New 2023 Educational Guidelines for Invasive Cardiovascular Technology Personnel in the Adult Cardiovascular Catheterization Laboratory

Endorsed by the Society for Cardiovascular Angiography and Interventions (SCAI)

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In addition to highly trained physicians, cardiovascular catheterization laboratories are comprised of a multitude of credentialed healthcare professionals. These professionals include registered cardiovascular invasive specialists (RCISs), registered nurses (RNs), registered radiologic technologists (RT[R]s), registered respiratory therapists (RRTs), and others. The cardiovascular technology (CVT) profession, which now includes RCIS members, was formally recognized as an allied health profession by the American Medical Association Counsel on Medical Education in December 1981.[1] With the establishment of the cardiovascular technology profession, it was recognized that there was a need for educational standards and guidelines for post-secondary cardiovascular technology educational programs, and in September 1983, the first draft of the *Essentials and Guidelines of an Accredited Educational Program in Cardiovascular Technology* was published.[1] The *Essentials and Guidelines* describes educational guidelines and other requirements for cardiovascular technology educational programs to become accredited. The most recent *Educational Guidelines for Invasive Cardiovascular Technology Personnel in the Cardiovascular Catheterization Laboratory* was published by the Society of Invasive Cardiovascular Professionals (SICP) and endorsed by the Society for Cardiovascular Angiography and Interventions (SCAI) in 2015.[2] In 2017, the SICP joined forces with the Alliance of Cardiovascular Professionals (ACVP). In order to provide for the continuing training of invasive cardiovascular technologists and to update the educational framework for accredited invasive cardiovascular training programs, the ACVP has now published, with the endorsement of the SCAI, the *2023 Educational Guidelines for Invasive Cardiovascular Technology Personnel in the Adult Cardiovascular Catheterization Laboratory* standards (Appendix A, available with the article at CathLabDigest.com). These updated guidelines have been developed by a multidisciplinary team of interventional cardiologists, RCISs, cardiovascular technology educators, RNs, RT(R)s, and cardiovascular cath lab managers, among others.

The invasive cardiovascular technology accreditation *Essentials and Guidelines* was, and continues to be, influenced by the triad of invasive cardiovascular technology professional organizations:

- The Alliance of Cardiovascular Professionals (ACVP), the professional society;
- Cardiovascular Credentialing International (CCI), the credentialing organization; and
- The Commission on Accreditation of Allied Health Education Programs/Joint Review Committee on Education in Cardiovascular Technology (CAAHEP/JRC-CVT), the programmatic accrediting organization.

Alliance for Cardiovascular Professionals (ACVP)

For over 40 years, the ACVP has served as the professional society representing nonphysician professionals involved in all levels of cardiovascular service and specialties, including invasive cardiovascular technology/cardiovascular catheterization. The ACVP is both the invasive cardiovascular technology professional organization and sponsoring organization for the CAAHEP/JRC-CVT.

Society for Cardiovascular Angiography and Interventions (SCAI)

While the ACVP represents the nonphysician cath lab professionals, SCAI is the physician-based medical society and represents over 4500 members specializing in invasive and interventional cardiology. Founded in 1978, SCAI's mission is to lead the global interventional cardiovascular community through education, advocacy, research, and quality patient care.[3] Invasive/interventional cardiologists and cath lab professionals share a close working relationship, and the input and endorsement from these cardiologists and SCAI for the *2023 Educational Guidelines* helps to ensure they reflect current practice.

Cardiovascular Credentialing International (CCI)

The credentialing organization for the invasive CVT profession is Cardiovascular Credentialing International (CCI). CCI has developed and administered cardiovascular technology credentialing examinations for the various subspecialties in the cardiovascular technology professions since 1968.[4] Applicants that meet the eligibility requirements, including graduates of accredited invasive cardiovascular technology programs, are eligible to take the Registered Cardiovascular Invasive Specialist

These guidelines can also provide a valuable resource to cath labs around the United States as part of the orientation of new personnel, cross-training of staff, continuing education programs, and in the adoption of new invasive types of procedures. The invasive CVT profession continues to evolve at a rapid pace and requires current curriculum to be updated on a regular basis.

(RCIS) exam offered by CCI. The content of the RCIS exam is influenced by a Job Task Analysis (JTA) specific to the invasive cardiovascular technology profession. CCI conducts the JTA to quantify the importance and frequency of the tasks performed by cardiovascular invasive specialists during elective and emergent cardiovascular catheterization procedures. This information provides CCI with an additional focus in the development of certification examinations. The RCIS credential is recognized by ACVP as the credential developed for cardiovascular technologists specific to the practice of invasive cardiovascular technology. The American College of Cardiology (ACC) also recognizes and endorses the RCIS credential.[5,6]

Commission on Accreditation of Allied Health Education Programs (CAAHEP) and Joint Review Committee on Education in Cardiovascular Technology (JRC-CVT)

The programmatic accrediting organization for invasive cardiovascular technology post- secondary educational programs is the Commission on Accreditation of Allied Health Education Programs (CAAHEP). CAAHEP provides accreditation services for over 30 health professions in the health sciences field.[7] CAAHEP makes its accreditation decisions based on the recommendations of its Committees of Accreditation. The Committee on Accreditation for the Invasive Cardiovascular Technology Profession is the Joint Review Committee on Education in Cardiovascular Technology (JRC-CVT). The JRC-CVT was established in 1985.[1] CAAHEP and the JRC-CVT collaborate on the development of the accreditation standards and guidelines for post-secondary educational programs in invasive cardiovascular technology. Graduates of CAAHEP-accredited invasive cardiovascular programs are eligible to sit for the RCIS exam.

The CAAHEP/JRC-CVT accreditation standards describe the educational content that should be incorporated in the curricula of CAAHEP-accredited invasive cardiovascular technology programs. Members of the CAAHEP/JRC-CVT defer to the expertise of the professional societies to develop these educational curricula. In the case of invasive cardiovascular technology programs, the CAAHEP Standards defer to the content developed by the ACVP.

What's Next for the *2023 Educational Guidelines*

The *2023 Educational Guidelines* will provide invasive CVT education programs with guidance as they develop and update their curricula. All of the accredited invasive cardiovascular technology programs and those programs pursuing accreditation will be notified about the *2023 Educational Guidelines for Invasive Cardiovascular Technology Personnel in the Adult Cardiovascular Catheterization Laboratory* by the CAAHEP/JRC-CVT. Programs will have at least one year to demonstrate, based on recommendations from their programs advisory boards, their plans to include the relevant content for the profession of invasive cardiovascular technology.

There are significant regional differences as to the variety and scope of invasive cardiovascular catheterization procedures around the United States. For that reason, it is not required that every accredited invasive cardiovascular technology program will include all of the elements described in the *2023 Educational Guidelines*. However, it is expected that programs will include specific content areas determined by their profession to be mandatory. These content areas include, but are not limited to, aseptic technique, bloodborne pathogens, radiation production and safety, cardiovascular anatomy, physiology, pathophysiology, procedures and protocols for diagnostic left and right heart and vascular catheterization, interventional cardiovascular catheterization procedures, hemodynamic monitoring, cardiovascular patient assessment, cardiovascular pharmacology, and cardiovascular cath lab complications.

The *2023 Educational Guidelines for Invasive Cardiovascular Technology Personnel in the Adult Cardiovascular Catheterization Laboratory* is intended to provide a framework for invasive cardiovascular programs as these programs develop or refine their curricula. These guidelines can also provide a valuable resource to cath labs around the United States as part of the orientation of new personnel, cross-training of staff, continuing education programs, and in the adoption of new invasive types of procedures. The invasive CVT profession continues to evolve at a rapid pace and requires current curriculum to be updated on a regular basis. Educational programs will also need to respond to advances and changes in the profession. Working together, SCAI, ACVP, credentialing organizations, accrediting organizations, and educational programs will continue to advance the profession and the practice of invasive cardiovascular technology, further benefiting the patients they serve.■

References

1. Joint Review Committee on Education in Cardiovascular Technology. Cardiovascular Technology History. Accessed March 13, 2023. https://www.jrccvt.org/about-us/
2. Davis J. New 2015 educational guidelines for invasive cardiovascular technology personnel in the cardiovascular catheterization laboratory. *Cath Lab Digest.* 2015; 23(5): 1,8. https://www.hmpgloballearningnetwork.com/site/cathlab/article/society-invasive-cardiovascular-professionals-new-2015-educational-guidelines-invasive
3. Society for Cardiovascular Angiography and Interventions. SCAI History. Accessed March 13, 2023. https://scai.org/about-us
4. Cardiovascular Credentialing International. About CCI. Accessed March 13, 2023. https://cci-online.org/why-credential/
5. Otto CM. ACC recognizes cardiovascular sonographer and technologist credentials. *Cardiology.* 1995; 24(7): 19.
6. American College of Cardiology. CV Team Section: Membership Criteria/Who We Are. Accessed March 13, 2023. https://www.acc.org/membership/sections-and-councils/cardiovascular-team-section/join-the-cv-team/membership-criteria
7. Commission on Accreditation of Allied Health Education Programs. CAAHEP Program Directors. Accessed March 13, 2023. https://www.caahep.org/program-directors/program-directors

Appendix A

The *2023 Educational Guidelines for Invasive Cardiovascular Technology Personnel in the Adult Cardiovascular Catheterization Laboratory* can be found online by scanning the QR code below.

View the Guidelines online by scanning the QR code with your phone camera or find it at CathLabDigest.com

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Appendix A

2023 ACVP Educational Guidelines for Invasive Cardiovascular Technology Personnel in the Adult Cardiovascular Catheterization Laboratory

Invasive Cardiovascular History and General Procedure Descriptions

A. Pioneers and Historical Overview of the Profession

B. Cardiovascular Terminology

C. Right Heart Catheterization
   1. Indications & Contraindications
   2. Risks & Complications

D. Left Heart Catheterization and Coronary Angiography
   1. Indications & Contraindications
   2. Risks & Complications

E. Peripheral procedures
   1. Indications & Contraindications
   2. Risks & Complications

F. Structural Interventions: (Valve Procedures)
   1. Indications & Contraindications
   2. Risks & Complications

G. The Evolving Role of Registered Cardiovascular Invasive Specialists (RCIS)

I. Patient Rights and Professional Standards

A. Patients' Rights and Safety
   1. Informed Consent
   2. Patient Identification
   3. Confidentiality/HIPAA
   4. Patient Bill of Rights
   5. Patient Safety Methods

B. Professionalism
   1. Professional Behavior in the Workplace
   2. Respect for Patients and Colleagues

C. Communication and Handoffs

II. Normal Anatomy and Physiology

A. Normal Cardiovascular Anatomy and Physiology
    1. Cardiac Anatomy and Physiology
    2. Vascular Anatomy and Physiology

B. Flow Dynamics – Cardiac Cycle

C. Wigger's Diagram

D. Coronary Artery Anatomy and Physiology
    1. Left Coronary Artery
    2. Right Coronary Artery
    3. Coronary Perfusion Pressure
    4. Determinates of Coronary Flow
    5. Microcirculation and Autoregulation

E. Sympathetic/Parasympathetic Nervous System

F. Cardiac Action Potential and Conduction System

G. Renal Regulation of Blood Pressure

H. Congenital Development and Abnormalities

I. Pulmonary Ventilation/Perfusion

III. Cardiovascular Diseases, Assessment and Treatments

A. Identification of Pathologies and Complications

B. Evaluation of Statistical Data for Cardiovascular Diseases

C. Etiology, Pathophysiology, Clinical Manifestations, and Treatment of:
    1. Coronary Artery Disease – Atherosclerosis
    2. Angina
        a. Stable, Unstable Variants
    3. Acute Coronary Syndromes – Myocardial Infarction (STEMI, UA/NSTEMI)
        a. No-Reflow, Microvascular Obstruction
    4. Heart Failure (Left Heart, Right Heart, Biventricular)
    5. Shock (Cardiogenic, Hypovolemic, Septic, Distributive)
    6. Valvular Heart Disease (Aortic, Mitral, Pulmonic, Tricuspid, Stenosis, Regurgitant/Insufficient)
        a. Medical, Transcatheter, and Surgical Approaches

7. Cardiomyopathies (Dilated, Hypertrophic, Restrictive, Takotsubo)
8. Pericardial Diseases (Acute Pericarditis, Constrictive Pericarditis, Pericardial Effusion, Tamponade)
9. Abdominal and Thoracic Aortic Aneurysms & Dissections
10. Systemic and Pulmonary Hypertension
11. Hereditary Diseases
12. Pulmonary Diseases (COPD)
13. Peripheral and Central Arterial and Venous Diseases
14. Infectious Diseases
15. Tumors
16. Cerebrovascular Diseases
17. Renal Disease
18. Endocrine Disease
19. COVID-19

D. Surgical Procedures Overview
    1. Coronary Artery Bypass Graft Surgery
    2. Minimally Invasive Coronary Bypass
    3. Surgical Valvular Repair/Replacement
    4. Transcatheter Valvular Repair/Replacement
    5. Heart Transplant
    6. Cardiac Implantable Electronic Devices (Pacemaker, Defibrillator, Cardiac Resynchronization Therapy, Implantable Loop Recorder)
    7. Investigational Clinical Procedures

E. Ventricular Assist Devices

IV. Pre-Procedure Patient Assessment and Preparation

A. Patient Prep/Pre-Cardiovascular Catheterization Lab Teaching/Assessment/Time-Out
    1. Patient Medical Record
    2. Physician Orders
    3. Cultural Diversity and Patient Sensitivity

B. Procedure Preparation and Premedication

C. Basic Assessment Techniques
    1. History & Physical Examination
        a. Medical, Surgical, and Invasive History
        b. Skeletal and Skin Assessments
    2. Vital Signs
    3. Central Nervous System Assessment
    4. Chest X-Ray
    5. Respiratory System Assessment
        a. Whole Blood Oximetry Sampling
        b. PaO_2, SaO_2, SvO_2, CaO_2, CvO_2

c. Interpretation of Arterial Blood Gases

6. Cardiovascular Assessment
    a. Auscultation, Murmurs, Pulses, Arrhythmias, 12-Lead Analysis, etc.
    b. Pain Assessment
7. EKG
    a. EKG Monitoring
    b. EKG Paper/Caliper Measurements/Heart Rate Calculations
    c. Rhythm Interpretation
    d. Understanding Electrical/Mechanical Relationships
    e. 12-Lead Interpretation/Hypertrophy, Axis, Bundle Branch, and Infarct Patterns
    f. Pacemakers: Overview
        1. Temporary and Permanent
    g. Defibrillation and Cardioversion
8. Peripheral Vascular Assessment
    a. Pulses
    b. Use of Doppler
    c. Allen Test and Barbeau Grades (Radial Cases)
    d. Skin Mottling
    e. Introduction to ultrasound imaging for vascular access

D. Interpretation of Laboratory Studies
    1. Chemistries, A1C, Cardiac Enzymes, Troponin
    2. Electrolytes
    3. Hematology & Coagulation Studies
    4. Lipid Panel/Profile

E. Patient Laboratory Management Before and During Procedures
    1. Point of Care Testing (POCT)
        a. ACT
        b. Whole Blood Oximetry
        c. PT/INR
        d. hCG testing
        e. Rapid Platelet Function Assays
        f. Ultrasound utilization

F. IV Therapy
    1. IV Insertion
    2. IV Assessment and Maintenance
    3. Troubleshooting

G. Foley Insertion

H. Patient Transport and Transfer

I. Post-Cardiovascular Cath Patient Care, Hemostasis, and Teaching

J. High-Risk Patient Management

K. Clinical Emergencies and Complications
   1. Acute MI (STEMI, UA/NSTEMI) and emergent catheterization
   2. Chest Pain
   3. Shortness of Breath
   4. Shock – All Types
   5. Dysrhythmias
   6. Tamponade
   7. Acute Stent Closure
   8. Pericardial Tamponade
   9. Dissections – Coronary/Aortic/Iliac/Femoral/Radial
   10. Perforations
   11. Cerebrovascular Accident – CVA/TIA
   12. Pulmonary Edema
   13. Pulmonary Embolism
   14. Acute Pulmonary Hemorrhage
   15. Hypertension/Hypotension
   16. Anaphylaxis and Allergic Reactions
   17. Bronchospasm
   18. Air Embolism
   19. Airway Management/Oxygen Delivery Devices

L. ACLS and BCLS Protocols

V. X-Ray Generation and Radiation Physics/Safety

A. X-Ray Tube Components and Imaging Chain
   1. Radiation Production, Radiation Units, Characteristics and Physics
   2. Imaging System (X-Ray Tube and Flat Panel Detector)
   3. Positioning and Operation of the Fluoroscopic X-Ray Machine
   4. Quantitative Image Analysis and Road Mapping

B. Quantitative Image Analysis Image Acquisition and Equipment
   1. Fluoroscopy
   2. Cineangiography
   3. Automatic exposure quality control
   4. Functions
   5. Projections
   6. Magnification

C. Specialized Equipment Instrumentation
   1. Radiographic tube requirements

2. Radiographic exposure (kVp, mAs)
3. Image intensification
4. Imaging systems
5. Digital imaging
6. 3D Rotational Angiography, CT Overlay
7. Data acquisition
8. Quality control
9. Data archiving systems
10. Cardiac and vascular-interventional table

D. Radiation Biology & Protection
    1. Cellular Biology Overview
    2. Biological Effects of Radiation
    3. Radiation Exposure Monitoring
    4. Limits for Exposure to Ionizing Radiation
        a. ALARA
        b. Sentinel Events (eg >15Gy)
    5. Quality Assurance

E. Radiation Protection
    1. Patients
    a. Collimation, Magnification, Frame rates, Geometry (e.g., SID, OID, tube angle), Pulsed or Continuous, Shielding, Last Image Hold, Dose Rate, Cumulative Timer
    2. Personnel (ALARA)
    b. Lead apron, Protective goggles/glasses, shielding, monitoring devices, Occupational exposure reports, promotion of radiation awareness

VI. Cardiovascular Catheterization Lab Environment and Safety

A. Room Preparation and Regulatory Compliance
    1. Regulatory Compliance and Procedure Room Preparation
    2. Body Mechanics/Ergonomics
        a. Safely Moving Patients
        b. Safety Strategies for Staff
    3. Electronics
        a. Biomedical Instrumentation, Including Ohms Law, Resistance

B. Aseptic Technique and Infection Control
    1. OSHA Regulations
    2. Universal Precautions
    3. Hand Washing
    4. PPE (Personal Protective Equipment)
        a. Accident Exposure
            1. Engineering Controls
            2. Workplace Controls
    5. Gowning and Gloving, Donning and Doffing

        a. Open & Closed Techniques
    6. Sterile Field/Tray Setup
    7. Maintaining the Sterile Field
    8. Methods of Sterilization and Disinfection
    9. Tear Down – Biohazard Handling and Disposal
    10. Latex Allergy
    11. Isolation
        a. Contact
        b. Airborne
        c. Droplet
    12. Review of Specific Pathogens
        a. Bloodborne, Airborne, Bacteria, HIV, TB, Hepatitis, MRSA, C-Diff, COVID-19, others

C. Patient Preparation and Sterile Table Setup
    1. Patient Positioning, Instruction/Education, and Setup
    2. Sterile Table Setup
    3. Percutaneous Vascular Access
        a. Femoral
        b. Radial
        c. Jugular
        d. Brachial
        e. Other (Dorsalis Pedis, Popliteal, etc.)

D. Equipment
    1. Disposable and Non-Disposable Equipment
        a. Needles, Sheaths, Guide Wires, Catheters, Stents, Manifolds, Transducers, Automatic Power Injector, Imaging Equipment, Defibrillator, etc.

VII. Cardiovascular Catheterization Procedures and Protocols

A. Diagnostic Procedure Protocols/Steps
    1. Left Heart Catheterization and Coronary Angiography
    2. Right Heart Catheterization
    3. Combined Right and Left Heart Catheterization
    4. Peripheral procedures

B. Manipulation and Positioning of the Patient and X-Ray Equipment

C. Contrast Media
    1. Ionic, Non-Ionic
    2. Osmolarity
    3. Contrast Reactions – Risk Factors, Side Effects, Precautions, Premedication
    4. Contrast-Induced Nephropathy (CIN) and CIN Predictive Scores

D. Angiography – Vessel and Graft Identification, Standard Techniques and Projections
    1. Native Coronaries
    2. Grafts: SVG, Arterial
    3. Collateral Circulation
    4. TIMI Flow
    5. Anomalous Coronary Arteries and Fistulas

E. Injection Techniques and Waveform Identification
    1. Damped and Ventricularized Waveforms
    2. Hand Injection
    3. Automatic Pressure Injectors

F. Left Ventriculography

G. Aortography

H. Peripheral and Cerebrovascular Arteriography
    1. Lower Extremities
    2. Renal
    3. Carotid
    4. Cerebral
    5. Subclavian

I. Pulmonary Angiography

J. Venography

K. Quantitative Analysis – Vessel Measurement, LV Analysis

L. Arterial, Venous, Pulmonary Artery Lines/Catheters

M. Hemostasis (Femoral, Radial, and Alternative Sites)
    1. Manual Technique
    2. Topical Accelerators and Related Devices
    3. Femoral and Radial Compression Devices (C-Clamps, FemoStop, Radial Bands)
    4. Collagen Plug closure devices
    5. Sutures and Staple closure devices
    6. Pressure Dressings
    7. Complications
        a. Hematoma
        b. Vasovagal Reactions

c. Pseudoaneurysm
d. Retroperitoneal Bleed
e. AV Fistula
f. Limb Ischemia
g. Compartment Syndrome
h. Volkmann's Contracture

N. Diagnostic Specialty Procedures
1. Coronary Physiologic Assessment (FFR, iFR, CFR, etc.)
2. Intravascular Ultrasound
3. Intracardiac Echo (ICE)
4. Optical Coherence Tomography (OCT)
5. Near-Infrared Spectroscopy (NIRS)
6. Endomyocardial Biopsy
7. Covered Stents and Coil Embolization

O. Provocative Maneuvers for Specific Conditions
1. Hypertrophic Cardiomyopathy
2. Myocardial Viability
3. Coronary Spasm

P. Interventional Procedures
1. Percutaneous Coronary Interventions (PCI) Including Coronary Stents
    a. Balloon Angioplasty and Stenting
    b. Atherectomy Procedures
    c. Thrombectomy Procedures
    d. Laser Procedures
    e. Use of Embolic Protection Devices
    f. CTO Procedures Including Antegrade and Retrograde Techniques
2. Structural Procedures:
    a. Balloon Valvuloplasty
    b. Transcatheter Valve Replacement (TAVR, TMVR, Tricuspid, Pulmonic)
    c. Transcatheter Valve Repair (MitraClip, others)
    d. Nonvalvular Structural Heart Interventions (PFO, ASD, VSD, PDA, LAA Closure)
3. ICE Procedural Guidance
4. Cardiovascular/Hemodynamic Support Devices
    a. Intra-Aortic Balloon Counter Pulsation
    b. Impella Devices (Right and Left)
    c. Tandem Heart
    d. ECMO
5. Transseptal Approaches for Interventions
6. CardioMEMS Device Placement
7. Pulmonary Embolism
    a. Acute PE (catheter-directed thrombectomy/thrombolysis)

b. Chronic PE (Balloon Pulmonary Angioplasty [BPA] for Chronic Thromboembolic Pulmonary Hypertension [CTEPH])

8. Pericardiocentesis
    a. Anterior and Subxiphoid Approaches
    b. Echo Guidance
9. Current Investigational Therapies
10. Clinical Research Trials

VIII. Hemodynamics

A. Hemodynamic Pressure Recognition
1. Transducers & Fluid-Filled Pressure Monitoring Systems
2. Normal Pressures and Hemodynamic Values
    a. Waveform Identification (Atrial/Venous – a, x, c, v, y, mean, ventricular-s, d, edp, arterial-s, d, m)
    b. Pressure Values (Intracardiac & Vascular)
    c. Cardiac Cycle/Wigger's Diagram
    d. Cardiac Output/Cardiac Index (Preload, Afterload, Contractility)
    e. Systemic and Pulmonary Vascular Resistance
    f. Poiseuille's Law
    g. Starling's Law
2. Time-Pressure Relationships
3. Pullback Waveform Identification and Analysis
    a. LV to AO, PCWP to Pa to RV to RA
4. Abnormal Pressure Recognition
    a. Valvular Stenosis
    b. Valvular Insufficiencies
    c. Other Gradients
    d. Constrictive Pressures
    e. Restrictive Pressures
    f. Tamponade
    g. Heart Failure Pressures
    h. Cardiomyopathies
    i. Pericardial Disorders
5. Provocative Maneuvers
6. Analysis of Pulmonary Artery Monitoring (Swan Ganz) Data
7. Quality Control – QC

B. Cardiac Output and Blood Flow Determinations
1. Comparison of Various Cardiac Output Methods
    a. Including Fick, Angiographic, Thermodilution

C. Hemodynamic Calculations
1. Cardiac Output
2. Cardiac Index
3. Mean Atrial Pressure

4. Systemic and Pulmonary Vascular Resistance
5. Systemic and Pulmonary Blood Flow
6. Shunts (Right to Left, Left to Right, Bi-Directional)
7. Regurgitant Fraction
8. Ejection Fraction/LV Tracing
9. Valve Area Calculations – Gorlin and Haaki Formulas
10. Evaluation of Calculated Values
11. Pulmonary Artery Pulsatility Index, Cardiac Power Output

IX. Pharmacology

A. Medical & Legal Aspects, Documentation

B. Sympathetic/Adrenergic and Parasympathetic/Cholinergic Nervous Systems

C. Indications, Contraindications, Mechanism of Action, Normal Dosages, Side Effects, and Patient Care Consideration of the Medications Listed Below (E 1-27)

D. Routes of Administration

E. Pharmacokinetics and Pharmacodynamics of:
1. Vasopressors and Vasodilators
2. Diuretics
3. Antihypertensives
4. Local Anesthetics
5. Anticoagulants (Heparins, Low Molecular Weight Heparins)
6. Direct Thrombin Inhibitors
7. Fibrinolytics
8. Nitrates
9. Antiarrhythmics
10. Antianginals
11. Calcium Channel Blockers
12. Contrast Media
13. Cardiac Glycosides
14. Analgesics and Reversal Agents
15. Sedatives and Reversal Agents
16. Insulin Therapy
17. Steroids
18. Angiotensin Converting Enzyme Inhibitors (ACEI), Angiotensin Receptor Blockers (ARBs), Aldosterone Antagonists
19. Antiemetics
20. Antibiotics
21. Antihistamines
22. Oxygen
23. Beta Blockers
24. Antiplatelet Agents (Aspirin, Oral and IV P2Y12 Inhibitors, IIb/IIIa Inhibitors)

25. Oral Anticoagulants
26. Protocols in ACLS (1st and 2nd Line)
27. Cholesterol Lowering Agents
28. Conscious Sedation Agents and Other Types of Procedural Sedation
    a. Monitoring, Aldrete Score, Mallampati Classification

F. Drug and IV Drip Calculations

X. Congenital/Pediatrics

A. Congenital Anomalies
   1. Fetal Embryology/Circulation/Transition at Birth
   2. Common Anomalies
      a. ASD, VSD, PFO, PDA, Coarctation, Transposition, Tetralogy, AV Canal Defect, Hypoplastic Right and Left Ventricle, Truncus Arteriosus, Tricuspid Atresia, Total Anomalous Venous Return, Pulmonary & Aortic Stenosis
   3. Palliative and Corrective Surgical Interventions
      a. Prostaglandin E, Rashkind Atrial Septostomy, Pulmonary Artery Banding, ASD and PDA Closure Devices, Arterial Switch, Blalock Taussig Shunt, Fontan Procedure, Norwood Procedure, Transcatheter Pulmonary Valve Replacement (TPVR)
   4. Catheter Interventions

B. Pediatric Catheterization Techniques

XI. Electrophysiology (Optional Content for RCIS Programs)

A. Implantable Devices
   1. Permanent Pacemaker Implantation
   2. ICD Implantation
   3. CRT Devices, Loop Recorders, Subcutaneous ICD

B. Diagnostic/Mapping Procedures

C. Cardioversion

D. Tilt Table/Syncope

E. Radiofrequency Ablation – RFA

F. 3D Mapping Techniques (CARTO, Contact and Non-Contact Electroanatomical Mapping)

G. Pulmonary Vein Angioplasty
H. Drug Infusion Testing for the Diagnosis of Brugada Syndrome and/or Inappropriate Sinus Tachycardia

XII. Clinical Competencies

A. Pre- and Post- Cardiovascular Cath Patient Care and Teaching

B. Communication Skills (MD, Staff, Healthcare Professionals, Patient)

C. Monitoring – Recording
   1. Diagnostic – Left Heart, Right Heart, Vascular
   2. Interventional – Cardiac, Vascular

D. Manipulation of Imaging Equipment

E. Quality Control

F. Scrubbing
   1. Diagnostic – Left Heart, Right Heart, Vascular
   2. Interventional – Cardiac, Vascular

G. Circulating
   1. Diagnostic – Left Heart, Right Heart, Vascular
   2. Interventional – Cardiac, Vascular