



**Standards and Guidelines
for the Accreditation of Educational Programs in
Advanced Cardiovascular Sonography**

**Standards initially adopted in 2012; revised in 2016, 2020, 2026;
and effective 1/1/2027.**

**Developed by
Committee on Accreditation for Advanced Cardiovascular Sonography**

**Endorsed by
American Society of Echocardiography
Society of Diagnostic Medical Sonography**

and

**Approved by the
Commission on Accreditation of Allied Health Education Programs**

The Commission on Accreditation of Allied Health Education Programs (CAAHEP) accredits programs upon the recommendation of the Committee on Accreditation for Advanced Cardiovascular Sonography (CoA-ACS).

These accreditation **Standards** are the minimum standards of quality used in accrediting programs that prepare individuals to enter the Advanced Cardiovascular Sonography profession. Standards are the minimum requirements to which an accredited program is held accountable. Guidelines are descriptions, examples, or recommendations that elaborate on the Standards. Guidelines are not required but can assist with the interpretation of the Standards.

Standards are printed in regular typeface in outline form. *Guidelines are printed in italic typeface.*

Preamble

The Commission on Accreditation of Allied Health Education Programs (CAAHEP), Committee on Accreditation for Advanced Cardiovascular Sonography, and the American Society of Echocardiography and Society of Diagnostic Medical Sonography cooperate to establish, maintain and promote appropriate standards of quality for educational programs in advanced cardiovascular sonography and to provide recognition for educational programs that meet or exceed the minimum standards outlined in these accreditation **Standards and Guidelines for the Accreditation of Educational Programs**. CAAHEP encourages innovation and quality education programs throughout the CAAHEP accreditation process, consistent with the CAAHEP policy on institutional autonomy. These **Standards and Guidelines** are designed to ensure the integrity of the CAAHEP accreditation process. Directories of accredited programs are published for the information of students, employers, educational institutions and organizations, credentialing bodies, and the public.

These **Standards and Guidelines** are to be used for the development, evaluation, and self-analysis of advanced cardiovascular sonography programs. Site visit teams assist in the evaluation of a program's compliance with the accreditation standards.

Description of the Profession

The profession of advanced cardiovascular sonography includes advanced cardiac sonographers (ACS) and advanced vascular sonographers (AVS) who: 1) assist staff sonographers to assess cases that require 2D, Doppler, advanced measurements, and advanced imaging/non-imaging techniques; 2) review studies that have been performed by the staff sonographer in preparation for review by the supervising physician; 3) provide in-service education for staff sonographers of new methods that are to be incorporated in the examination; 4) ensure that the necessary data is obtained based on the clinical history and presentation; and 5) establish quality assurance measures to maintain the highest standard of care of a laboratory by closely monitoring sonographer performance and identifying training needs.

The ACS or AVS is a highly skilled professional qualified by education, experience and certification to provide the above services. The ACS or AVS works under physician supervision, applying clinical knowledge to the exam to ensure that all information is obtained from the exam to answer the clinical question.

I. Sponsorship

A. Program Sponsor

A program sponsor must be at least one of the following

1. A post-secondary academic institution accredited by an institutional accrediting agency that is recognized by the U.S. Department of Education and must be authorized under applicable law or other acceptable authority to provide a post-secondary program, which awards a minimum of a certificate at the completion of the program.
2. A hospital, clinic or medical center accredited by a healthcare accrediting agency that is recognized by the U.S. Department of Health and Human Services, and authorized under applicable law to provide healthcare, and authorized under applicable law to provide the post-secondary program, which awards a minimum of a certificate at the completion of the program.
3. A branch of the United States Armed Forces, or a federal or state governmental agency, which awards a minimum of a certificate at the completion of the program.

B. Responsibilities of Program Sponsor

The program sponsor must

1. Ensure that the program meets the Standards.
2. Award academic credit for the program or have an articulation agreement with an accredited post-secondary institution;
3. Have a preparedness plan in place that assures continuity of education services in the event of an unanticipated interruption; and

Examples of unanticipated interruptions may include unexpected departure of key personnel, natural disaster, public health crisis, fire, flood, power failure, failure of information technology services, or other events that may lead to inaccessibility of educational services.

4. Ensure that the graduates of the program have obtained or will obtain a minimum of a bachelor's degree upon completion of the program.

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

II. Program Goals

A. Program Goals and Minimum Expectations

The program must have one of the following minimum expectations statements for the learning concentration(s) offered:

1. "To prepare advanced cardiac sonographers who are competent in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains to enter the profession."
2. "To prepare advanced vascular sonographers who are competent in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains to enter the profession."
3. "To prepare advanced cardiac and advanced vascular sonographers who are competent in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains to enter the profession."

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.

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.

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

B. Program Advisory Committee

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.

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.

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

III. Resources

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;
7. Classroom and laboratory (physical or virtual);
8. Ancillary student facilities;
9. Clinical affiliates;
10. Equipment;
11. Supplies;
12. Information technology;
13. Instructional materials; and
14. Support for faculty professional development.

B. Personnel

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

At a minimum, the following positions are required.

1. Program Director

a. Responsibilities

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

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

b. Qualifications

- 1) The program director for the advanced cardiac sonography concentration must
 - a) Have documented education or experience in instructional methodology; and
 - b) Meet at least one of the following
 - i. Possess a minimum of a bachelor's degree and an advanced cardiac credential offered by an organization accredited by the National Commission for Certifying Agencies (NCCA), by the American National Standards Institute (ANSI), or under International Organization for Standardization (ISO); or
 - ii. Possess a minimum of a master's degree and a cardiac credential offered by an organization accredited by the National Commission for Certifying Agencies (NCCA), by the American National Standards Institute (ANSI), or under International Organization for Standardization (ISO); or
 - iii. Be a physician board-certified in the cardiac discipline.

The ACS credential fulfills the advanced cardiac credential.

Examples of cardiac credentials are RDCS and RCS credentials.

- 2) The program director for the advanced vascular sonography concentration must
 - a) Have documented education or experience in instructional methodology; and
 - b) Meet at least one of the following

- i. Possess a minimum of a bachelor's degree, vascular credential offered by an organization accredited by the National Commission for Certifying Agencies (NCCA), by the American National Standards Institute (ANSI), or under International Organization for Standardization (ISO), and 3 years of experience; or
- ii. Possess a master's degree and vascular credential offered by an organization accredited by the National Commission for Certifying Agencies (NCCA), by the American National Standards Institute (ANSI), or under International Organization for Standardization (ISO); or
- iii. Be a physician board-certified in the vascular discipline.

Examples of vascular credentials are RVT, RVS, and RT(VS) credentials.

One individual may serve as program director for both concentrations provided the qualifications of each position are met.

2. Medical Advisor

a. Responsibilities

The medical advisor(s) must

- 1) Provide the input necessary to ensure that the medical components of the curriculum, both didactic and supervised practice, meet current standards of medical practice; and
- 2) Engage in cooperative involvement with the program director.

b. Qualifications

The medical advisor(s) must

- 1) Be a physician (MD or DO) currently licensed and board certified in the discipline(s) offered;
- 2) Have the requisite knowledge and skills to advise the program leadership about the clinical/academic aspects of the program; and
- 3) Be knowledgeable in teaching the subjects assigned, when applicable.

3. Faculty/Instructional Staff

a. Responsibilities

For all didactic, laboratory, and clinical instruction to which a student is assigned, there must be a qualified individual(s) clearly designated by the program to provide instruction, supervision, and timely assessment of the student's progress in meeting program requirements.

b. Qualifications

Faculty/instructional staff must be effective in teaching and knowledgeable in subject matter as documented by appropriate professional credential(s)/certification(s), education, and experience in the designated content area.

The ACS credential fulfills the advanced cardiac credential.

Examples of cardiac credentials are RDCS and RCS credentials.

Examples of vascular credentials are RVT, RVS, and RT(VS) credentials.

C. Curriculum

The curriculum content must ensure that the program goals are achieved. Instruction must be based on clearly written course syllabi that include course description, course objectives, methods of evaluation, topic outline, and competencies required for graduation. Instruction must be delivered in an appropriate sequence of classroom, laboratory, and clinical activities.

The program must demonstrate that the curriculum offered meets or exceeds the content listed in Appendix B of these **Standards**.

CAAHEP supports and encourages innovation in the development and delivery of the curriculum.

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).

2. Reporting

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

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

V. Fair Practices

A. Publications and Disclosure

1. Announcements, catalogs, publications, advertising, and websites must accurately reflect the program offered.
2. At least the following must be made known to all applicants and students
 - a. Sponsor's institutional and programmatic accreditation status;
 - b. Name and website address of CAAHEP;
 - c. Admissions policies and practices;
 - d. Technical standards
 - e. Occupational risks;
 - f. Policies on advanced placement, transfer of credits, and credits for experiential learning;
 - g. Number of credits required for completion of the program;
 - h. Availability of articulation agreements for transfer of credits;
 - i. Tuition/fees and other costs required to complete the program;
 - j. Policies and processes for withdrawal and for refunds of tuition/fees; and
 - k. Policies and processes for assignment of clinical experiences.
3. At least the following must be made known to all students
 - a. Academic calendar;
 - b. Student grievance procedure;
 - c. Appeals process;
 - d. Criteria for successful completion of each segment of the curriculum and for graduation; and
 - e. Policies by which students may perform clinical work while enrolled in the program.
4. The sponsor must maintain and make accessible to the public on its website a current and consistent summary of student/graduate achievement that includes one or more of these program outcomes: national credentialing examination(s), programmatic retention, and placement in full or part-time employment in the profession or a related profession as established by the CoA-ACS.

B. Lawful and Non-discriminatory Practices

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

faculty.

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 A

Application, Maintenance, and Administration of Accreditation

A. Program and Sponsor Responsibilities

1. Applying for Initial Accreditation

- a. The chief executive officer or an officially designated representative of the sponsor completes a “Request for Accreditation Services” form.

The “Request for Accreditation Services” form can be obtained from the [CAAHEP website](#).

Note: There is **no** CAAHEP fee when applying for accreditation services; however, individual committees on accreditation may have an application fee.

- b. The program undergoes a comprehensive review, which includes a written self-study report and an on-site review.

The self-study instructions and report form are available from the CoA-ACS. The on-site review will be scheduled in cooperation with the program and CoA-ACS once the self-study report has been completed, submitted, and accepted by the CoA-ACS.

2. Applying for Continuing Accreditation

- a. Upon written notice from the CoA-ACS, the chief executive officer or an officially designated representative of the sponsor completes a “Request for Accreditation Services” form.

The “Request for Accreditation Services” form can be obtained from the [CAAHEP website](#).

- b. The program may undergo a comprehensive review in accordance with the policies and procedures of the CoA-ACS.

If it is determined that there were significant concerns with the conduct of the on-site review, the sponsor may request a second site visit with a different team.

After the on-site review team submits a report of its findings, the sponsor is provided the opportunity to comment in writing and to correct factual errors prior to the CoA-ACS forwarding a recommendation to CAAHEP.

3. Administrative Requirements for Maintaining Accreditation

- a. The program must inform the CoA-ACS and CAAHEP within a reasonable period of time (as defined by the committee on accreditation and CAAHEP policies) of changes in chief executive officer, dean of health professions or equivalent position, and required program personnel (Refer to Standard III.B.).

- b. The sponsor must inform CAAHEP and the CoA-ACS of its intent to transfer program sponsorship. To begin the process for a Transfer of Sponsorship, the current sponsor must submit a letter (signed by the CEO or designated individual) to CAAHEP and the CoA-ACS that it is relinquishing its sponsorship of the program. Additionally, the new sponsor must submit a “Request for Transfer of Sponsorship Services” form. The CoA-ACS has the discretion of requesting a new self-study report with or without an on-site review. Applying for a transfer of sponsorship does not guarantee that the transfer will be granted.
- c. The sponsor must promptly inform CAAHEP and the CoA-ACS of any adverse decision affecting its accreditation by recognized institutional accrediting agencies and/or state agencies (or their equivalent).
- d. Comprehensive reviews are scheduled by the CoA-ACS in accordance with its policies and procedures. The time between comprehensive reviews is determined by the CoA-ACS and based on the program’s on-going compliance with the Standards, however, all programs must undergo a comprehensive review at least once every ten years.
- e. The program and the sponsor must pay CoA-ACS and CAAHEP fees within a reasonable period of time, as determined by the CoA-ACS and CAAHEP respectively.
- f. The sponsor must file all reports in a timely manner (self-study report, progress reports, probation reports, annual reports, etc.) in accordance with CoA-ACS policy.
- g. The sponsor must agree to a reasonable on-site review date that provides sufficient time for CAAHEP to act on an CoA-ACS accreditation recommendation prior to the “next comprehensive review” period, which was designated by CAAHEP at the time of its last accreditation action, or a reasonable date otherwise designated by the CoA-ACS.

Failure to meet any of the aforementioned administrative requirements may lead to administrative probation and ultimately to the withdrawal of accreditation. CAAHEP will immediately rescind administrative probation once all administrative deficiencies have been rectified.

4. Voluntary Withdrawal of a CAAHEP- Accredited Program

Notification of voluntary withdrawal of accreditation from CAAHEP must be made by the Chief Executive Officer or an officially designated representative of the sponsor by writing to CAAHEP indicating: the desired effective date of the voluntary withdrawal, and the location where all records will be kept for students who have completed the program.

5. Requesting Inactive Status of a CAAHEP- Accredited Program

Inactive status for any accredited program may be requested from CAAHEP at any time by the Chief Executive Officer or an officially designated representative of the sponsor writing to CAAHEP indicating the desired date to become inactive. No students can be enrolled or matriculated in the program at any time during the time period in which the program is on inactive status. The maximum period for inactive status is two years. The sponsor must continue to pay all required fees to the CoA-ACS and CAAHEP to maintain its accreditation status.

To reactivate the program the Chief Executive Officer or an officially designated representative of the sponsor must provide notice of its intent to do so in writing to both CAAHEP and the CoA-ACS. The sponsor will be notified by the CoA-ACS of additional requirements, if any, that must be met to restore active status.

If the sponsor has not notified CAAHEP of its intent to re-activate a program by the end of the two-year period, CAAHEP will consider this a “Voluntary Withdrawal of Accreditation.”

B. CAAHEP and Committee on Accreditation Responsibilities – Accreditation Recommendation Process

1. After a program has had the opportunity to comment in writing and to correct factual errors on the on-site review report, the CoA-ACS forwards a status of public recognition recommendation to the CAAHEP Board of Directors. The recommendation may be for any of the following statuses: initial accreditation, continuing accreditation, transfer of sponsorship, probationary accreditation, withhold of accreditation, or withdrawal of accreditation.

The decision of the CAAHEP Board of Directors is provided in writing to the sponsor immediately following the CAAHEP meeting at which the program was reviewed and voted upon.

2. Before the CoA-ACS forwards a recommendation to CAAHEP that a program be placed on probationary accreditation, the sponsor must have the opportunity to request reconsideration of that recommendation or to request voluntary withdrawal of accreditation. The CoA-ACS’s reconsideration of a recommendation for probationary accreditation must be based on conditions existing both when the committee arrived at its recommendation as well as on subsequent documented evidence of corrected deficiencies provided by the sponsor.

The CAAHEP Board of Directors’ decision to confer probationary accreditation is not subject to appeal.

2. Before the CoA-ACS forwards a recommendation to CAAHEP that a program’s accreditation be withdrawn or that accreditation be withheld, the sponsor must have the opportunity to request reconsideration of the recommendation, or to request voluntary withdrawal of accreditation or withdrawal of the accreditation application, whichever is applicable. The CoA-ACS’s reconsideration of a recommendation of withdraw or withhold accreditation must be based on conditions existing both when the CoA-ACS arrived at its recommendation as well as on subsequent documented evidence of corrected deficiencies provided by the sponsor.

The CAAHEP Board of Directors’ decision to withdraw or withhold accreditation may be appealed. A copy of the CAAHEP “Appeal of Adverse Accreditation Actions” is enclosed with the CAAHEP letter notifying the sponsor of either of these actions.

At the completion of due process, when accreditation is withheld or withdrawn, the sponsor’s Chief Executive Officer is provided with a statement of each deficiency. Programs are eligible to re-apply for accreditation once the sponsor believes that the program is in compliance with the accreditation Standards.

Note: Any student who completes a program that was accredited by CAAHEP at any time during his/her matriculation is deemed by CAAHEP to be a graduate of a CAAHEP-accredited program.

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

- g) Qualitative Data Collection
- h) Qualitative Data Analysis
- i) Mixed Methods
- 2) Biostatistics
 - a) Probability
 - b) Data Distribution Types
 - c) Concepts of Inference
 - d) Inference for Single Samples
 - e) Inference for Two Samples
 - f) Inference for Proportions
 - g) Regression and Correlation
 - h) Analysis of Variance (ANOVA)
 - 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.

- 1) Adult Learning Modules
- 2) Behaviorism
- 3) Cognitivism
- 4) Social Learning Theory
- 5) Motivation to learn
 - a) Learners' beliefs and values
 - b) Setting and pursuing meaningful goals
 - c) Fostering self-regulated and continual learning
- 6) Social and emotional influences on learning
 - a) Optimal learning environments
 - b) Belongingness
 - c) Interpersonal relationships
 - d) Sense of agency and purpose
 - e) Teamwork and collaboration
- 7) Providing effective feedback
- 8) Recognizing and responding to individual differences and needs
- 9) Building on existing knowledge and skills

e. Accreditation Preparedness (Cognitive)

Demonstrate knowledge of a quality control and improvement program.

- 1) Equipment Information
- 2) Procedure Volumes
- 3) Training/Experience Qualification for Physicians and Technologists
- 4) Credential Information
- 5) Continuing Medical Education
- 6) Policies
 - a) Primary Source Verification Policy
 - b) Patient Complaint Policy
 - c) Personnel Safety Policy (Ergonomics)
 - d) Patient Safety Policy
 - e) Patient Confidentiality Policy
 - f) Quality Improvement (QI) Policy

- 7) Quality Improvement
 - a) Program
 - b) Oversight
 - c) Measures
 - d) Meetings
 - e) Documentation
- 8) Examination Protocols
- 9) Case Studies
- 10) Ergonomics

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.

- 1) Cardiac Cycle
 - a) Generation of action potentials
 - b) Electrical activation of the heart
 - c) Mechanical sequence of events
 - i. Pressure curves for ventricles, atria and great arteries
 - ii. Left ventricular volume curve
 - iii. Valve movements and heart sounds
 - iv. Pressure-Volume loops: normal
- 2) Determinants of Ventricular Function
 - a) Stroke volume, cardiac index and ejection fraction
 - b) Ventricular strain
 - c) Control of myocardial contractile performance
 - i. Preload and Starling's curves
 - ii. Afterload and Afterload-Velocity curves
 - iii. Contractility
 - iv. Pressure-Volume loops: altered preload, afterload and contractility
 - d) Diastolic Function
 - i. Relaxation
 - ii. Compliance/Stiffness
- 3) Autonomic Nervous System
 - a) Anatomy of the sympathetic and parasympathetic systems
 - b) Distribution and properties of autonomic receptors
 - c) Cardiovascular responses evoked by agonists and antagonists of the autonomic nervous system
- 4) Reflex and Humoral Control of the Circulation
 - a) Baroreceptor reflexes
 - b) Renin-Angiotensin-Aldosterone
 - c) Anti-Diuretic Hormone
 - d) Cardiac Natriuretic Peptides
- 5) Vascular Flow, Including Coronary Blood Flow
 - a) Relationship between blood viscosity and hematocrit
 - b) Relationship between blood viscosity and flow rate (shear stress)
 - c) Turbulence; Reynolds Number
 - d) Flow, pressure, resistance relationship and Poiseuille's Law
 - i. Autoregulation
 - ii. Mechanical factors
 - iii. Metabolic factors (myocardial oxygen demand)
 - iv. Neural factors
 - v. Pharmacologic agents

- vi. Coronary flow reserve
- 6) Valvular Heart Disease
 - a) Pathophysiology of aortic and mitral stenosis
 - i. Geometric valve area and effective orifice area
 - ii. Blood velocity and pressure gradient
 - iii. Pressure curves
 - iv. Effects on chambers
 - b) Pathophysiology of aortic and mitral regurgitation
 - i. Regurgitant orifice area and regurgitant volume
 - ii. Pressure curves
 - iii. Effects on chambers
 - c) Pathophysiology of right-sided valve disease
- 7) Exercise Physiology
 - a) Cardiovascular responses to upright aerobic exercise
 - i. Oxygen uptake, heart rate, stroke volume, cardiac output and A-V O₂ difference
 - ii. Effects of training
 - b) Cardiovascular responses to supine exercise
 - c) Cardiovascular responses to isometric exercise

b. Acquired Cardiovascular Disease (Cognitive)

Demonstrate knowledge of mechanisms of disease, sonographic technique, measurements, quantitative principles, and Doppler patterns in both the normal heart and with cardiac disease.

- 1) Valvular Heart Disease
- 2) Prosthetic Valve Disease
- 3) Ischemic Heart Disease
- 4) Cardiomyopathy
- 5) Pericardial Disease
- 6) Cardiac Trauma
- 7) Cardiac Masses
- 8) Radiation Heart Disease
- 9) Diseases of the Aorta
- 10) Infective Endocarditis
- 11) Systemic Hypertension
- 12) Pulmonary Hypertension
- 13) Systemic Disease

c. Congenital Cardiovascular Disease (Cognitive)

Demonstrate knowledge in cardiac embryology, identify anatomy and anatomic variants, and sonographic appearance of normal cardiac structures.

- 1) Embryology and fetal cardiac development - Segmental approach
- 2) Cardiac chambers and septation
- 3) Valve anatomy and dynamics
- 4) Simple and Complex Congenital Heart Defects
- 5) Adult Congenital Heart Disease
- 6) Coronary artery anatomy
- 7) Relationships of cardiac chambers and great vessels
- 8) Mediastinal structures

d. Surgical and Interventional Treatment of Cardiovascular Disease (Cognitive)

Explain the type of interventional and intraoperative procedures and integrate the role of the advanced sonographer.

- 1) Intraoperative evaluation
- 2) Use of TEE for hemodynamic monitoring
- 3) Post-procedure follow-up
- 4) Transcatheter interventions
- 5) Myocardial Biopsy
- 6) Pericardiocentesis
- 7) Mechanical Circulatory Support
- 8) Cardiac Transplant
- 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.

- 1) Contrast Echocardiography
- 2) Myocardial Perfusion
 - a) Triggered
 - b) Realtime
- 3) Agitated Saline
- 4) TEE
- 5) Stress Echocardiography
- 6) 3D Echocardiography
- 7) Strain Imaging and Analysis
- 8) Intracardiac Echocardiography
- 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.

1. Correlating Test Results with Echocardiography
 - a) Sensitivity
 - b) Specificity
 - c) Positive Predictive Value
 - d) Negative Predictive Value
 - e) Accuracy
 - f) Reliability
 - g) Achieving “gold standard” diagnostic status
 - h) Current “gold standard” correlative testing
 - i) Quality Assurance
2. Angiography
 - a) Indications and Contraindications
 - b) Limitations
 - c) Risk Factors and Complications
 - d) Cost analysis
3. Magnetic Resonance Angiography (MRA) or Venography (MRV)
 - a) Indications and Contraindications
 - b) Limitations
 - c) Risk factors and Complications
 - d) Cost analysis
4. Computed Tomographic Angiography (CTA)
 - a) Indications and Contraindications

- b) Limitations
- c) Risk factors and Complications
- d) Cost Analysis
- 5. Nuclear Medicine and Hybrid Imaging, PET/CT
 - a) Indications and Contraindications
 - b) Limitations
 - c) Risk factors and Complications
 - d) Cost analysis
- 6. Rest and Exercise Electrocardiography
 - a) Indications and Contraindications
 - b) Limitations
 - c) Risk factors and Complications
- 7. Radiation Safety

g. Cardiovascular Pharmacology (Cognitive)

Demonstrate knowledge of the commonly used cardiac pharmacological agents and role in clinical practice.

- 1) Antihypertensives
- 2) Diuretics
- 3) ACE Inhibitors
- 4) Angiotensin Receptor Blockers
- 5) Beta Blockers
- 6) Calcium Channel Blockers
- 7) Antiarrhythmics
- 8) Antiplatelet /Anticoagulants
- 9) Chronotropic Agents
- 10) Inotropic agents
- 11) Nitrates
- 12) Amyl Nitrates
- 13) Local Anesthetics
- 14) Vasopressors
- 15) Medications for Sedation

h. Patient Assessment (Cognitive/Psychomotor)

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

- 1) Chart Review
- 2) Evaluate Indication
- 3) Review Relevant Prior Testing
- 4) Relevant Symptoms
- 5) Relevant Surgical Histories
- 6) Cardiac Risk Factors and Family History
- 7) Physical Assessment

3. Learning competencies for the advanced vascular sonography concentration

a. Vascular Hemodynamics/Pathology (Cognitive)

Demonstrate knowledge of normal and abnormal vascular pathophysiology and hemodynamics with application in the vascular laboratory.

- 1) Arterial Hemodynamics
 - a) $Q = (P_1 - P_2) / R$
 - i. Kinetic

- ii. Potential
 - iii. Total
 - b) Flow, Pressure, and Resistance
 - i. Poiseuille's Law and Equation
 - c) Pressure Gradients Through the Circulation
 - d) Effects of Gravity on Pressure
 - e) Resistance to Flow
 - i. $Q = \Delta P \pi r^4 / 8$
 - f) Flow Characteristics: High and Low Resistance Flow Patterns
 - g) Normal Velocity Changes and Flow Patterns
 - i. Laminar
 - ii. Blunt
 - iii. Bifurcations
 - iv. Curved Vessels
 - h) Abnormal Flow Characteristics
 - i. Stenosis
 - i) Bernouli Principle
 - ii) Spectral Broadening
 - iii) Turbulence
 - 1. Reynolds Number (disturbed and turbulent flow)
 - a. $Re = Vq2r/\eta$ (viscosity)
 - iv) Tandem Lesions
 - v) Exercise
 - vi) Collateral Blood Flow
- 2) Venous Hemodynamics
 - a) Hydrostatic Pressure
 - b) Compliance and Capacitance
 - c) Flow/Pressure/Volume Relationships
 - d) Venous Return
 - e) Normal Flow Characteristics
 - f) Abnormal Flow Characteristics
 - g) Edema
 - h) Ambulatory Venous Pressure (AVP)
- 3) Arteriovenous Fistula/Grafts

b. Vascular Anatomy and Acquired/Congenital Disease (Cognitive and Psychomotor)

Explain the role of the following vascular anatomy and acquired/congenital disease concepts in performing vascular physiologic and/or vascular sonographic procedures.

- 1) Peripheral Arterial Disease
- 2) Peripheral Venous Disease
 - a) Anatomy/Anatomic Variants
 - i. Normal anatomy
 - ii. Anatomic variants
 - i) Vessel duplication (partial or complete)
 - ii) Variance of vessel origin/termination
 - iii) Vessel absence/agenesis
 - b) Venous Thromboembolism
 - i. Acute deep venous thrombosis
 - i) Phlegmasia alba dolens

- ii) Phlegmasia cerulea dolens
 - ii. Chronic post-thrombotic change
 - iii. Superficial venous thrombosis
 - iv. Recurrent thrombosis
 - v. Pulmonary embolism
- c) Chronic Venous Insufficiency
 - i. Clinical-Etiology-Anatomy-Pathophysiology (CEAP) classification
- d) Incidental Findings
 - i. Edema
 - ii. Pathologic lymph nodes
 - iii. Popliteal cyst
 - iv. Hematoma
 - v. Sermoa
 - vi. Lymphocele
- 3) Peripheral Arterial Disease
 - a) Anatomy/Anatomic Variants
 - i. Normal anatomy
 - ii. Anatomic variants
 - i) Variance of vessel origin/termination
 - ii) Vessel absence/agenesis
 - b) Atherosclerotic occlusive disease
 - i. Stenosis criteria
 - ii. Collateral routes
 - iii. Bypass graft complications
 - iv. Endovascular intervention complications
 - c) Traumatic Processes
 - i. Pseudoaneurysm
 - ii. Arteriovenous fistula
 - iii. Compartment Syndrome
 - iv. Hypothenar hammer syndrome
 - d) Embolic Disease
 - e) Inflammatory Processes
 - i. Takayasu's arteritis
 - ii. Giant cell arteritis
 - iii. Thromboangitis obliterans
 - f) Vasospastic Disorders
 - i. Primary Raynaud's
 - ii. Secondary Raynaud's
 - g) Entrapment Syndromes
 - i. Popliteal artery entrapment syndrome
 - ii. Thoracic outlet syndrome
 - h) Aneurysm
 - i) Aortic Coarctation
 - j) Fibromuscular Dysplasia
 - k) Fibrointimal Hyperplasia
 - l) Adventitial Cystic Disease
- 4) Hemodialysis access dysfunction/complications
 - a) Arteriovenous Fistula (AVF) Maturation Failure
 - b) Stenosis

- i. AVF potential stenotic sites
 - ii. Arteriovenous graft (AVG) potential stenotic sites
- c) Thrombosis
- d) Abnormal Flow Volume (inadequate, excessive)
- e) Access Related Steal Syndrome
- f) Pseudoaneurysm
- g) Aneurysm
- h) Infection
- i) Peri-access Fluid Collections
- 5) Cerebrovascular disease
 - a) Anatomy/Anatomic Variants
 - i. Normal anatomy
 - ii. Anatomic variants
 - i) Variance of vessel origin/termination
 - ii) Vessel absence/agenesis
 - b) Extracranial
 - i. Atherosclerotic disease
 - i) Plaque neovascularity
 - ii) Intraplaque hemorrhage
 - iii) Stenosis, near-stenosis, and/or occlusion of the carotid and vertebral vessels
 - ii. Internal carotid artery (ICA) stenosis criteria
 - i) Society of Radiologists in Ultrasound Consensus Conference (SRUCC) 2003 criteria
 - ii) Intersocietal Accreditation Commission (IAC) Vascular Testing 2021 modification of the SRUCC criteria
 - iii. Subclavian steal phenomenon (pre-, partial, and complete steal)
 - iv. Arterial dissection
 - v. Carotid body tumor
 - vi. Fibromuscular dysplasia
 - vii. Carotid web
 - viii. Takayasu arteritis
 - ix. Giant cell arteritis
 - x. Transient perivascular inflammation of the carotid artery
 - xi. Radiation-induced arterial injury
 - xii. Aneurysm
 - xiii. Pseudoaneurysm
 - xiv. Flow re-direction via bypass grafting with thoracic endovascular aneurysm repair (TEVAR)
 - xv. Carotid endarterectomy complications and/or restenosis
 - xvi. Carotid stent complications and/or restenosis
 - xvii. Carotid bypass graft complications and/or thrombosis
 - c) Intracranial
 - i. Stenosis/Occlusion
 - i) Collateral route of flow
 - ii. Cerebral vasospasm
 - iii. Arteriovenous malformation
 - iv. Sickle cell disease
 - v. Microemboli
 - vi. Aneurysm
 - vii. Fibromuscular dysplasia
 - viii. Patent foramen ovale

- ix. Cerebral circulatory arrest/brain death
- x. Stroke
 - i) Ischemic
 - ii) Hemorrhagic
- 6) Abdominal and Pelvic Vascular Disease
 - a) Anatomy/Anatomic Variants
 - i. Normal anatomy
 - ii. Anatomic variants
 - i) Variance of vessel origin/termination
 - ii) Vessel absence/agenesis
 - iii) Vessel duplication or transposition
 - b) Aorta and Iliac Arteries
 - i. Stenotic disease
 - i) Atherosclerosis
 - 1) Bypass graft complications
 - 2) Endovascular intervention complications
 - ii) Takayasu arteritis
 - iii) Midaortic syndrome
 - iv) Posttraumatic aortic stenosis
 - v) External Iliac Artery Endofibrosis
 - ii. Aortic dissection
 - i) Branch vessel involvement
 - ii) Thrombus formation
 - iii) Aneurysm development
 - iii. Abdominal aortic aneurysm
 - i) Location (infrarenal, juxtarenal, suprarenal)
 - ii) Type (fusiform, inflammatory, saccular, mycotic)
 - iii) Branch vessel involvement
 - iv) Thrombus formation
 - v) Size, growth rate, and risk of rupture
 - vi) Graft (open surgical repair) complications
 - vii) Endovascular aneurysm repair (EVAR) complications
 - iv. Common iliac artery aneurysm
 - v. Ruptured aneurysm
 - vi. Penetrating ulcer
 - vii. Acute aortic syndrome
 - viii. Retroperitoneal fibrosis
 - ix. Pseudoaneurysm
 - c) Hepatoportal vasculature
 - i. Portal hypertension
 - i) Transjugular intrahepatic portosystemic shunt (TIPS) complications
 - ii. Portal vein thrombosis
 - i) Malignant/tumor thrombus
 - ii) Bland thrombus
 - iii. Budd-Chiari syndrome
 - iv. Congestive hepatopathy/cardiac cirrhosis
 - v. Sinusoidal obstruction syndrome
 - vi. Arteriovenous fistula
 - vii. Organ procedures

- i) Native
 - ii) Transplanted
- d) Renal vasculature
 - i. Renal artery stenosis
 - i) Atherosclerosis
 - ii) Fibromuscular dysplasia
 - ii. Renal artery aneurysm
 - iii. Renal vein thrombosis
 - iv. Left renal vein compression (nutcracker syndrome)
 - v. Renal artery stent complications
 - vi. Renal vein stent complications
- e) Mesenteric arteries
 - i. Stenosis and/or occlusion of the celiac and mesenteric arteries
 - ii. Median arcuate ligament syndrome/celiac artery compression syndrome
 - iii. Celiac/superior mesenteric artery stent complications
 - iv. Celiac/superior mesenteric artery bypass graft complications
- f) Liver transplant
 - i. Vascular complications
 - i) Hepatic artery thrombosis
 - ii) Hepatic artery stenosis
 - iii) Hepatic artery pseudoaneurysm
 - iv) Portal vein thrombosis
 - v) Portal vein stenosis
 - vi) Portal vein steal
 - vii) Outflow vein (IVC and/or hepatic vein) thrombosis
 - viii) Outflow vein (IVC and/or hepatic vein) stenosis
 - Splenoral shunt
 - ii. Biliary complications
 - iii. Parenchymal abnormalities
 - iv. Extrahepatic fluid collections
- g) Kidney transplant
 - i. Vascular complications
 - i) Renal artery thrombosis
 - ii) Renal artery stenosis
 - iii) Renal vein thrombosis
 - iv) Renal vein stenosis
 - v) Arteriovenous fistula
 - vi) Arterial pseudoaneurysm
 - ii. Parenchymal abnormalities
 - iii. Extrarenal fluid collections
- h) Pancreas transplant
 - i. Vascular complications
 - i) Venous thrombosis
 - 1) Donor splenic, superior mesenteric, and/or portal vein
 - 2) Recipient iliac vein, IVC, or superior mesenteric vein
 - ii) Arterial thrombosis
 - 1) Splenic artery, superior mesenteric artery, and/or Y-graft
 - iii) Arteriovenous fistula
 - iv) Arterial pseudoaneurysm

- ii. Parenchymal abnormalities
 - iii. Peritransplant fluid collections
- i) Inferior vena cava and iliac veins
 - i. Thrombosis
 - ii. Intraluminal tumor/neoplastic obstruction
 - iii. Caval fistula
 - iv. Iliac vein compression syndrome (May-Thurner syndrome)
 - v. Iliac vein stent complications
 - vi. Portalcaval shunt
- j) Pelvic venous disorders
 - i. Symptoms-Varices-Pathophysiology (SVP) classification
- k) Penile vasculature
 - i. Vasculogenic erectile dysfunction
 - i) Arterial insufficiency
 - ii) Venous incompetence
 - ii. Peyronie's disease
 - iii. Priapism
 - i) Ischemic
 - ii) Nonischemic

c. Patient Assessment (Cognitive/Psychomotor)

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

- 1) Evaluate Indication
- 2) Review Relevant Prior Testing
- 3) Relevant Symptoms
- 4) Relevant Surgical Histories
- 5) Vascular Risk Factors and Family History
- 6) Physical Assessment
 - a) Palpation of Pulses
 - b) Wound Assessment
 - c) Skin Integrity
 - d) Edema Assessment
 - e) Gait Assessment
 - f) Auscultation
- 7) Ancillary Testing
 - a) Brachial Pressure(s)
 - b) Ankle Brachial Index
 - c) Allen's Test
- 8) Provocative Maneuvers

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

Explain the types of interventional and intraoperative procedures and integrate the role of the advanced sonographer.

- 1) Venous Disease
 - a) Thrombolysis
 - b) Thrombectomy
 - c) Anticoagulation Management
 - d) IVC filter
 - e) Compression therapy

- f) Superficial Vein Procedures
 - i. Ligation and Stripping
 - ii. Thermal Ablation
 - iii. Non-thermal Ablation
 - iv. Phlebectomy
 - v. Sclerotherapy
- g) Venoplasty
- h) H) Venous Stenting
- i) Pelvic Vein Embolization
- j) Surgical Bypass
- k) Valve Replacement/Repair
- 2) Arterial Disease
 - a) Atherosclerotic disease
 - i. Walking program
 - ii. Pharmacological treatment
 - iii. Interventional procedures
 - i) Angioplasty
 - ii) Atherectomy
 - iii) Arterial Stenting
 - iv) Deep Venous Arterialization
 - iv. Surgical intervention
 - i) Endarterectomy
 - ii) Bypass
 - iii) Amputation
 - b) Dissection
 - i. Types
 - ii. Pharmacological treatment
 - iii. Surgical treatment
 - iv. Interventional procedures
 - c) Aneurysm
 - i. Types
 - ii. Pharmacological treatment
 - iii. Surveillance Guidelines
 - iv. Surgical treatment
 - v. Interventional procedures
 - d) Pseudoaneurysm
 - i. Types
 - ii. Pharmacological treatment
 - iii. Surveillance Guidelines
 - iv. Surgical treatment
 - v. Interventional procedures
- 3) Thoracic Outlet Syndrome
 - a) Physical Therapy
 - b) Thrombolysis
 - c) Angio/venoplasty and Stenting
 - d) Bypass
 - e) Surgical Decompression
- 4) Vasculitis
 - a) Anti-inflammatory Therapy (Corticosteroids)

- b) Immunosuppressants
- c) Biologics
- d) IVIG
- e) Plasmapheresis
- 5) Portal Hypertension
 - a) Transjugular intrahepatic portosystemic shunt (TIPS)
 - b) Mechanical thrombectomy

e. Advanced Vascular Modalities (Cognitive)

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

- 1) Contrast Enhanced Studies
- 2) Computed Tomography (CT)
- 3) Magnetic Resonance Imaging (MRI)
- 4) Interventional Studies
 - a) Angiography
 - b) Fistulogram
 - c) Venography
 - d) Intravascular Ultrasound
- 5) Laser Doppler
- 6) Other Advanced Modalities
 - a) TCD
 - b) Neonatal brain Doppler
 - c) Temporal arteries
 - d) Venous insufficiency
 - e) Lower extremity vein mapping for surgical harvest
 - f) Radial arteries for CABG harvest
 - g) Dialysis vein mapping for hemodialysis access
 - h) Arteriovenous malformation
 - i) Intraoperative cases

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

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

- 1. Correlating Test Results with Noninvasive Vascular Testing
 - a) Sensitivity
 - b) Specificity
 - c) Positive Predictive Value
 - d) Negative Predictive Value
 - e) Accuracy
 - f) Reliability
 - g) Achieving “gold standard” diagnostic status
 - h) Current “gold standard” correlative testing
 - i) Quality Assurance
- 2. Diagnostic and Interventional Vascular using Fluoroscopy
 - a) Indications
 - i. Arterial and Venous Thrombosis or Embolism
 - ii. Atherosclerotic disease
 - b) Limitations

- i. Cost of procedure
 - ii. Scheduling interventional fluoroscopy suite with the use of sterile field
 - iii. Invasive: Requires catheter insertion into patient and will use iodine contrast
- c) Risk Factors and Complications
 - i. Radiation exposure and Radiation safety
 - ii. Sedation risk
 - iii. Patient allergies to iodine
 - iv. Thrombolytic agent use
 - v. Potential iatrogenic trauma
 - i) Dissection
 - ii) Aneurysm
 - iii) Perforation or Fistula
- d) Angiogram/Angiography (Digital subtraction Angiography)
 - i. Diagnostic: Identify arterial lesion and evaluate perfusion
 - ii. Arterial stenting to treat atherosclerotic lesions
 - iii. Mechanical catheter to remove atherosclerotic lesions
 - iv. Thrombolysis
- e) Venogram/Venography
 - i. Diagnostic: Identify venous issue
 - ii. Mechanical catheter to remove venous thrombosis
 - iii. Thrombolysis
- 3. Magnetic Resonance Angiography (MRA) or Venography (MRV)
 - a) Indications
 - i. Atherosclerotic disease
 - ii. Aneurysm
 - iii. Embolism
 - iv. Venous thrombosis
 - v. Cerebral sinus thrombosis
 - vi. Cerebral Edema
 - b) Limitations
 - i. Cost of procedure
 - ii. Renal failure/renal insufficiency patients
 - iii. Patient fear of MRI machine
 - iv. Patient body habitus
 - v. Patient movement creating motion artifacts or venous artifacts
 - c) Contrast Agents
 - d) Risk factors and Complications
- 4. Computed Tomographic Angiography (CTA)
 - a) Indications
 - i. Atherosclerotic Disease
 - ii. Aneurysm
 - iii. Embolism
 - b) Limitations
 - i. Cost of procedure
 - ii. Renal failure/Insufficiency patients
 - iii. Patient body habitus
 - iv. Motion artifact
 - c) Contrast Agents
 - d) Risk factors and Complications

5. CT Lung Scan
 - a) Indications
 - i. Pulmonary Embolism
 - b) Limitations
 - c) Risk factors and Complications
6. Nuclear Medicine and Hybrid Imaging, PET/CT
 - a) Indications
 - i. Cerebrovascular
 - ii. Gastrointestinal bleeding
 - b) Limitations
 - c) Risk factors and Complications
 - i. Uses radioactive agents

g. Vascular Pharmacology (Cognitive)

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

- 1) Antihypertensives
 - a) ACE Inhibitors
 - b) Angiotensin Receptor Blockers
 - c) Calcium Channel Blockers
 - d) Beta Blockers
 - e) Diuretics
- 2) Cholesterol Medications
 - a) Statins
 - b) Ezetimibe
 - c) PCSK9 Inhibitors
 - d) Adenosine Triphosphate-Citrate Lyase Inhibitors
- 3) Antihyperglycemics with Cardiovascular Risk Reduction
 - a) SGLT2 Inhibitors
 - b) GLP-1 Receptor Agonists
 - c) GLP-1/GIP Receptor Agonists
 - d) DPP4 Inhibitors
- 4) Antiplatelets
 - a) Platelet Aggregation Inhibitors
 - i. ASA
 - ii. Thienopyridines
 - b) PDE3 Inhibitor (Cilostazol)
- 5) Anticoagulants
 - a) Unfractionated Heparin
 - b) LMWH
 - c) Factor Xa Inhibitors
 - d) Direct Thrombin Inhibitors
 - e) Vitamin K Antagonists
- 6) Fibrinolytics
- 7) Corticosteroids
- 8) Immunosuppressants
- 9) Biologics