



# Commission on Accreditation of Allied Health Education Programs

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

**Standards initially adopted in 2012; revised in 2016, 2020**

**Adopted by the**

**American Society of Echocardiography  
Society of Diagnostic Medical Sonography  
Committee on Accreditation for Advanced Cardiovascular Sonography  
and  
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 and Guidelines** 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 interpretation of the Standards.

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

## **Preamble**

The Commission on Accreditation of Allied Health Education Programs (CAAHEP), the Committee on Accreditation for Advanced Cardiovascular Sonography (CoA-ACS), the American Society of Echocardiography (ASE), and the Society of Diagnostic Medical Sonography (SDMS) cooperate to establish, maintain and promote appropriate standards of quality for educational programs in the advanced cardiovascular sonography profession and to provide recognition for educational programs that meet or exceed the minimum standards outlined in these accreditation **Standards and Guidelines**. Lists of accredited programs are published for the information of students, employers, educational institutions and agencies, and the public.

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

## **Description of the Profession**

The profession of Adult Echocardiography Advanced Cardiovascular Sonographer (ACS): 1) assists staff sonographers to assess cases that require 2D, Doppler, advanced measurements, contrast, strain, and 3D; 2)

reviews studies that have been performed by the staff sonographer in preparation for review by the supervising cardiologist; 3) provides in-service education for staff sonographers of new methods that are to be incorporated in the echocardiographic examination; 4) ensures that the necessary echocardiographic data is obtained based on the clinical history and presentation; and 5) establishes quality assurance measures to maintain the highest standard of care of a laboratory by closely monitoring sonographer performance and identifying training needs.

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

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## **I. Sponsorship**

### **A. Sponsoring Educational Institution**

A sponsoring institution 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 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 or medical center or other governmental medical service, which is accredited by a healthcare accrediting agency or equivalent that is recognized by the U.S. Department of Health and Human Services, and authorized under applicable law or other acceptable authority to provide healthcare, which awards a minimum of a certificate at the completion of the program.
3. A branch of the United States Armed Forces, which awards a minimum of a certificate at the completion of the program.

### **B. Consortium Sponsor**

1. A consortium sponsor is an entity consisting of two or more members that exists for the purpose of operating an educational program. In such instances, at least one of the members of the consortium must meet the requirements of a sponsoring educational institution as described in I.A.
2. The responsibilities of each member of the consortium must be clearly documented in a formal affiliation agreement or memorandum of understanding, which includes governance and lines of authority.

### **C. Responsibilities of Sponsor**

1. The Sponsor must ensure that the provisions of these **Standards and Guidelines** are met.
2. The Sponsor must ensure that the graduates of the program have obtained or will obtain a minimum of a bachelor's degree, and a cardiac sonography or vascular specialist/technologist entry-level technical credential upon completion of the program.

*The student entering the program should hold a bachelor's degree and an entry-level technical credential in sonography.*

## **II. Program Goals**

### **A. Program Goals and Outcomes**

There must be a written statement of the program's goals and learning domains (cognitive, psychomotor, affective) consistent with and responsive to the demonstrated needs and expectations of the various communities of interest served by the educational program. The communities of interest that are served by the program must include, but are not limited to: students, graduates, faculty, sponsor administration, employers, physicians, and the public.

Program-specific statements of goals and learning domains provide the basis for program planning, implementation, and evaluation. Such goals and learning domains must be compatible with the mission of the sponsoring institution(s), the expectations of the communities of interest, and nationally accepted standards of roles and functions. Goals and learning domains are based upon the substantiated needs of health care providers and employers, and the educational needs of the students served by the educational program.

**B. Appropriateness of Goals and Learning Domains**

The program must regularly assess its goals and learning domains. Program personnel must identify and respond to changes in the needs and/or expectations of its communities of interest.

An advisory committee, which is representative of at least each of the communities of interest named in these **Standards**, must be designated and charged with the responsibility of meeting at least annually, to assist program and sponsor personnel in formulating and periodically revising appropriate goals and learning domains, monitoring needs and expectations, and ensuring program responsiveness to change.

*The annual advisory committee meeting need not be face-to-face, but can include participation by synchronous electronic means.*

**C. Minimum Expectations**

The program must have the following goal defining minimum expectations: “To prepare competent entry-level Advanced Cardiovascular Sonographers in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains.”

Programs adopting educational goals beyond entry-level competence must clearly delineate this intent and provide evidence that all students have achieved the basic competencies prior to entry into the field.

*Nothing in this Standard restricts programs from formulating goals beyond entry-level competence.*

**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: faculty; clerical and support staff; curriculum; finances; offices; classroom, laboratory, and, ancillary student facilities; clinical affiliates; equipment; supplies; computer resources; instructional reference materials; and faculty/staff continuing education.

Each clinical affiliate must be an accredited echocardiography laboratory or have a majority of cardiac sonography or vascular specialist/technologist entry-level technical credentialed sonographers.

**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.

**1. Program Director**

**a. Responsibilities**

The Program Director must:

- 1) ensure achievement of the program’s goals and outcomes, and
- 2) be responsible for all aspects of the program, including the organization, administration, continuous review, planning, development and general

- effectiveness of the program, and
- 3) provide supervision, administration and coordination of the instructional staff in the academic and practical phases of the education program.

b. **Qualifications**

The Program Director must possess proficiency in curriculum development; and must meet at least one of the following:

- 1) Possess a Baccalaureate degree and an ACS credential; or
- 2) Possess a minimum of a Master's degree and be a credentialed sonographer in the discipline that is offered; or
- 3) Be a physician board certified in the discipline that is offered.

2. **Medical Advisor**

a. **Responsibilities**

The Medical Advisor(s) must provide guidance to ensure that the clinical and didactic components of the curriculum meet currently acceptable performance standards.

b. **Qualifications**

The Medical Advisor(s) must be a licensed physician (MD or DO), board certified in cardiology and echocardiography.

3. **Faculty and Instructional Staff**

a. **Responsibilities**

In classrooms, laboratories, and all applied instructional settings where a student is assigned, there must be a qualified instructor who is clearly designated as liaison(s) to the program to provide instruction, supervision, and timely assessment of the student's progress in meeting program requirements.

b. **Qualifications**

Instructors must be one of the following:

- 1) a licensed physician (MD or DO) with board certification in the subject matter of his/her assigned subject(s), or
- 2) an individual with an earned doctorate degree in the subject matter of his/her teaching responsibilities, or
- 3) an individual who has graduated from a CAAHEP accredited ACS program, or
- 4) an individual with an advanced sonographer credential with a minimum of a baccalaureate degree.

C. **Curriculum**

The curriculum must ensure the achievement of program goals and learning domains. Instruction must be an appropriate sequence of classroom, laboratory, and clinical activities. 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.

- 1. The curriculum for the ACS must include the following content:
  - a. Advanced cardiovascular hemodynamics/pathophysiology
  - b. Acquired cardiovascular disease
  - c. Congenital cardiovascular disease
  - d. Medical and surgical treatment of cardiovascular disease (by disease)
  - e. Advanced echocardiography modalities
  - f. Comparative imaging analysis (angiography, nuclear cardiology, cardiac CT and cardiac MRI)
  - g. Research methods and biostatistics
  - h. Introduction to clinical trials research and IRB requirements

- i. Cardiovascular Pharmacology
  - j. Physics and Instrumentation
  - k. Patient Assessment
  - l. Instructional techniques for the adult learner
2. Upon successful completion of the program, the graduate must have demonstrated the following competencies:
- a. Perform preliminary assessment of the echocardiographic study with a preliminary findings' worksheet for the interpreting physician
  - b. Develop a quality assurance policy/program
  - c. Provide and present a literature review summary with case presentation or original research on new echocardiographic technology
  - d. Present technology integration strategies
  - e. Monitor the staff sonographers' performance of echocardiographic studies with written assessments that outline advice for performing improved imaging

*Additional related subjects should include Health Administration and Business, Interpersonal skills, Evidence Based Medicine/Appropriateness Criteria, Professional Standards and Ethics.*

*The curriculum should include the content in Appendix B listed under each of the content headings.*

#### **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 appropriate change. An action plan must be developed when deficiencies 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 competencies and learning domains stated in the curriculum.

#### **2. Documentation**

Records of student evaluations must be maintained in sufficient detail to document learning progress and achievements.

### **B. Outcomes**

#### **1. Outcomes Assessment**

The program must periodically assess its effectiveness in achieving its stated goals and learning domains. The results of this evaluation 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/attrition, graduate satisfaction, employer satisfaction, job (positive) placement, and programmatic summative measures. The program must meet the outcomes assessment thresholds.

*"Positive placement" means that the graduate is employed full or part-time in the profession or in a related field; or continuing his/her education; or serving in the military. A related field is one in which the*

*individual is using cognitive, psychomotor, and affective competencies acquired in the educational program.*

*“National credentialing examinations” are those accredited by the National Commission for Certifying Agencies (NCCA) or American National Standards Institute (ANSI).*

## **2. Outcomes Reporting**

The program must periodically submit to the CoA-ACS the program goal(s), learning domains, evaluation systems (including type, cut score, and appropriateness), outcomes, its analysis of the outcomes, and an appropriate action plan based on the analysis.

Programs not meeting the established thresholds must begin a dialogue with the CoA-ACS to develop an appropriate plan of action to respond to the identified shortcomings.

# **V. Fair Practices**

## **A. Publications and Disclosure**

1. Announcements, catalogs, publications, and advertising must accurately reflect the program offered.
2. At least the following must be made known to all applicants and students: the sponsor’s institutional and programmatic accreditation status as well as the name, mailing address, web site address, and phone number of the accrediting agencies; admissions policies and practices, including technical standards (when used); policies on advanced placement, transfer of credits, and credits for experiential learning; number of credits required for completion of the program; tuition/fees and other costs required to complete the program; policies and processes for withdrawal and for refunds of tuition/fees.
3. At least the following must be made known to all students: academic calendar, student grievance procedure, criteria for successful completion of each segment of the curriculum and for graduation, and policies and processes by which students may perform clinical work while enrolled in the program.
4. The sponsor must maintain, and make available to the public current and consistent summary information about student/graduate achievement that includes the results of one or more of the outcomes assessments required in these **Standards**.

*The sponsor should develop a suitable means of communicating to the communities of interest the achievement of students/graduates (e.g. through a website or electronic or printed documents).*

## **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, students, faculty, and other participants associated with the educational activities of the students must be adequately safeguarded.

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

## **D. Student Records**

Satisfactory records must be maintained for student admission, advisement, counseling, and evaluation. Grades and credits for courses must be recorded on the student transcript and permanently maintained by the sponsor in a safe and accessible location.

**E. Substantive Change**

The sponsor must report substantive change(s) as described in Appendix A to CAAHEP/CoA in a timely manner. Additional substantive changes to be reported to the CoA-ACS within the time limits prescribed include:

1. Change in accreditation of a clinical affiliate.
2. Additions or deletions of clinical affiliates.

**F. Agreements**

There must be a formal affiliation agreement or memorandum of understanding between the sponsor and all other entities that participate in the education of the students describing the relationship, roles, and responsibilities of the 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 and returns it electronically or by mail to:

**CoA-ACS**  
2530 Meridian Parkway, Suite 450  
Durham, NC 27713

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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography. The on-site review will be scheduled in cooperation with the program and Committee on Accreditation for Education in Advanced Cardiovascular Sonography once the self-study report has been completed, submitted, and accepted by the Committee on Accreditation for Education in Advanced Cardiovascular Sonography.

##### 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, and returns it electronically or by mail to:

**CoA-ACS**  
2530 Meridian Parkway, Suite 450  
Durham, NC 27713

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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography forwarding a recommendation to CAAHEP.



### **3. Administrative Requirements for Maintaining Accreditation**

- a. The program must inform the Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography that it is relinquishing its sponsorship of the program. Additionally, the new sponsor must submit a "Request for Transfer of Sponsorship Services" form. The Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 of accreditation will be granted.
- c. The sponsor must promptly inform CAAHEP and the Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography and CAAHEP fees within a reasonable period of time, as determined by the Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 a 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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography. The sponsor will be notified by the Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 Committee on Accreditation for Education in Advanced Cardiovascular Sonography allows the Initial Accreditation of a program to expire, the sponsor must have the opportunity to request reconsideration of that decision or to request voluntary withdrawal of accreditation. The CoA-ACS' decision is final and CAAHEP will not entertain any appeal on behalf of the program. CAAHEP will notify the sponsor in writing of the CoA-ACS' decision.
3. Before the Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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' 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.

4. Before the Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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' reconsideration of a recommendation of withdraw

or withhold accreditation must be based on conditions existing both when the Committee on Accreditation for Education in Advanced Cardiovascular Sonography 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 Advanced Cardiovascular Sonography

#### A. Advanced Cardiac Hemodynamics/Pathophysiology

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 O<sub>2</sub> difference*
- ii. *Effects of training*

B) *Cardiovascular responses to supine exercise*

C) *Cardiovascular responses to isometric exercise*

**B. Acquired Cardiovascular Disease**

1. *Valvular Heart Disease*
2. *Prosthetic Valve Disease*
3. *Ischemic Heart Disease*
4. *Cardiomyopathy*
5. *Pericardial Disease*
6. *Cardiac Trauma*
7. *Cardiac Neoplasms and Masses*
8. *Radiation Heart Disease*
9. *Diseases of the Aorta*

**C. Congenital Cardiovascular Disease**

1. *Embryology and fetal cardiac development - Segmental approach*
2. *Cardiac chambers and septation*
3. *Valve anatomy and dynamics*
4. *Coronary artery anatomy*
5. *Relationships of cardiac chambers and great vessels*
6. *Mediastinal structures*

**D. Medical and Surgical Treatment of Cardiovascular Disease**

1. *Prosthetic Valve*
2. *Balloon Valvuloplasty*
3. *Intraoperative evaluation*
4. *Use of TEE for hemodynamic monitoring*
5. *Transcatheter aortic valve implantation*
6. *Mitral repair*
7. *Closure of prosthetic paravalvular leaks*
8. *Post-procedure follow-up*
9. *Transcatheter interventions*
10. *Surgical options in cardiomyopathy*
11. *Myocardial Biopsy*
12. *Pericardiocentesis*
13. *Device closure of septal defects*

**E. Advanced Echocardiographic Modalities**

1. *Contrast Echocardiography*
2. *Indication*
3. *Physical interaction of contrast agents*
4. *Administration*
5. *Technique*
6. *Myocardial Perfusion*
  - A) *Triggered*
  - B) *Realtime*
8. *Optimization*
7. *Contrast vascular applications*
8. *3D*

9. *3D Quantification*
10. *Image Acquisition*
11. *Triplane Imaging*
12. *Full Volume*
13. *3D Volume Imaging*
14. *Heart Failure Assessment*
15. *Cardiac Resynchronization*
  - A) *Eligibility and Advantages*
  - B) *Types of conduction delays*
  - C) *Biventricular Pacing*
  - D) *Echocardiographic Assessment of Synchrony and Desynchrony*
  - E) *Methods of Optimization*
  - F) *Protocols for Treatment*
16. *Strain*

**F. Comparative imaging analysis (angiography, nuclear cardiology, cardiac CT and cardiac MRI)**

1. *Coronary angiography and physiology*
2. *Cardiac physiology and pathophysiology*
3. *Rest and exercise electrocardiography*
4. *Exercise physiology*
5. *Pharmacology of standard cardiovascular drugs*
6. *Patient safety*
7. *Cardiopulmonary resuscitation and treatment of other cardiac emergencies*
8. *Pharmacology and physiology of commonly used stress agents such as dipyridamole, adenosine, and dobutamine*
9. *Clinical outcomes assessment*
10. *Radiation and magnet safety*
11. *Radiopharmaceuticals*
12. *Nuclear cardiology diagnostic tests and procedures protocols*
13. *General cardiology*
14. *Indications for ordering imaging studies*
15. *Appropriateness*
16. *Image Interpretation*
17. *Pitfalls in interpretation and clinical application of imaging modalities*
18. *Patient risk stratification*
19. *Specificity, sensitivity, diagnostic accuracy, utility in assessing prognoses and interventions*
20. *Costs associated with different imaging modalities*
21. *Sources of artifacts in various cardiac imaging, including motion, arrhythmias, and metal objects in MRI*
22. *Cardiology imaging contrast agents side effects*
23. *Clinical utility of all cardiology imaging modalities*
24. *Hemodynamic assessment by various imaging modalities*
25. *Coronary artery imaging*
26. *Role of complementary imaging modalities in various conditions including CAD, myocardial diseases, valvular heart disease, diseases of the aorta, congenital heart disease*

**G. Research Methods and Biostatistics**

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*
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*

**H. Introduction to clinical trials research and IRB requirements**

- 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*

**I. Cardiovascular Pharmacology**

- 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. *Local Anesthetics*
- 13. *Vasopressors*

**J. Physics and Instrumentation**

- 1. *Advanced hemodynamics*
- 2. *Advanced principles of Doppler ultrasound*
- 3. *Spectral analysis and color flow imaging*
- 4. *Strain/Strain rate and torsion imaging*
- 5. *3D (TTE and TEE)*
- 6. *Harmonics*
- 7. *Contrast agents*
- 8. *Biological effects*
- 9. *Image acquisition and storage*
- 10. *Quality control*
- 11. *Equipment selection*
- 12. *Image optimization*
- 13. *Recent advances in technology and ultrasound techniques*

**K. Patient Assessment**

- 1. *Patient Historical Assessment*
- 2. *Physical Exam with incorporation of hemodynamic information*

3. *Chart Review*

**L. Instructional techniques for the adult learner**

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