b) Pathophysiology of aortic and mitral regurgitation
- 535 i. Regurgitant orifice area and regurgitant volume
- 536 ii. Pressure curves
- 537 iii. Effects on chambers
- 538 c) Pathophysiology of right-sided valve disease
- 539 7) Exercise Physiology
- 540 a) Cardiovascular responses to upright aerobic exercise
- 541 i. Oxygen uptake, heart rate, stroke volume, cardiac output and A-V O<sub>2</sub> difference
- 542 ii. Effects of training
- 543 b) Cardiovascular responses to supine exercise
- 544 c) Cardiovascular responses to isometric exercise
- 545
- 546 **b. Acquired CardiovascularDisease (Cognitive)**
- 547 **Demonstrate knowledge of mechanisms of disease, sonographic technique, measurements,**
- 548 **quantitative principles, and Doppler patterns in both the normal heart and with cardiac disease.**
- 549 1) Valvular HeartDisease
- 550 2) Prosthetic ValveDisease
- 551 3) Ischemic HeartDisease
- 552 4) Cardiomyopathy
- 553 5) PericardialDisease
- 554 6) Cardiac Trauma
- 555 7) Cardiac Masses
- 556 8) Radiation HeartDisease
- 557 9) Diseases of the Aorta
- 558 10) Infective Endocarditis
- 559 11) Systemic Hypertension
- 560 12) Pulmonary Hypertension
- 561 13) Systemic Disease
- 562
- 563 **c. Congenital CardiovascularDisease (Cognitive)**
- 564 **Demonstrate knowledge in cardiac embryology, identify anatomy and anatomic variants, and**
- 565 **sonographic appearance of normal cardiac structures.**
- 566 1) Embryology and fetal cardiac development - Segmental approach
- 567 2) Cardiac chambers andseptation
- 568 3) Valve anatomy and dynamics
- 569 4) Simple and Complex Congenital Heart Defects
- 570 5) Adult Congenital Heart Disease
- 571 6) Coronary artery anatomy
- 572 7) Relationships of cardiac chambers and great vessels
- 573 8) Mediastinal structures
- 574
- 575 **d. Surgical and Interventional Treatment of Cardiovascular Disease (Cognitive)**
- 576 **Explain the type of interventional and intraoperative procedures and integrate the role of the**
- 577 **advanced sonographer.**

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- 578 1) Intraoperative evaluation
- 579 2) Use of TEE for hemodynamic monitoring
- 580 3) Post-procedure follow-up
- 581 4) Transcatheter interventions
- 582 5) Myocardial Biopsy
- 583 6) Pericardiocentesis
- 584 7) Mechanical Circulatory Support
- 585 8) Cardiac Transplant
- 586 9) Cardiac Resynchronization

**e. Basic and Advanced Echocardiographic Modalities (Cognitive/Psychomotor)**

**Demonstrate knowledge of the indications, utility, limitations, and technical procedures for related echocardiographic studies.**

- 591 1) Contrast Echocardiography
- 592 2) Myocardial Perfusion
  - 593 a) Triggered
  - 594 b) Realtime
- 595 3) Agitated Saline
- 596 4) TEE
- 597 5) Stress Echocardiography
- 598 6) 3D Echocardiography
- 599 7) Strain Imaging and Analysis
- 600 8) Intracardiac Echocardiography
- 601 9) POCUS

**f. Comparative imaging analysis (angiography, nuclear cardiology, cardiac CT and cardiac MRI) (Cognitive/Psychomotor)**

**Demonstrate knowledge of the indications, utility, limitations, and technical procedures for comparative imaging modalities.**

- 607 1. Correlating Test Results with Echocardiography
  - 608 a) Sensitivity
  - 609 b) Specificity
  - 610 c) Positive Predictive Value
  - 611 d) Negative Predictive Value
  - 612 e) Accuracy
  - 613 f) Reliability
  - 614 g) Achieving “gold standard” diagnostic status
  - 615 h) Current “gold standard” correlative testing
  - 616 i) Quality Assurance
- 617 2. Angiography
  - 618 a) Indications and Contraindications
  - 619 b) Limitations
  - 620 c) Risk Factors and Complications
  - 621 d) Cost analysis
- 622 3. Magnetic Resonance Angiography (MRA) or Venography (MRV)
  - 623 a) Indications and Contraindications
  - 624 b) Limitations
  - 625 c) Risk factors and Complications
  - 626 d) Cost analysis
- 627 4. Computed Tomographic Angiography (CTA)
  - 628 a) Indications and Contraindications

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- 629            b) Limitations
- 630            c) Risk factors and Complications
- 631            d) Cost Analysis
- 632            5. Nuclear Medicine and Hybrid Imaging, PET/CT
- 633            a) Indications and Contraindications
- 634            b) Limitations
- 635            c) Risk factors and Complications
- 636            d) Cost analysis
- 637            6. Rest and Exercise Electrocardiography
- 638            a) Indications and Contraindications
- 639            b) Limitations
- 640            c) Risk factors and Complications
- 641            7. Radiation Safety
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- 643            **g. Cardiovascular Pharmacology (Cognitive)**
- 644            **Demonstrate knowledge of the commonly used cardiac pharmacological agents and role in clinical**
- 645            **practice.**
- 646            1) Antihypertensives
- 647            2) Diuretics
- 648            3) ACE Inhibitors
- 649            4) Angiotensin Receptor Blockers
- 650            5) Beta Blockers
- 651            6) Calcium Channel Blockers
- 652            7) Antiarrhythmics
- 653            8) Antiplatelet /Anticoagulants
- 654            9) Chronotropic Agents
- 655            10) Inotropic agents
- 656            11) Nitrates
- 657            12) Amyl Nitrates
- 658            13) Local Anesthetics
- 659            14) Vasopressors
- 660            15) Medications for Sedation
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- 662            **h. Patient Assessment (Cognitive/Psychomotor)**
- 663            **Integrate knowledge and apply simulated competencies in the following patient assessment areas.**
- 664            1) Chart Review
- 665            2) Evaluate Indication
- 666            3) Review Relevant Prior Testing
- 667            4) Relevant Symptoms
- 668            5) Relevant Surgical Histories
- 669            6) Cardiac Risk Factors and Family History
- 670            7) Physical Assessment
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- 672            **3. Learning competencies for the advanced vascular sonography concentration**
- 673            **a. Vascular Hemodynamics/Pathology (Cognitive)**
- 674            **Demonstrate knowledge of normal and abnormal vascular pathophysiology and hemodynamics with c**
- 675            **in the vascular laboratory.**
- 676            1) Arterial Hemodynamics
- 677            a) Energy  $Q = (P1-P2)/R$
- 678            i. Kinetic

- 679 ii. Potential
- 680 iii. Total
- 681 b) Flow, Pressure, and Resistance
- 682 i. Poiseuille's Law and Equation
- 683 c) Pressure Gradients Through the Circulation
- 684 d) Effects of Gravity on Pressure
- 685 e) Resistance to Flow
- 686 i.  $Q = \Delta P \pi r^4 / 8$
- 687 f) Flow Characteristics: High and Low Resistance Flow Patterns
- 688 g) Normal Velocity Changes and Flow Patterns
- 689 i. Laminar
- 690 ii. Blunt
- 691 iii. Bifurcations
- 692 iv. Curved Vessels
- 693 h) Abnormal Flow Characteristics
- 694 i. Stenosis
- 695 i) Bernouli Principle
- 696 ii) Spectral Broadening
- 697 iii) Turbulence
- 698 1. Reynolds Number (disturbed and turbulent flow)
- 699 a.  $Re = Vq2r/\eta$  (viscosity)
- 700 iv) Tandem Lesions
- 701 v) Exercise
- 702 vi) Collateral Blood Flow
- 703 2) Venous Hemodynamics
- 704 a) Hydrostatic Pressure
- 705 b) Compliance and Capacitance
- 706 c) Flow/Pressure/Volume Relationships
- 707 d) Venous Return
- 708 e) Normal Flow Characteristics
- 709 f) Abnormal Flow Characteristics
- 710 g) Edema
- 711 h) Ambulatory Venous Pressure (AVP)
- 712 3) Arteriovenous Fistula/Grafts
- 713
- 714 **b. Vascular Anatomy and Acquired/Congenital Disease (Cognitive and Psychomotor)**
- 715 **Explain the role of the following vascular anatomy and acquired/congenital disease concepts in**
- 716 **performing vascular physiologic and/or vascular sonographic procedures.**
- 717 1) Peripheral Arterial Disease
- 718 2) Peripheral Venous Disease
- 719 a) Anatomy/Anatomic Variants
- 720 i. Normal anatomy
- 721 ii. Anatomic variants
- 722 i) Vessel duplication (partial or complete)
- 723 ii) Variance of vessel origin/termination
- 724 iii) Vessel absence/agenesis
- 725 b) Venous Thromboembolism
- 726 i. Acute deep venous thrombosis
- 727 i) Phlegmasia alba dolens

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Standards initially adopted in 2012; revised in 2016, 2020, xxxx.

- 728 ii) Phlegmasia cerulea dolens
- 729 ii. Chronic post-thrombotic change
- 730 iii. Superficial venous thrombosis
- 731 iv. Recurrent thrombosis
- 732 v. Pulmonary embolism
- 733 c) Chronic Venous Insufficiency
- 734 i. Clinical-Etiology-Anatomy-Pathophysiology (CEAP) classification
- 735 d) Incidental Findings
- 736 i. Edema
- 737 ii. Pathologic lymph nodes
- 738 iii. Popliteal cyst
- 739 iv. Hematoma
- 740 v. Sermoa
- 741 vi. Lymphocele
- 742 3) Peripheral Arterial Disease
- 743 a) Anatomy/Anatomic Variants
- 744 i. Normal anatomy
- 745 ii. Anatomic variants
- 746 i) Variance of vessel origin/termination
- 747 ii) Vessel absence/agenesis
- 748 b) Atherosclerotic occlusive disease
- 749 i. Stenosis criteria
- 750 ii. Collateral routes
- 751 iii. Bypass graft complications
- 752 iv. Endovascular intervention complications
- 753 c) Traumatic Processes
- 754 i. Pseudoaneurysm
- 755 ii. Arteriovenous fistula
- 756 iii. Compartment Syndrome
- 757 iv. Hypothenar hammer syndrome
- 758 d) Embolic Disease
- 759 e) Inflammatory Processes
- 760 i. Takayasu's arteritis
- 761 ii. Giant cell arteritis
- 762 iii. Thromboangitis obliterans
- 763 f) Vasospastic Disorders
- 764 i. Primary Raynaud's
- 765 ii. Secondary Raynaud's
- 766 g) Entrapment Syndromes
- 767 i. Popliteal artery entrapment syndrome
- 768 ii. Thoracic outlet syndrome
- 769 h) Aneurysm
- 770 i) Aortic Coarctation
- 771 j) Fibromuscular Dysplasia
- 772 k) Fibrointimal Hyperplasia
- 773 l) Adventitial Cystic Disease
- 774 4) Hemodialysis access dysfunction/complications
- 775 a) Arteriovenous Fistula (AVF) Maturation Failure
- 776 b) Stenosis

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- 777 i. AVF potential stenotic sites
- 778 ii. Arteriovenous graft (AVG) potential stenotic sites
- 779 c) Thrombosis
- 780 d) Abnormal Flow Volume (inadequate, excessive)
- 781 e) Access Related Steal Syndrome
- 782 f) Pseudoaneurysm
- 783 g) Aneurysm
- 784 h) Infection
- 785 i) Peri-access Fluid Collections
- 786 5) Cerebrovascular disease
- 787 a) Anatomy/Anatomic Variants
- 788 i. Normal anatomy
- 789 ii. Anatomic variants
- 790 i) Variance of vessel origin/termination
- 791 ii) Vessel absence/agenesis
- 792 b) Extracranial
- 793 i. Atherosclerotic disease
- 794 i) Plaque neovascularity
- 795 ii) Intraplaque hemorrhage
- 796 iii) Stenosis, near-stenosis, and/or occlusion of the carotid and vertebral vessels
- 797 ii. Internal carotid artery (ICA) stenosis criteria
- 798 i) Society of Radiologists in Ultrasound Consensus Conference (SRUCC) 2003 criteria
- 799 ii) Intersocietal Accreditation Commission (IAC) Vascular Testing 2021 modification of the
- 800 SRUCC criteria
- 801 iii. Subclavian steal phenomenon (pre-, partial, and complete steal)
- 802 iv. Arterial dissection
- 803 v. Carotid body tumor
- 804 vi. Fibromuscular dysplasia
- 805 vii. Carotid web
- 806 viii. Takayasu arteritis
- 807 ix. Giant cell arteritis
- 808 x. Transient perivascular inflammation of the carotid artery
- 809 xi. Radiation-induced arterial injury
- 810 xii. Aneurysm
- 811 xiii. Pseudoaneurysm
- 812 xiv. Flow re-direction via bypass grafting with thoracic endovascular aneurysm repair (TEVAR)
- 813 xv. Carotid endarterectomy complications and/or restenosis
- 814 xvi. Carotid stent complications and/or restenosis
- 815 xvii. Carotid bypass graft complications and/or thrombosis
- 816 c) Intracranial
- 817 i. Stenosis/Occlusion
- 818 i) Collateral route of flow
- 819 ii. Cerebral vasospasm
- 820 iii. Arteriovenous malformation
- 821 iv. Sickle cell disease
- 822 v. Microemboli
- 823 vi. Aneurysm
- 824 vii. Fibromuscular dysplasia
- 825 viii. Patent foramen ovale

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- 826 ix. Cerebral circulatory arrest/brain death
- 827 x. Stroke
- 828 i) Ischemic
- 829 ii) Hemorrhagic
- 830 6) Abdominal and Pelvic Vascular Disease
- 831 a) Anatomy/Anatomic Variants
- 832 i. Normal anatomy
- 833 ii. Anatomic variants
- 834 i) Variance of vessel origin/termination
- 835 ii) Vessel absence/agenesis
- 836 iii) Vessel duplication or transposition
- 837 b) Aorta and Iliac Arteries
- 838 i. Stenotic disease
- 839 i) Atherosclerosis
- 840 1) Bypass graft complications
- 841 2) Endovascular intervention complications
- 842 ii) Takayasu arteritis
- 843 iii) Midaortic syndrome
- 844 iv) Posttraumatic aortic stenosis
- 845 v) External Iliac Artery Endofibrosis
- 846 ii. Aortic dissection
- 847 i) Branch vessel involvement
- 848 ii) Thrombus formation
- 849 iii) Aneurysm development
- 850 iii. Abdominal aortic aneurysm
- 851 i) Location (infrarenal, juxtarenal, suprarenal)
- 852 ii) Type (fusiform, inflammatory, saccular, mycotic)
- 853 iii) Branch vessel involvement
- 854 iv) Thrombus formation
- 855 v) Size, growth rate, and risk of rupture
- 856 vi) Graft (open surgical repair) complications
- 857 vii) Endovascular aneurysm repair (EVAR) complications
- 858 iv. Common iliac artery aneurysm
- 859 v. Ruptured aneurysm
- 860 vi. Penetrating ulcer
- 861 vii. Acute aortic syndrome
- 862 viii. Retroperitoneal fibrosis
- 863 ix. Pseudoaneurysm
- 864 c) Hepatoportal vasculature
- 865 i. Portal hypertension
- 866 i) Transjugular intrahepatic portosystemic shunt (TIPS) complications
- 867 ii. Portal vein thrombosis
- 868 i) Malignant/tumor thrombus
- 869 ii) Bland thrombus
- 870 iii. Budd-Chiari syndrome
- 871 iv. Congestive hepatopathy/cardiac cirrhosis
- 872 v. Sinusoidal obstruction syndrome
- 873 vi. Arteriovenous fistula
- 874 vii. Organ procedures

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- 875 i) Native
- 876 ii) Transplanted
- 877 d) Renal vasculature
- 878 i. Renal artery stenosis
- 879 i) Atherosclerosis
- 880 ii) Fibromuscular dysplasia
- 881 ii. Renal artery aneurysm
- 882 iii. Renal vein thrombosis
- 883 iv. Left renal vein compression (nutcracker syndrome)
- 884 v. Renal artery stent complications
- 885 vi. Renal vein stent complications
- 886 e) Mesenteric arteries
- 887 i. Stenosis and/or occlusion of the celiac and mesenteric arteries
- 888 ii. Median arcuate ligament syndrome/cealic artery compression syndrome
- 889 iii. Celiac/superior mesenteric artery stent complications
- 890 iv. Celiac/superior mesenteric artery bypass graft complications
- 891 f) Liver transplant
- 892 i. Vascular complications
- 893 i) Hepatic artery thrombosis
- 894 ii) Hepatic artery stenosis
- 895 iii) Hepatic artery pseudoaneurysm
- 896 iv) Portal vein thrombosis
- 897 v) Portal vein stenosis
- 898 vi) Portal vein steal
- 899 vii) Outflow vein (IVC and/or hepatic vein) thrombosis
- 900 viii) Outflow vein (IVC and/or hepatic vein) stenosis
- 901 Splenoral shunt
- 902 ii. Biliary complications
- 903 iii. Parenchymal abnormalities
- 904 iv. Extrahepatic fluid collections
- 905 g) Kidney transplant
- 906 i. Vascular complications
- 907 i) Renal artery thrombosis
- 908 ii) Renal artery stenosis
- 909 iii) Renal vein thrombosis
- 910 iv) Renal vein stenosis
- 911 v) Arteriovenous fistula
- 912 vi) Arterial pseudoaneurysm
- 913 ii. Parenchymal abnormalities
- 914 iii. Extrarenal fluid collections
- 915 h) Pancreas transplant
- 916 i. Vascular complications
- 917 i) Venous thrombosis
- 918 1) Donor splenic, superior mesenteric, and/or portal vein
- 919 2) Recipient iliac vein, IVC, or superior mesenteric vein
- 920 ii) Arterial thrombosis
- 921 1) Splenic artery, superior mesenteric artery, and/or Y-graft
- 922 iii) Arteriovenous fistula
- 923 iv) Arterial pseudoaneurysm

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- 924 ii. Parenchymal abnormalities
- 925 iii. Peritransplant fluid collections
- 926 i) Inferior vena cava and iliac veins
- 927 i. Thrombosis
- 928 ii. Intraluminal tumor/neoplastic obstruction
- 929 iii. Caval fistula
- 930 iv. Iliac vein compression syndrome (May-Thurner syndrome)
- 931 v. Iliac vein stent complications
- 932 vi. Portalcaval shunt
- 933 j) Pelvic venous disorders
- 934 i. Symptoms-Varices-Pathophysiology (SVP) classification
- 935 k) Penile vasculature
- 936 i. Vasculogenic erectile dysfunction
- 937 i) Arterial insufficiency
- 938 ii) Venous incompetence
- 939 ii. Peyronie’s disease
- 940 iii. Priapism
- 941 i) Ischemic
- 942 ii) Nonischemic

944 **c. Patient Assessment (Cognitive/Psychomotor)**

945 **Integrate knowledge and apply simulated competencies in the following patient assessment areas.**

- 946 1) Evaluate Indication
- 947 2) Review Relevant Prior Testing
- 948 3) Relevant Symptoms
- 949 4) Relevant Surgical Histories
- 950 5) Vascular Risk Factors and Family History
- 951 6) Physical Assessment
- 952 a) Palpation of Pulses
- 953 b) Wound Assessment
- 954 c) Skin Integrity
- 955 d) Edema Assessment
- 956 e) Gait Assessment
- 957 f) Auscultation
- 958 7) Ancillary Testing
- 959 a) Brachial Pressure(s)
- 960 b) Ankle Brachial Index
- 961 c) Allen’s Test
- 962 8) Provocative Maneuvers

964 **d. Non-Invasive, Minimally-Invasive and Surgical Treatment of Vascular Disease (Cognitive)**

965 **Explain the types of interventional and intraoperative procedures and integrate the role of the**

966 **advanced sonographer.**

- 967 1) Venous Disease
- 968 a) Thrombolysis
- 969 b) Thrombectomy
- 970 c) Anticoagulation Management
- 971 d) IVC filter
- 972 e) Compression therapy

- 973 f) Superficial Vein Procedures
- 974 i. Ligation and Stripping
- 975 ii. Thermal Ablation
- 976 iii. Non-thermal Ablation
- 977 iv. Phlebectomy
- 978 v. Sclerotherapy
- 979 g) Venoplasty
- 980 h) H) Venous Stenting
- 981 i) Pelvic Vein Embolization
- 982 j) Surgical Bypass
- 983 k) Valve Replacement/Repair
- 984 2) Arterial Disease
- 985 a) Atherosclerotic disease
- 986 i. Walking program
- 987 ii. Pharmacological treatment
- 988 iii. Interventional procedures
- 989 i) Angioplasty
- 990 ii) Atherectomy
- 991 iii) Arterial Stenting
- 992 iv) Deep Venous Arterialization
- 993 iv. Surgical intervention
- 994 i) Endarterectomy
- 995 ii) Bypass
- 996 iii) Amputation
- 997 b) Dissection
- 998 i. Types
- 999 ii. Pharmacological treatment
- 1000 iii. Surgical treatment
- 1001 iv. Interventional procedures
- 1002 c) Aneurysm
- 1003 i. Types
- 1004 ii. Pharmacological treatment
- 1005 iii. Surveillance Guidelines
- 1006 iv. Surgical treatment
- 1007 v. Interventional procedures
- 1008 d) Pseudoaneurysm
- 1009 i. Types
- 1010 ii. Pharmacological treatment
- 1011 iii. Surveillance Guidelines
- 1012 iv. Surgical treatment
- 1013 v. Interventional procedures
- 1014 3) Thoracic Outlet Syndrome
- 1015 a) Physical Therapy
- 1016 b) Thrombolysis
- 1017 c) Angio/venoplasty and Stenting
- 1018 d) Bypass
- 1019 e) Surgical Decompression
- 1020 4) Vasculitis
- 1021 a) Anti-inflammatory Therapy (Corticosteroids)

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- 1022 b) Immunosuppressants
- 1023 c) Biologics
- 1024 d) IVIG
- 1025 e) Plasmapheresis
- 1026 5) Portal Hypertension
- 1027 a) Transjugular intrahepatic portosystemic shunt (TIPS)
- 1028 b) Mechanical thrombectomy

1030 **e. Advanced Vascular Modalities (Cognitive)**

1031 **Demonstrate knowledge of the indications, utility, limitations, and technical procedures for related**

1032 **vascular studies.**

- 1033 1) Contrast Enhanced Studies
- 1034 2) Computed Tomography (CT)
- 1035 3) Magnetic Resonance Imaging (MRI)
- 1036 4) Interventional Studies
- 1037 a) Angiography
- 1038 b) Fistulogram
- 1039 c) Venography
- 1040 d) Intravascular Ultrasound
- 1041 5) Laser Doppler
- 1042 6) Other Advanced Modalities
- 1043 a) TCD
- 1044 b) Neonatal brain Doppler
- 1045 c) Temporal arteries
- 1046 d) Venous insufficiency
- 1047 e) Lower extremity vein mapping for surgical harvest
- 1048 f) Radial arteries for CABG harvest
- 1049 g) Dialysis vein mapping for hemodialysis access
- 1050 h) Arteriovenous malformation
- 1051 i) Intraoperative cases

1052

1053 **f. Comparative Imaging Analysis (Angiography, Nuclear, CT, and MRI) (Cognitive)**

1054 **Demonstrate knowledge of the indications, utility, limitations, and technical procedures for**

1055 **comparative imaging modalities.**

- 1056 1. Correlating Test Results with Noninvasive Vascular Testing
- 1057 a) Sensitivity
- 1058 b) Specificity
- 1059 c) Positive Predictive Value
- 1060 d) Negative Predictive Value
- 1061 e) Accuracy
- 1062 f) Reliability
- 1063 g) Achieving “gold standard” diagnostic status
- 1064 h) Current “gold standard” correlative testing
- 1065 i) Quality Assurance
- 1066 2. Diagnostic and Interventional Vascular using Fluoroscopy
- 1067 a) Indications
- 1068 i. Arterial and Venous Thrombosis or Embolism
- 1069 ii. Atherosclerotic disease
- 1070 b) Limitations

- 1071 i. Cost of procedure
- 1072 ii. Scheduling interventional fluoroscopy suite with the use of sterile field
- 1073 iii. Invasive: Requires catheter insertion into patient and will use iodine contrast
- 1074 c) Risk Factors and Complications
- 1075 i. Radiation exposure and Radiation safety
- 1076 ii. Sedation risk
- 1077 iii. Patient allergies to iodine
- 1078 iv. Thrombolytic agent use
- 1079 v. Potential iatrogenic trauma
- 1080 i) Dissection
- 1081 ii) Aneurysm
- 1082 iii) Perforation or Fistula
- 1083 d) Angiogram/Angiography (Digital subtraction Angiography)
- 1084 i. Diagnostic: Identify arterial lesion and evaluate perfusion
- 1085 ii. Arterial stenting to treat atherosclerotic lesions
- 1086 iii. Mechanical catheter to remove atherosclerotic lesions
- 1087 iv. Thrombolysis
- 1088 e) Venogram/Venography
- 1089 i. Diagnostic: Identify venous issue
- 1090 ii. Mechanical catheter to remove venous thrombosis
- 1091 iii. Thrombolysis
- 1092 3. Magnetic Resonance Angiography (MRA) or Venography (MRV)
- 1093 a) Indications
- 1094 i. Atherosclerotic disease
- 1095 ii. Aneurysm
- 1096 iii. Embolism
- 1097 iv. Venous thrombosis
- 1098 v. Cerebral sinus thrombosis
- 1099 vi. Cerebral Edema
- 1100 b) Limitations
- 1101 i. Cost of procedure
- 1102 ii. Renal failure/renal insufficiency patients
- 1103 iii. Patient fear of MRI machine
- 1104 iv. Patient body habitus
- 1105 v. Patient movement creating motion artifacts or venous artifacts
- 1106 c) Contrast Agents
- 1107 d) Risk factors and Complications
- 1108 4. Computed Tomographic Angiography (CTA)
- 1109 a) Indications
- 1110 i. Atherosclerotic Disease
- 1111 ii. Aneurysm
- 1112 iii. Embolism
- 1113 b) Limitations
- 1114 i. Cost of procedure
- 1115 ii. Renal failure/Insufficiency patients
- 1116 iii. Patient body habitus
- 1117 iv. Motion artifact
- 1118 c) Contrast Agents
- 1119 d) Risk factors and Complications

- 1120 5. CT Lung Scan
- 1121 a) Indications
- 1122 i. Pulmonary Embolism
- 1123 b) Limitations
- 1124 c) Risk factors and Complications
- 1125 6. Nuclear Medicine and Hybrid Imaging, PET/CT
- 1126 a) Indications
- 1127 i. Cerebrovascular
- 1128 ii. Gastrointestinal bleeding
- 1129 b) Limitations
- 1130 c) Risk factors and Complications
- 1131 i. Uses radioactive agents
- 1132
- 1133

**g. Vascular Pharmacology (Cognitive)**

**Demonstrate knowledge of the types of vascular pharmacological agents and role in clinical practice.**

- 1134 1) Antihypertensives
- 1135 a) ACE Inhibitors
- 1136 b) Angiotensin Receptor Blockers
- 1137 c) Calcium Channel Blockers
- 1138 d) Beta Blockers
- 1139 e) Diuretics
- 1140
- 1141 2) Cholesterol Medications
- 1142 a) Statins
- 1143 b) Ezetimibe
- 1144 c) PCSK9 Inhibitors
- 1145 d) Adenosine Triphosphate-Citrate Lyase Inhibitors
- 1146 3) Antihyperglycemics with Cardiovascular Risk Reduction
- 1147 a) SGLT2 Inhibitors
- 1148 b) GLP-1 Receptor Agonists
- 1149 c) GLP-1/GIP Receptor Agonists
- 1150 d) DPP4 Inhibitors
- 1151 4) Antiplatelets
- 1152 a) Platelet Aggregation Inhibitors
- 1153 i. ASA
- 1154 ii. Thienopyridines
- 1155 b) PDE3 Inhibitor (Cilostazol)
- 1156 5) Anticoagulants
- 1157 a) Unfractionated Heparin
- 1158 b) LMWH
- 1159 c) Factor Xa Inhibitors
- 1160 d) Direct Thrombin Inhibitors
- 1161 e) Vitamin K Antagonists
- 1162 6) Fibrinolytics
- 1163 7) Corticosteroids
- 1164 8) Immunosuppressants
- 1165 9) Biologics
- 1166