Standards and Guidelines for the Accreditation of Educational Programs in Cardiovascular Technology

Essentials/Standards initially adopted in 1985; revised in 2003, 2009, 2010, 2015, 2016, 2024; and effective 8/1/2025.

Developed by
Joint Review Committee on Education in Cardiovascular Technology

Endorsed by
American College of Radiology
American Society of Echocardiography
Society for Vascular Ultrasound
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 Joint Review Committee on Education in Cardiovascular Technology (JRC-CVT).

These accreditation **Standards** are the minimum standards of quality used in accrediting programs that prepare individuals to enter the cardiovascular technology 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 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), Joint Review Committee on Education in Cardiovascular Technology (JRC-CVT), American College of Radiology (ACR), American Society of Echocardiography (ACE), Society for Vascular Ultrasound (SVU), and Society of Diagnostic Medical Sonography (SDMS) cooperate to establish, maintain and promote appropriate standards of quality for educational programs in cardiovascular technology 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 cardiovascular technology programs. Site visit teams assist in the evaluation of a program's compliance with the accreditation standards.

Description of the Profession

Cardiovascular technology is an allied health profession specifically focused on the diagnosis and treatment of patients with cardiac and vascular disease. The cardiovascular technologist or diagnostic medical sonographer in each of the cardiovascular technology specialties performs or assists in the performance of procedures and examinations. The cardiovascular technologist or diagnostic medical sonographer may either work independently or as part of a team. The cardiovascular technologist or diagnostic medical sonographer always works under the supervision of a physician. The cardiovascular technologist or diagnostic medical sonographer is proficient in the use of required equipment and has the cognitive and psychomotor skills and professionalism to contribute to safe and effective care of patients with cardiac and vascular problems.

The profession of cardiovascular technology encompasses five specialties: 1) invasive cardiovascular technology; 2) adult cardiac sonography; 3) pediatric cardiac sonography; 4) noninvasive vascular sonography; and 5) cardiac electrophysiology.

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.

4. A consortium, which is a group made up of two or more education providers that operate an educational program through a written agreement that outlines the expectations and responsibilities of each of the partners. At least one of the consortium partners must meet the requirements of a program sponsor set forth in I.A.1.- I.A.3.

Consortium does not refer to clinical affiliation agreements with the program sponsor.

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. Ensure that graduates of the program have previously obtained or will obtain a minimum of an associate degree upon completion of the program; and

4. Have a preparedness plan in place that assures continuity of education services in the event of an unanticipated interruption.

   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.

II. Program Goals

A. Program Goals and Minimum Expectations

The program must have a separate minimum expectation statement for each concentration offered which must be worded as follows: "To prepare cardiovascular technologists or diagnostic medical sonographers who are competent in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains to enter the profession of [concentration]."

In the goal statement(s), the word "concentration" is replaced by one of the following disciplines:

1. Adult cardiac sonography;
2. Cardiac electrophysiology;
3. Invasive cardiovascular technology;
4. Noninvasive vascular sonography; or
5. Pediatric cardiac sonography.

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 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 a cardiovascular technologist or diagnostic medical 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 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, supervision of the program;
2) Continuous quality review and improvement of the program;
3) Academic oversight, including curriculum planning and development; and
4) Management, coordination, and orientation of all faculty members, all preceptors, and all other instructional and support staff in the academic and clinical phases of the program.

b. Qualifications

The program director must

1) Possess a minimum of a bachelor's degree which has been awarded by an institution accredited by an agency that is recognized by the United States Department of Education or the equivalent;
2) Hold a cardiovascular credential from at least one of the concentrations identified in these Standards;
3) Have at least two years' experience in cardiovascular health care; and
4) Have documented education or experience in instructional methodology.

Program directors, approved under previous CAAHEP Standards, who do not hold a minimum of a bachelor's degree will continue to be approved provided they remain continuously employed as the program director with the same program.

2. Curriculum Coordinator(s)

The sponsor must appoint a curriculum coordinator(s) when the program director does not hold the credential relevant to the concentration(s) offered by the sponsor.

a. Responsibilities

The curriculum coordinator(s) report(s) to the program director and must be responsible for the coordination of that concentration when the program director does not hold the credential relevant to the concentration(s).

b. Qualifications

The curriculum coordinator(s) must

1) Be an appointed faculty member or institutional equivalent;
2) Hold the appropriate credential(s) specific concentration;
3) Hold academic credentials at least equivalent to the academic credential that is offered by the program; and
4) Demonstrate clinical and teaching experience.

3. Medical Director

a. Responsibilities

The medical director of the program must

1) Provide the input necessary to ensure 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 director must

1) Be a physician licensed and authorized to practice medicine in the United States or the country in which the program is located;
2) Hold board certification in the US or the country in which the program is located in a specialty relevant to the concentration;
3) Have the requisite knowledge and skills to advise the program leadership about the clinical/academic aspects of the program; and
4) Be knowledgeable in teaching the subjects assigned, when applicable.

4. Associate Medical Director

One or more associate medical director(s) must be appointed by the sponsor when either the medical director delegates specified responsibilities to another physician or when the medical director does not hold professional credentials appropriate to the concentrations that are offered by the program.

a. Responsibilities

1) Fulfill responsibilities delegated by the program medical director;
2) Provide the input necessary to ensure that the medical components of the curriculum, both didactic and supervised clinical practice, that are delegated by the program medical director meet current standards of medical practice; and
3) Promote the cooperation and support of practicing physicians for interaction with, and instruction of, students.

b. Qualifications

The associate medical director(s) must be a physician licensed to practice medicine in the country in which students are enrolled, with appropriate credentials and experience for the duties delegated by the medical director.

5. 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 assessments 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.

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 the 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 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.

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).

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

2. Reporting

At least annually, the program must submit to the Joint Review Committee on Education in Cardiovascular Technology 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 Joint Review Committee on Education in Cardiovascular Technology 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 Joint Review Committee on Education in Cardiovascular Technology.

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. Cardiovascular Technology students must be readily identifiable as students.

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

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 student 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 Joint Review Committee on Education in Cardiovascular Technology in a timely manner. Additional substantive changes to be reported to Joint Review Committee on Education in Cardiovascular Technology within the time limits prescribed include:

1. Changes in the curriculum that result in a change of 10% or more of the program credits;
2. Changes in the degree awarded; and
3. Changes in the organizational structure or mission of the sponsoring institution, including changes in other departments (e.g., general education) that have an impact on the program.

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 JRC-CVT. The on-site review will be scheduled in cooperation with the program and JRC-CVT once the self-study report has been completed, submitted, and accepted by the JRC-CVT.

2. Applying for Continuing Accreditation

a. Upon written notice from the JRC-CVT, 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 JRC-CVT.

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 JRC-CVT forwarding a recommendation to CAAHEP.

3. Administrative Requirements for Maintaining Accreditation

a. The program must inform the JRC-CVT 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 JRC-CVT 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 JRC-CVT that it is relinquishing its sponsorship of the program. Additionally, the new sponsor must submit a "Request for Transfer of Sponsorship Services" form. The JRC-CVT 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 JRC-CVT 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 JRC-CVT in accordance with its policies and procedures. The time between comprehensive reviews is determined by the JRC-CVT 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 JRC-CVT and CAAHEP fees within a reasonable period of time, as determined by the JRC-CVT 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 JRC-CVT policy.

g. The sponsor must agree to a reasonable on-site review date that provides sufficient time for CAAHEP to act on an JRC-CVT 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 JRC-CVT.

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 JRC-CVT 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 JRC-CVT. The sponsor will be notified by the JRC-CVT 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 JRC-CVT 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 JRC-CVT 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 JRC-CVT'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.

3. Before the JRC-CVT 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 JRC-CVT's reconsideration of a recommendation of withdraw or withhold accreditation must be based on conditions existing both when the JRC-CVT 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 for Educational Programs in Cardiovascular Technology

INTRODUCTION: Appendix B contains seven content areas of graduate competencies.

Content Area 1: General Education competencies (required for all concentrations)
Content Area 2: Competencies that apply to all concentrations
Content Area 3: Graduate competencies for the Adult Echocardiography concentration
Content Area 4: Graduate competencies for the Cardiac Electrophysiology concentration
Content Area 5: Graduate competencies for the Invasive Cardiovascular Technology concentration
Content Area 6: Graduate competencies for the Noninvasive Vascular Study concentration
Content Area 7: Graduate competencies for the Pediatric Echocardiography concentration

1. General Education

a. Mathematics

Upon completion of an educational program in cardiovascular technology, the student will:

1) Demonstrate knowledge of mathematics relevant to the practice of cardiovascular technology;
2) Apply mathematical computations to solve equations relevant to the practice of cardiovascular technology; and
3) Explain appropriate strategies/procedures when solving mathematical problems.

b. Written and oral communications

Upon completion of an educational program in cardiovascular technology, the student will:

1) Identify styles and types of verbal communication;
2) Recognize elements of fundamental writing skills;
3) Identify types of non-verbal communication;
4) Recognize barriers to communication; and
5) Identify techniques to overcome communication barriers.

c. Social and Behavioral Sciences

Upon completion of an educational program in cardiovascular technology, the student will:

1) Develop an understanding of self and the world by examining the dynamic interaction of individuals, groups, and societies as they change and are shaped by history, culture, institutions, and ideas; and
2) Identify differences among and between individuals, cultures, or societies across space and time.

d. Computer Science

Upon completion of an educational program in cardiovascular technology, the student will:

1) Demonstrate the ability to use computers hardware and applications relevant to cardiovascular education and patient care; and
2) Identify computer applications used in health care.

e. Critical Thinking

Upon completion of an educational program in cardiovascular technology, the student will:

1) Define critical thinking;
2) Identify the skills used in critical thinking;
3) Identify the barriers to critical thinking in terms of beliefs, attitudes, feelings, and behaviors;
4) Analyze concepts for problem solving; and
5) Demonstrate the ability to draw reasonable conclusions and decisions.

f. Human Anatomy and Physiology

Upon completion of an educational program in cardiovascular technology, the student will:

1) Describe the structural organization of the human body;
2) Identify body systems and describe body planes, directional terms, quadrants, and body cavities;
3) List major organs and identify the anatomical location in each body system;
4) Compare the structure and function of the human body across the life span; and
5) Describe the normal function of each body system.

g. Physics

Upon completion of an educational program in cardiovascular technology, the student will:

1) Demonstrate foundational knowledge of general physics principles and concepts, and the application of this knowledge in solving problems in cardiovascular technology.

h. Microbiology

Upon completion of an educational program in cardiovascular technology, the student will:

1) Discuss the role of microbiology and infection control in our society, industry, research, health, and medicine;
2) Identify the major types of pathogens; and
3) Explain the relationship between microorganisms and the human host.

2. Competencies required in all concentrations.

*** Indicates a skill that the terminal competency assessment must occur in a clinical setting with a patient.**

a.	**Professional Behaviors**		
	1) ***Show awareness of a patient's concerns related to the diagnostic procedure(s) being performed.** 2) ***Show awareness of a patient's concerns related to pathologic conditions and the associated functional changes.** 3) ***Demonstrate cultural awareness when working with patients and other health care team members.** 4) ***Use therapeutic communication when working with aging patients and their caretaker(s)/family.** 5) ***Use sound judgment and clinical decision making to ensure safety and prevent errors during all therapeutic and diagnostic procedures.** 6) ***Demonstrates time management.** 7) ***Adheres to personal hygiene standards.** 8) Demonstrates initiative by performing tasks without prompting. 9) Demonstrates confidence by upholding personal choices. 10) Demonstrates active listening as evidenced by not asking for instructions to be repeated. 11) Implements alternative communication strategies based on situation. 12) Demonstrates teamwork by implementing changes to benefit others.		
	Cognitive	**Psychomotor**	**Affective**
b.	**Basic Life Support**		
	1) Apply knowledge of the electrocardiogram. 2) Obtain BLS certification.	3) Demonstrate basic life support skills.	4) Reflect and promote the importance of a healthy heart and lungs.
c.	**Industry Standards and Safety**		
	1) Discuss industry safety standards and OSHA guidelines related to safety in the clinical laboratory. 2) Identify types of work-related musculoskeletal disorders. 3) Demonstrate knowledge of radiation protection and safety by describing: a) the proper placement of a dosimetry badge; b) ALARA principles; and	4) ***Use effective ergonomics during all therapeutic and diagnostic procedures.** 5) Apply radiation protection and safety principles by: a) properly placing the dosimetry badge; b) applying ALARA principles; and c) properly positioning radiation protection.	

	c) how to properly use radiation protection.		
d.	**Ethics**		
	1) List and explain the patients' rights and safety including: a) informed consent; b) patient identification; c) confidentiality; d) HIPAA; and e) Patient Bill of Rights. 2) Describe the communication that must occur during hand-off.	3) Communicate appropriate information to a member of the healthcare team during a hand-off.	
e.	**Documentation and the Medical Record**		
	1) Discuss the documentation needed for: a) preprocedural activities; and b) postprocedural activities.	2) Complete appropriate documentation: a) preprocedural; and b) postprocedural. 3) Protect the integrity of the medical record.	4) ***Show respect for confidentiality of the medical record.**
f.	**Preprocedural activities**		
	1) Discuss the importance of reviewing physicians' orders. 2) State the rationale for identifying patient allergies. 3) Define informed consent. 4) Identify pre-procedural teaching that is required for the procedure. 5) Define procedural time-out for overall safety. 6) State the rationale for using sterile technique.	7) ***Identify orders that need clarification and communicate with the ordering provider.** 8) ***Perform pre-procedural teaching.** 9) Obtain informed consent.	
g.	**Infection Control**		
	1) Define Standard Precautions. 2) Discuss isolation procedures used to prevent transmission of infections.	4) Demonstrate asepsis and proper hand-washing techniques.	7) ***Adhere conscientiously to required precautions when participating in patient care.**

	3) Identify personal protective equipment (PPE) used for specific barriers.	5) Select PPE for various categories of precautions and isolations. 6) Demonstrate proper procedures for donning and doffing PPE.	
h.	**Vascular flow and hemodynamics**		
	1) Relate the relevance of the following concepts/equations on the circulatory system: a) resistance equation; b) volumetric flow equation; c) simplified law of hemodynamics; d) Poiseuille's Law; e) Ohm's Law; and f) Reynold's number. 2) Contrast steady, pulsatile, and phasic flow. 3) Discuss the arterial system, including: a) normal physiology; b) pathophysiology; and c) hemodynamics. 4) Discuss the venous system, including: a) normal physiology; b) pathophysiology; and c) hemodynamics.		
i.	**Quality Assurance**		
	1) Correlate clinical findings with other imaging findings.	2) Participate in quality assurance activities. 3) Monitory equipment for safety.	

3. Adult Echocardiography concentration

*** Indicates a skill that the terminal competency assessment must occur in a clinical setting with a patient.**

a.	**Cardiovascular anatomy and physiology**		
	Cognitive	**Psychomotor**	**Affective**
	1) Identify the: a) cardiac chambers and concomitant septa; b) valvular anatomy and accompanying apparatus; c) arterial and venous circulation; d) coronary artery anatomy and distribution; and e) relationship between cardiac chambers and great vessels. 2) Describe the structure and function of the: a) cardiac chambers and concomitant septa; b) valvular anatomy and accompanying apparatus; c) arterial and venous circulation; d) coronary artery anatomy and distribution; and e) relationship between cardiac chambers and great vessels. 3) Identify normal/abnormal embryologic cardiac development.	4) Use 2-dimensional (2D) echocardiographic views to identify: a) cardiac chambers and concomitant septa; b) valvular anatomy and accompanying apparatus; c) arterial and venous circulation; d) coronary artery anatomy and distribution; and e) relationship between cardiac chambers and great vessels. 5) **Use 2D, M-mode, color Doppler, pulsed wave, wave and continuous wave Doppler to identify:** a) ***venous circulation (e.g., IVC, collapse and flow);** b) ***valvular function (e.g., stenosis, regurgitation;** c) pericardial disease (e.g., inflow variation, RC diastolic collapse), constriction vs restrictive CM); d) ***cardiac ventricular diastolic function;** and e) ***cardiac chamber volumetric and linear dimensions and function (e.g., bi-plane volumes, internal dimensions, TAPSE).**	6) Reflect and promote the importance of a healthy heart and lungs. 7) Show awareness of a patient's concerns related to diagnostic procedures being performed.
b.	**Cardiac hemodynamic principles to evaluate normal cardiac flow**		

	1) Compare right and left ventricular systolic and diastolic function, relative to loading conditions and filling pressures. 2) List the normal intracardiac pressures. 3) Recognize abnormal intracardiac pressures. 4) Calculate hemodynamics, including: a) stroke volume; b) cardiac output; c) cardiac index; d) pressure gradients; and e) valve area. 5) Discuss electrophysiology, including: a) ECG waveform; b) identify cardiac rhythms; c) identify ECG changes associated with physiologic events; d) electrical pathway of the heart; and e) recognize ECG artifacts. 6) Analyze the components of the Wigger's diagram.	7) Use echocardiography to assess right and left ventricular systolic and diastolic function. 8) ***Assess intracardiac pressures.** 9) ***Use Doppler to assess valvular velocity and pressures.** 10) ***Use Doppler to calculate:** **a) stroke volume** **b) cardiac output** **c) cardiac index** **d) pressure gradients; and** **e) valve area.** 11) ***Perform 3-lead ECG.**	
c.	**Cardiovascular Pathophysiology**		
	1) Contrast how the cardiovascular system coordinates its functions under normal and abnormal conditions. 2) Describe the most common cardiovascular disorders and the functional changes that occur with each disorder. 3) Identify pathologic changes commonly seen on echocardiography.	6) ***Assess the cardiopulmonary status of a patient.** 7) Adjust the echocardiography imaging protocol appropriately for the specific cardiovascular pathology being assessed (e.g., valvular stenosis, valvular regurgitation, prosthetic valve function, pericardial tamponade, pericardial constriction, cardiomyopathies (CM) including	8) Show awareness of a patient's concerns related to pathologic conditions and the associated functional changes.

	4) Identify pathology changes commonly seen on other imaging modalities (e.g., cardiac MRI, chest radiograph). 5) Describe the clinical findings seen in patients with cardiopulmonary disease.	ischemic, hypertrophic, HOCM, and apical HCM, heart failure, pulmonary hypertension, cardiac tumors and masses, and aortopathies).	
d.	**Indications and limitations of echocardiography**		
	1) Identify appropriate use of: a) transthoracic echocardiography; b) stress echocardiography; c) transesophageal echocardiography; d) intraoperative echocardiography; e) ultrasound enhancing agents; f) 3-D echocardiography; g) interventional echocardiography; h) 2-D myocardial strain imaging; i) ultrasound respirogram; and j) color M-mode.		
e.	**Pharmacology**		
	1) Discuss intravenous administration of echo enhancing agents. 2) Discuss the medications commonly used for cardiac stress testing.		
f.	**Discuss cardiac changes that occur in the athletic heart.**		
g.	**Describe the most common artifacts seen in cardiography.**		

4. Cardiac Electrophysiology concentration

*** Indicates a skill that the terminal competency assessment must occur in a clinical setting with a patient.**

a.	Cardiac Electrophysiology		
	Cognitive	**Psychomotor**	**Affective**
	1) Summarize anatomical and physiological features of the cardiac system. 2) Relate the structure and function of key components of the cardiovascular system. 3) Define action potential, including: a) describing the phases, to include ion control and movement of each phase; b) differentiating action potentials among different types of cells; and c) the pharmacological effects on action potential. 4) Correlate historical concepts and cardiac research trials to current trends in cardiac electrophysiology including: a) EP studies; b) pacemaker; c) ICD; d) CRT; and e) equipment. 5) Identify the standard protocol for a procedure-specific EP study. 6) Assess refractory periods, recovery times, and blocks. 7) Interpret the following rhythms: a) sinus; b) atrial;	21) Obtain and analyze data from a 12-lead ECG. 22) Evaluate device settings using specific analyzers/programmers. 23) ***Assemble appropriate tools and equipment for specific electrophysiology procedures.** 24) ***Demonstrate proper asepsis and scrubbing techniques for procedures in the electrophysiology lab.** 25) Perform a diagnostic EP study using a pacing simulator. 26) Measure basic intervals on the intracardiac electrograms (EGM). 27) ***Disassemble and dispose of equipment and supplies in a safe and efficient manner.** 28) ***Maintain sterile technique during all pre-procedural activities.**	29) Integrate cultural sensitivity into the care provided and into interactions with others.

	c) junctional; d) heart blocks; e) ventricular; and f) paced. 8) Synthesize diagnostic measures for specific arrhythmias. 9) Identify eccentric and concentric conduction patterns during an EP study. 10) Correlate cardiac vectors, anatomy, and the 12-lead ECG. 11) Discuss and relate the etiology of cardiac disease with clinical and procedural data. 12) Explain pathophysiology of heart failure. 13) Identify arrhythmias and describe the mechanism of each. 14) Identify indications, risks, and complications of cardiac electrophysiology procedures. 15) Choose the most appropriate cardiac device given specific indications. 16) Compare cardiac resynchronization to pharmacological therapy in the treatment of tachyarrhythmia(s). 17) Correlate patient symptoms in structural and non-structural heart disease with treatments. 18) Explain the concepts of cardiac ablation physics. 19) Differentiate between 3-D EP mapping technologies.		

	20) Correlate specific electrophysiologic properties with procedural endpoints of different pathologies.		

5. Invasive Cardiovascular Technology concentration

*** Indicates a skill that the terminal competency assessment must occur in a clinical setting with a patient.**

a.	**Anatomy and Physiology**		
	Cognitive	**Psychomotor**	**Affective**
	1) Identify the: a) cardiac chambers and concomitant septa; b) valvular anatomy and accompanying apparatus: i. central; and ii. peripheral; c) arterial and venous circulation: i. central; and ii. peripheral; d) coronary artery anatomy and distribution; and e) relationship between cardiac chambers and great vessels. 2) Describe the structure and function of the: a) cardiac chambers and concomitant septa; b) valvular anatomy and accompanying apparatus; c) arterial and venous circulation i. central; ii. peripheral d) coronary artery anatomy and distribution; e) relationship between cardiac chambers and great vessels; and f) sympathetic and parasympathetic nervous system.	7) ***Manipulate the imaging equipment to obtain appropriate views of the**: a) **cardiac chambers and concomitant septa;** b) **valvular anatomy and accompanying apparatus:** i. **central; and** ii. **peripheral;** c) **arterial and venous apparatus:** i. **central; and** ii. **peripheral;** d) **coronary artery anatomy and distribution; and** e) **relationship between cardiac chambers and great vessels.** **8) *Select and prepare the appropriate equipment for cardiac hemodynamic measurements.**	

	3) Describe cardiovascular circulation. 4) Analyze the components of the Wigger's diagram. 5) Identify coronary artery physiology, including: a) coronary perfusion pressure; b) determinates of coronary flow; and c) microcirculation and autoregulation. 6) Discuss the mechanism by which the kidney regulates blood pressure.		
b.	**Perioperative Patient Management**		
	1) Describe the activities included in preparing a patient for a procedure. 2) Discuss the activities and purpose of a time out. 3) Recognize cardiac monitoring activities that occur during the procedure. 4) Describe postprocedural care activities. 5) Recognize complications associated with cardiovascular procedures. 6) Discuss the signs and symptoms of compromised respiratory status. 7) Discuss electrophysiology, including: a) the ECG waveform; b) identifying cardiac rhythms; c) identifying ECG changes associated with physiologic events; d) the electrical pathway of the heart;	8) ***Prepare a patient for the procedure.** 9) Perform time out. 10) ***Monitor the patient and respond appropriately during the procedure.** 11) Perform postprocedural care. 12) Respond to patient emergencies that occur during invasive cardiovascular procedures. 13) Establish a patent airway and apply supplemental oxygen. 14) Perform a 12-lead ECG.	

	e) recognizing ECG artifacts; and f) the cardiac action potential.		
c.	**Radiation physics, biology and safety**		
	1) Identify the X-ray tube components and imaging chain; 2) Describe radiation science, including: a) production; b) units; and c) physics. 3) Discuss the biological effects of radiation. 4) Discuss intraprocedural strategies to protect patients and personnel from radiation (e.g., shielding, collimation, magnification). 5) Identify technical strategies to reduce radiation dose (e.g., reduce pulse rate). 6) Identify strategies to reduce exposure to radiation including: a) ALARA; and b) sentinel event.	**7) *Position a patient in relation to the imaging equipment.** 8) ***Operate the fluoroscopic X-ray machine**.	
d.	**Diagnostic and Interventional Procedures**		
	1) Describe safety procedures for the hospital/cardiovascular catheterization, including: a) regulatory compliance; and b) procedure room prep. 2) Describe the equipment used during a cardiac catheterization, including: a) disposable; and b) non-disposable. 3) Describe aseptic and sterilization techniques used in the cath lab.	6) Safely transfer a patient from the procedure table to a stretcher. 7) Perform safety checks on equipment in the procedure room (e.g., crash cart). 8) Select and obtain equipment needed for the procedure table. 9) Maintain sterile technique while preparing the table. 10) Position and secure a patient for an invasive cardiovascular procedure; and	

	4) Identify proper patient positioning for safety during the procedure. 5) Identify the areas used for percutaneous access: a) femoral; and b) radial.	**11) *Palpate the patient's pulse and position appropriately.**	
e.	**Cardiovascular Diseases, Assessment, and Treatments**		
	1) Discuss the: a) pathologies; b) complications; c) etiologies; d) signs and symptoms; and e) treatment of cardiovascular diseases (e.g., CAD, STEMI, cardiomyopathies, athlete's heart). 2) Discuss the types of percutaneous coronary interventions (PCI) (e.g., angioplasty, atherectomy, thrombectomy, laser, fibrinolytic). 3) Discuss the use of supportive devices (e.g., LVAD, balloon pump, embolic protection). 4) Describe the different types of structural heart repair and replacement (e.g., TAVR, TMVR, valvuloplasty, PFO/ASD/PDA/LAA closure). 5) Discuss the transeptal route and what devices use it (e.g., PFO, ASD, PDA, LAA closure). 6) Discuss the indications for pericardiocentesis (e.g., perforated coronary artery, perforated	8) Review case studies to identify: a) pathologies; b) complications; c) etiologies; d) signs and symptoms; and e) treatment of cardiovascular diseases (e.g., CAD, STEMI, cardiomyopathies, athlete's heart). 9) Select the correct equipment needed for each procedure (e.g., guide catheter, wire, balloon, stent). 10) Select the correct supportive device that provides optimal treatment for the patient's situation. 11) Select the equipment required for a procedure based on the patient's diagnosis. 12) Select the repair devices that use the transeptal approach. 13) Select the correct equipment needed for a pericardiocentesis. 14) Evaluate the patient's airway and determine the Mallampati classification.	

	myocardium, cardiac tamponade, pericarditis). 7) Explain the Mallampati classification.		
f.	**Pharmacology**		
	1) Discuss the concepts of pharmacokinetics and pharmacodynamics as they relate to drug response and disposition in the body. 2) Define Indications and contraindications for medications used in the management of cardiac diseases. 3) Describe the mode of action of medications used in the management of cardiac diseases. 4) Discuss the calculations required for administration of medications. 5) Discuss the proper way to chart the administration of medications used in cardiac diseases.	6) Monitor vital signs (e.g., SpO2 and ETCO2, activity, respiration, circulation, consciousness, skin color) and calculate the Aldrete score. 7) Select appropriate route of administration (e.g., intracoronary, IV bolus, or IV drip). 8) Calculate the amount of medication to administer based on the concentration and dosage ordered. 9) Communicate with the team medication administration and route.	10) Demonstrate cultural awareness when working with patients. 11) Show awareness of a patient's concerns related to pathologic conditions and the associated functional changes.
g.	**Congenital/Pediatrics**		
	1) Discuss fetal circulation and transition at birth. 2) Identify the normal anatomical fetal shunts from a diagram of fetal circulation. 3) Describe the congenital anomalies of the heart. 4) Discuss the surgical and palliative treatment for congenital cardiac anomalies. 5) Compare adult and pediatric catheterization techniques.		

h.	**Electrophysiology**		
	1) Describe the types of implantable devices (e.g., permanent pacemaker, implantable cardioverter defibrillator, bi-ventricular pacemaker). 2) Discuss the indications and contraindications for cardioversion.	3) Identify and select a specific implantable device. 4) Select and prepare the equipment used during cardioversion.	
i.	**Hemodynamics**		
	1) Recognize normal hemodynamics of the heart (e.g., parts of a pressure waveforms, vascular resistance). 2) Describe the function of a transducer. 3) Describe the process of preparing a bubble free transducer. 4) Discuss the purpose of advancing and withdrawing a catheter across a valve. 5) Describe abnormal pressures in various cardiac diseases. 6) Discuss the types of hemodynamic calculations (e.g., Fick equation, MAP, shunts).	7) Identify systole and diastole when viewing a pressure waveform. 8) Flush a transducer with fluid to remove all the air. 9) When viewing a waveform, identify the cardiac chambers and vessels. 10) Calculate the pressure gradient across the valve. 11) Use a pressure waveform to Identify a cardiac disease. 12) Given a case study, identify and select the clinical components required to calculate various hemodynamics.	13) Show awareness of a patient's concerns related to pathologic conditions.

6. Noninvasive Vascular Concentration

*** Indicates a skill that the terminal competency assessment must occur in a clinical setting with a patient.**

	Cognitive	Psychomotor	Affective
a.	**Identify vascular anatomy, including the:**		
	1) extracranial cerebrovascular; 2) intracranial cerebrovascular; 3) peripheral arterial (upper and lower); 4) peripheral venous (upper and lower); 5) abdominal vasculature, including arterial and venous; and 6) cardiac structures, including chambers, valves, and vessels.		
b.	***Obtain diagnostic images to demonstrate the following anatomy using grey scale and color Doppler of the:**		
		1) ***extracranial cerebrovascular;** 2) intracranial cerebrovascular; 3) ***peripheral arterial (upper and lower);** 4) ***peripheral venous (upper and lower); and** 5) ***abdominal vascular, including arterial and venous.**	
c.	**Recognize sonographic appearances, normal imaging measurements, and Doppler flow characteristics of the following normal and abnormal vascular structures:**		
	1) extracranial cerebrovascular; 2) intracranial cerebrovascular; 3) peripheral venous (upper and lower); 4) peripheral arterial (upper and lower); and 5) pulmonary circulation.		
d.	***Obtain diagnostic images to demonstrate grey scale, measurements and Doppler flow characteristics of the following normal and abnormal vascular structures:**		
		1) ***extracranial cerebrovascular;** 2) Intracranial cerebrovascular; 3) ***peripheral arterial (upper and lower);**	

		4) ***peripheral venous (upper and lower); and** 5) abdominal vasculature (arterial and venous).	
e.	**Analyze accurately the following noninvasive vascular exams:**		
	1) cerebrovascular duplex; 2) transcranial Doppler/imaging; 3) physiologic testing, including: a) ankle/brachial index; b) plethysmography; c) continuous wave and pulsed Doppler wave; d) segmental pressures and waveform analysis; e) exercise treadmill testing; f) pneumoplethysmography (PVR); g) venous and arterial mapping; h) peripheral venous duplex studies, i. patency; and ii. insufficiency. i) peripheral arterial duplex studies; and j) abdominal duplex studies, including: i. renal; ii. mesenteric; iii. hepatoportal; and iv. aortoiliac.		
f.	***Perform the following examinations:**		
		1) ***cerebrovascular duplex;** 2) transcranial Doppler/imaging; 3) ***physiologic testing on the upper and lower extremities;**	

		4) venous mapping of the upper and lower extremities; 5) ***peripheral venous duplex studies, including:** a) ***patency (upper and lower); and** b) **insufficiency.** 6) ***peripheral arterial duplex studies (upper and lower); and** 7) ***abdominal duplex studies, including:** a) ***renal;** b) ***mesenteric;** c) ***hepatoportal; and** d) ***aortoiliac.**	
g.	**Comprehend application of quantitative principles of vascular testing including:**		
	1) acceleration time; 2) ankle/wrist brachial pressure ratios; 3) aorta/renal ratios; 4) area and diameter reduction measurements; 5) digital/brachial indices; 6) velocity change across stenosis for grading arterial lesions; 7) pulsatility index; 8) resistive index; 9) segmental pressures, including digits; 10) velocity ratios; and 11) venous reflux time.		
h.	**Use grey scale and Doppler to assess the following principles:**		
		1) ***acceleration time;** 2) ***ankle/wrist brachial pressure ratios;** 3) ***aorta/renal ratios;** 4) ***area and diameter reduction measurements;** 5) ***digital/brachial indices;** 6) ***resistive index;**	

		7) ***segmental pressures, including digits;** 8) ***velocity ratios; and** 9) ***venous reflux time.**	
i.	**Identify outcomes and potential complications of vascular**		
	1) procedures; and 2) surgeries.		
j.	**Discuss scanning protocols based on patient specific factors, including:**		
	1) history, including location, of prior vascular procedures; 2) physical examination and assessment of patient-specific factors; 3) relating imaging, laboratory, and functional testing procedures; 4) contraindications; and 5) pharmacological effects on the patient.	6) ***Modify protocols properly based on patient-specific factors.**	
k.	**Discuss the protocols for post-procedure and post-surgical patients:**		
	1) angioplasty; 2) atherectomy; 3) coil embolization; 4) dialysis fistula/graft; 5) embolectomy; 6) endograft; 7) endovascular aortic aneurysm repair (EVAR); 8) endovenous ablation; 9) inferior vena cava filter; 10) patch angioplasty; 11) stents (venous and arterial); 12) synthetic grafts; 13) thrombolysis and thrombectomy; 14) trans-jugular intrahepatic porto-systemic shunt; and 15) venous bypass grafts.		

7. Pediatric Echocardiography Concentration

*** Indicates a skill that the terminal competency assessment must occur in a clinical setting with a patient.**

a.	**Cardiovascular anatomy and physiology**		
	Cognitive	**Psychomotor**	**Affective**
	1) Describe the normal pediatric ECG. 2) Discuss cardiac embryology, including the gestational age at which each structure develops. 3) Identify normal anatomy of heart, including: a) fetal; b) neonatal; c) infant; d) child; and e) adolescent.	4) Obtain a 3-lead ECG on a pediatric patient. 5) Use echocardiographic views to identify the: a) situs; b) cardiac chambers and concomitant septa; c) valvular anatomy and accompanying apparatus; d) arterial and venous circulation; e) coronary artery anatomy and distribution; and f) relationship between cardiac chambers and great vessels. 6) Perform pulse oximetry.	7) ***Demonstrate sensitivity to the needs of the patient or his/her family.** 8) ***Recognize how cultural or ethnic differences may affect the assessment of a patient.** 9) ***Use therapeutic communication when working with patients and families.**
b.	**Cardiac hemodynamic principles to evaluate normal cardiac flow**		
	1) Describe cardiac physiology, including: a) fetal circulation; and b) transitional circulation. 2) Describe ventricular systolic and diastolic function relative to loading conditions and filling pressures. 3) List intracardiac pressures. 4) Recognize abnormal intracardiac pressures.	5) ***Use echocardiography to assess ventricular systolic and diastolic function.** 6) ***Acquire echocardiographic images to measure intracardiac pressures.** 7) ***Use Doppler to assess valvular velocity and pressures.**	
c.	**Electrophysiology Principles**		
	1) Discuss electrophysiology, including: a) ECG waveform;	2) ***Perform 3-lead ECG**	

	b) identify normal and abnormal cardiac rhythms and rate; c) identify ECG changes associated with physiologic events; d) electrical pathway of the heart; and e) recognize ECG artifacts.		
d.	**Cardiovascular Pathophysiology**		
	1) Describe cardiac pathophysiology, including common and critical lesions including: a) BAV; b) coarctation; c) RVOT obstruction; d) TOF; e) TGA; f) tricuspid atresia; g) truncus arteriosus; h) RVOT obstruction; i) pulmonary atresia; j) Ebstein's anomaly; k) interrupted aortic arch; l) intracardiac shunts: i. ASD; ii. VSC; and iii. PDA; m) single ventricle i. double inlet RV; and ii. HLHS. 2) Discuss cardiac changes that occur in the athletic heart. 3) Identify and describe atrial defects. 4) Identify and describe ventricular defects.	6) **Use echocardiographic views (e.g., 2D and Doppler) to calculate the following:** a) ***Qp/Qs;** b) ***stroke volume;** c) cardiac output; d) cardiac index; e) ***pressure gradients;** and f) valve area. 7) Obtain echocardiographic views to image atrial septal defects. 8) Obtain echocardiographic views to image ventricular septal defects. 9) Obtain echocardiographic views to image atrioventricular defects.	

	5) Identify and describe atrioventricular defects.		
e.	**Indications and limitations of echocardiography**		
	1) Identify appropriate use of: a) transthoracic echocardiography; b) stress echocardiography; c) transesophageal echocardiography; d) intraoperative echocardiography; e) ultrasound enhancing agents; f) 3D echocardiography; g) interventional echocardiography; h) strain imaging; and i) ultrasound respirogram.	2) ***Use echocardiographic views to calculate the following:** a) ***3D volumetric EF; and** b) ***myocardial strain imaging (e.g., GLS).**	3) ***Demonstrate empathy towards patients that are in pain or distress.**
f.	**Pharmacology**		
	1) Discuss intravenous administration of ultrasound enhancing agents. 2) Discuss the medications commonly used for stress testing. 3) Discuss the appropriate use of sedatives and hypnotics.		
g.	**Post-operative pediatric imaging**		
	1) Describe the palliative and corrective surgical procedures for: a) PDA; b) valvular atresia; c) valvular stenosis; d) single ventricle (e.g., HLHS); e) TGA; and f) TOF. 2) Describe the interventional and surgical procedures for: a) palliative systemic to pulmonary shunts; b) corrective surgeries;	3) Obtain echocardiographic images in the post-operative patient to evaluate: a) residual shunts; b) cardiovascular hemodynamics; c) baffle/conduit function; and d) competency of anastomosis.	

	c) valvular implantation; d) balloon valvuloplasty; e) coil placement; f) stent placement; and g) device implantation.		