

ADULT CARDIAC ANESTHESIOLOGY EXAMINATION

Content Outline

November 2024

The Adult Cardiac Anesthesiology (ACA) Content Outline identifies the key topic areas that are assessed on the Adult Cardiac Anesthesiology Subspecialty Certification Examination. While individual practices may vary with respect to patient populations and management roles, this examination reflects core concepts in adult cardiac anesthesiology that each candidate is expected to understand. The Content Outline is divided into 12 sections, including Foundations (e.g. anatomy and physiology), Cardiothoracic diseases, Pharmacodynamics, and additional specialized areas. The examination includes items from each of the 12 content areas, though is more heavily weighted to clinical diseases and management. Specialized areas include devices and their management (e.g. cardiopulmonary bypass), specific pathophysiological states (e.g. valvular heart disease), and other topics related to patient populations cared for by adult cardiac anesthesiologists. The Content Outline is designed to serve as a resource for individuals preparing for the ACA subspecialty certification examination.



TABLE OF CONTENTS

A. Foundations of Adult Cardiac Anesthesiology	3
B. Preoperative Evaluation of the Patient for Cardiac Surgery	3
C. Intraoperative Monitoring of the Patient Undergoing Cardiac Surgery	4
D. Management of Cardiopulmonary Bypass (CPB)	5
E. Mechanical Circulatory Support	6
F. Cardiac Diseases	6
G. Valvular Heart Disease	8
H. Adult Congenital Heart Disease	10
I. Thoracic Aortic Disease.....	10
J. Electrophysiology Procedures	11
K. Postoperative Considerations	11
L. Other Topics	12

A. Foundations of Adult Cardiac Anesthesiology

1. Anatomy

- a. Embryological development (Primitive heart structures, Timing of development, Blood flow to the fetus and newborn)
- b. Cardiac Anatomy
 - i. Chambers and valves
 - ii. Coronary circulation
 - iii. Great vessels & surrounding structures
 - iv. Conduction system
- c. Thoracic anatomy
 - i. Lungs
 - ii. Chest wall
 - iii. Vascular structures
- d. Histology of the heart

2. Physiology

- a. Electrophysiology (e.g., Ion channels, Currents)
- b. Cardiac cycle
 - i. Pressure-volume relationships
 - ii. ECG timing
 - iii. Valvular function
- c. Ventricular function
 - i. Systolic function
 - 1. Myocardial contractility
 - 2. Myocardial oxygen balance
 - 3. LV vs. RV
 - ii. Diastolic function
- d. Regulation of circulation and blood volume
 - i. Arterial pressure
 - 1. Systolic, diastolic, mean and perfusion pressures
 - 2. Systemic and pulmonary vascular resistance
 - 3. Baroreceptors
 - a. Peripheral receptors
 - b. Reflexes
 - ii. Venous return
 - 1. Vascular compliance/venous capacitance
 - 2. Blood volume and distribution
 - iii. Central
 - 1. Vasomotor center
 - 2. Hypothalamic-Pituitary-Adrenal Axis

B. Preoperative Evaluation of the Patient for Cardiac Surgery

1. Non-invasive cardiovascular evaluation & interpretation

- a. Electrocardiography
- b. Echocardiography
- c. Evaluation of cardiac ischemia
 - i. Stress testing (ECG, ECHO)
 - ii. Myocardial nuclear scintigraphy (e.g., SPECT & PET)
- d. Cardiovascular imaging (e.g., MRI & CT)

2. Cardiac catheterization procedures and diagnostic interpretation

- a. Left-sided tracings
 - i. Normal pressures and waveforms

- ii. Valvular pathologies (stenotic & regurgitant)
 - b. Right-sided tracings
 - i. Normal pressures and waveforms
 - ii. Valvular pathologies (stenotic & regurgitant)
 - iii. Shunt calculations
 - c. Angiography
- 3. **Oral Medications – pharmacology and perioperative management**
 - a. Blood pressure
 - i. Beta-blockers
 - ii. ACE inhibitors
 - iii. Other medications
 - b. Antidiabetic agents
 - c. Antiarrhythmics
 - d. Diuretics
 - e. Statins
 - f. Anti-platelet agents
 - i. Dual anti-platelet therapy
 - ii. ADP inhibitors
 - g. Anticoagulants
 - i. Warfarin
 - ii. Direct oral anticoagulants
 - h. Guideline-directed medical therapy for heart failure
- 4. **Preoperative optimization**
 - a. Anemia/blood conservation
 - b. Prehabilitation

C. Intraoperative Monitoring of the Patient Undergoing Cardiac Surgery

1. **ECG monitoring**
2. **Arterial pressure monitoring**
 - a. Invasive/noninvasive differences
 - b. Site specific indications/contraindications and limitations
 - c. Complications
 - d. Waveform analysis (e.g., pulse pressure variation)
3. **Central venous (CVP) monitoring**
 - a. Cannulation sites / insertion techniques
 - b. Complications
 - c. Pressures and waveforms
4. **Pulmonary arterial catheterization**
 - a. Pressures and waveforms
 - b. Cardiac output measurement (e.g., thermodilution vs. other methods)
 - c. Mixed venous oxygen saturation
5. **Alternate methods of cardiac output assessment (e.g. esophageal Doppler, bioimpedance)**
6. **Transesophageal echocardiography**
 - a. Contraindications
 - b. Evaluation of myocardial function (e.g., EF, cardiac output calculation, strain)
 - c. Evaluation of valvular function
 - d. Evaluation of intracardiac masses
 - e. Evaluation of cannulas and devices
7. **Neurophysiologic monitoring (e.g., cerebral & peripheral oximetry)**
8. **Temperature monitoring**

9. **Coagulation monitoring**
 - a. Activated clotting time (ACT)
 - b. Viscoelastic testing (e.g., TEG[®], ROTEM[®])

D. Management of Cardiopulmonary Bypass (CPB)

1. **Anticoagulation issues**
 - a. Heparin pharmacology and management
 - b. Altered heparin responsiveness (i.e., “heparin resistance”)
 - c. Heparin-induced thrombocytopenia
 - i. Diagnosis
 - ii. Management
 - iii. Heparin alternatives
 - d. Antifibrinolytic therapy
2. **The CPB circuit**
 - a. Cannulation considerations
 - i. Central cannulation
 - ii. Alternate cannulation sites
 - iii. Aortic cross-clamp
 - iv. Complications during cannulation
 - b. Cardioplegia
 - i. Delivery
 - ii. Effects
 - c. Flow and line pressures
 - d. CPB effects on pharmacokinetics and pharmacodynamics
3. **Temperature management**
 - a. Effects of hypothermia
 - b. Rewarming
 - c. Inflow and outflow temperatures
 - d. ABG interpretation (e.g., alpha-stat vs. pH-stat)
 - e. Cold agglutinins
4. **Physiological disturbances of CPB**
 - a. Respiratory
 - b. Renal
 - c. Hematological
 - d. Neurological
 - e. Endocrine
5. **Separation from CPB**
 - a. Resuming cardio-respiratory function
 - i. Inotropes
 - ii. Vasopressors
 - iii. Vasodilators
 1. Intravenous (e.g., nitrates, phosphodiesterase inhibitors)
 2. Inhaled (e.g., nitric oxide, prostaglandin)
 - b. Pacing considerations
 - c. Reversal of anticoagulation
 - i. Protamine pharmacology
 - ii. Protamine reactions
6. **Complications after CPB**
 - a. Myocardial stunning
 - b. Vasoplegia
 - c. Coagulopathy

7. **Treatment of bleeding**
 - a. Transfusion of blood products
 - b. Pharmacologic agents

E. Mechanical Circulatory Support

1. **Intra-aortic balloon pump**
 - a. Indications and contraindications
 - b. Placement
 - c. Timing
 - d. Complications
2. **Temporary ventricular assist devices**
 - a. Indications / contraindications
 - b. Intraoperative management
 - i. Role of TEE
 - ii. Anesthetic considerations
 - c. Percutaneous devices
 - i. Transvalvular microaxial continuous flow devices (e.g., Impella®)
 - ii. Trans-septal, centrifugal devices (e.g., TandemHeart®)
3. **Durable ventricular assist devices**
 - a. Indications and contraindications
 - b. Intraoperative management for LVAD placement
 - i. Role of TEE
 - ii. Interpretation of VAD parameters
 - iii. Complications after LVAD placement
4. **Extracorporeal Membrane Oxygenation (ECMO)**
 - a. Indications and initiation of support
 - i. VA
 - ii. VV
 - iii. Other
 - b. Anticoagulation considerations
 - c. Complications
 - d. Anesthetic management
 - e. Weaning strategies

F. Cardiac Diseases

1. **Cardiomyopathy**
 - a. Types
 - i. Dilated
 - ii. Ischemic vs. non-ischemic
 - iii. Hypertrophic
 - iv. Restrictive
 - v. Other (e.g., viral, peripartum, arrhythmia-induced)
 - b. Medical/interventional management
 - i. Pharmacological interventions
 - ii. Pacing therapy
 - c. Surgical interventions
 - i. Septal ablation/myectomy
 - ii. Ventricular remodeling procedures
2. **Chronic heart failure**
 - a. Systolic (Heart Failure with Reduced Ejection Fraction, [HFrEF])
 - i. Etiology

- ii. Diagnostic criteria / testing
- b. Diastolic (Heart Failure with Preserved Ejection Fraction [HFpEF])
 - i. Etiology
 - ii. Diagnostic criteria / testing
- c. Medical/interventional management
 - i. Pharmacologic agents
 - ii. Cardiac resynchronization therapy
 - iii. Prophylactic ICD placement indications
- d. Surgical interventions
 - i. Durable MCS
 - ii. Heart transplant and allocation status
 - 1. Anesthetic considerations
 - 2. Immunosuppression
 - 3. Graft dysfunction
 - a. Primary
 - b. Delayed

3. Pericardial disease

- a. Cardiac Tamponade
 - i. Etiology
 - ii. Diagnosis
 - 1. CXR
 - 2. CVP/PAC waveforms
 - 3. Echocardiography
 - iii. Anesthetic management and goals
 - iv. Treatment
 - 1. Pericardiocentesis
 - 2. Pericardial window
- b. Constrictive pericarditis
 - i. Etiology and diagnosis
 - ii. Pericardiectomy

4. Ischemic heart disease

- a. Risk Factors
- b. Determinants of myocardial oxygen requirements and delivery
- c. Silent ischemia
- d. Acute coronary syndrome
 - i. Clinical presentation
 - ii. ECG and Echocardiographic findings
 - iii. Cardiac catheterization
- e. Treatment
 - i. Pharmacological
 - ii. Interventional cardiology procedures
 - 1. PCI, stent placements
 - 2. Complications (e.g., no-reflow, in-stent restenosis, dissection)
 - iii. Surgical (CABG)
 - 1. Indications for revascularization
 - 2. Anesthetic management for patients with coronary disease
 - 3. Alternate surgical techniques and anesthetic implications (e.g., off pump, minimally invasive, robotic)
 - 4. Conduit (e.g., vein vs. arterial, site of harvest, complications)

5. **Rare cardiac diseases**
 - a. Neoplastic disease
 - i. Types (benign vs. malignant)
 - ii. Anesthetic considerations
 - b. Infiltrative
 - i. Types
 - ii. Anesthetic considerations
 - c. Storage disease
 - i. Types
 - ii. Anesthetic considerations
 - d. Endomyocardial causes
 - i. Types
 - ii. Anesthetic considerations
 - e. CTEPH and pulmonary thromboendarterectomy

G. Valvular Heart Disease

1. **Aortic stenosis**
 - a. Etiologies
 - i. Subvalvular
 - ii. Valvular AS
 1. Pathophysiology (congenital and acquired)
 - b. Diagnosis and severity assessment
 - i. Pressure waveforms
 - ii. Echocardiography
 - c. Treatment
 - i. Medical management
 - ii. Structural heart interventions (e.g., TAVR)
 1. Anesthetic management
 2. Postprocedure complications
 - iii. Surgical AVR
 1. Timing considerations
 2. Anesthetic management for patients with severe aortic stenosis
2. **Aortic regurgitation**
 - a. Etiologies
 - b. Diagnosis and severity assessment
 - i. Pressure waveforms
 - ii. Echocardiography
 - c. Treatment
 - i. Medical management
 - ii. Surgical management
 1. Timing of intervention
 2. Anesthetic management for patients with severe aortic regurgitation
 3. CPB considerations (e.g., LV venting, cardioplegia)
3. **Mitral stenosis**
 - a. Etiologies
 - i. Rheumatic disease
 - ii. Non-rheumatic causes of MS
 - b. Diagnosis and severity assessment
 - i. Pressure waveforms
 - ii. Echocardiography

- c. Treatment
 - i. Medical management
 - ii. Surgical management
 - 1. Timing of intervention
 - 2. Anesthetic management for patients with severe mitral stenosis
- 4. **Mitral regurgitation**
 - a. Mechanisms of MR
 - i. Primary vs. secondary
 - ii. Carpentier classification
 - b. Acute vs. Chronic
 - c. Diagnosis and severity assessment
 - i. Pressure waveforms
 - ii. Echocardiography
 - d. Treatment
 - i. Medical management
 - ii. Percutaneous procedures
 - iii. Surgical management
 - 1. Timing of intervention
 - 2. Anesthetic management for patients with severe mitral regurgitation
 - 3. Repair vs. replacement considerations
 - 4. Surgical complications
 - 5. Minimally invasive approach
- 5. **Tricuspid regurgitation**
 - a. Etiologies (primary vs. secondary)
 - b. Diagnosis and severity assessment
 - i. Pressure waveforms
 - ii. Echocardiography
 - c. Treatment
 - i. Percutaneous interventions
 - ii. Surgical management
 - 1. Indications for replacement vs. repair
 - 2. Anesthetic management for patients with severe tricuspid regurgitation
- 6. **Tricuspid stenosis**
 - a. Etiologies
 - b. Diagnosis and severity assessment
 - i. Pressure waveforms
 - ii. Echocardiography
 - c. Treatment
 - i. Percutaneous interventions
 - ii. Surgical management
 - 1. Indications for replacement
 - 2. Anesthetic management for patients with severe tricuspid stenosis
- 7. **Prosthetic heart valves**
 - a. Evaluation
 - i. Echocardiography
 - ii. Other imaging modalities
 - b. Complications
- 8. **Endocarditis**
 - a. Diagnosis

- i. Clinical manifestations
 - 1. Risk factors
 - 2. Symptoms
- ii. Laboratory abnormalities
- iii. Echocardiographic evaluation
- b. Surgical treatment
- c. Complications

H. Adult Congenital Heart Disease

1. **General considerations**
 - a. Corrected vs. partial vs. uncorrected lesions
 - b. Cyanotic vs. acyanotic lesions
 - c. Existence of conduits
 - d. Pulmonary hypertension and Eisenmenger physiology
 - e. Single ventricle (i.e., Fontan) physiology
 - f. Repeat sternotomy considerations
2. **Pulmonary valve disease**
 - a. Echocardiographic diagnosis
 - b. Structural heart interventions
 - c. Surgical replacement
3. **Considerations for specific lesions**
 - a. Atrial septal defect
 - b. Ventricular septal defect
 - c. Aortic coarctation
 - d. Ebstein anomaly
 - e. Tetralogy of Fallot
 - f. Transposition of the great vessels

I. Thoracic Aortic Disease

1. **Acute aortic syndromes (e.g., dissection, intramural hematoma, penetrating aortic ulcer, trauma)**
 - a. Clinical presentation and complications
 - b. Diagnosis (CXR, Echo, CT)
 - c. Classification systems (Stanford, DeBakey)
 - d. Medical management
 - e. Surgical management
 - i. Indications for surgery
 - ii. Cannulation sites for CPB
 - iii. Complications
 - f. Anesthetic goals
 - g. Circulatory arrest considerations
 - i. Hypothermia
 - ii. Cerebral protection (pharmacologic, antegrade and retrograde perfusion)
2. **Ascending / Arch aneurysms**
 - a. True vs. pseudoaneurysm
 - b. Risk factors (connective tissue disorders, bicuspid aortic valve, etc.)
 - c. Diagnostic modalities
 - d. Crawford classification system for thoracoabdominal aneurysms
 - e. Surgical treatment
 - i. Size indications for surgery

- ii. Circulatory arrest considerations
- 3. **Descending aortic aneurysms**
 - a. TEVAR
 - b. Open repair
 - i. One-lung ventilation management
 - ii. Left heart bypass considerations
 - iii. Complications (e.g., spinal cord ischemia, renal failure, recurrent laryngeal nerve injury)
 - c. Spinal cord protection
 - i. Monitoring strategies (SSEP, MEP)
 - ii. Pharmacologic strategies
 - iii. CSF drainage (placement, management, complications)
 - iv. Spinal perfusion pressure

J. Electrophysiology Procedures

1. **Advanced arrhythmia identification and management**
2. **Pacemaker insertion**
 - a. Indications for PPM and ICDs
 - b. Types of PPM
 - i. Biventricular pacing (CRT)
 - ii. Leadless pacemakers
 - iii. Implantable cardioverter defibrillators (ICD)
 - iv. Subcutaneous implantable cardioverter defibrillators (S-ICD)
 - c. Perioperative management of cardiovascular implantable electrical devices
 - d. Modes of pacing
 - e. Anesthetic considerations for PPM lead extractions
3. **Ablations: Anesthetic considerations**
 - a. SVT
 - b. Atrial fibrillation and Atrial flutter
 - c. Convergent procedure
 - d. Ventricular tachycardia
4. **Left atrial appendage occluder devices**
5. **Cardioversion considerations (pharmacologic, electrical)**
6. **Radiation safety**

K. Postoperative Considerations

1. **Pulmonary**
 - a. Advanced mechanical ventilation modes
 - b. ARDS
 - c. TRALI
 - d. Considerations for liberation from mechanical ventilation
2. **Cardiac**
 - a. Management of arrhythmias
 - b. Coronary graft dysfunction
 - c. Tamponade
 - d. LV, RV, or biventricular failure
 - e. Vasoplegia
3. **Hematologic**
 - a. Management of coagulopathy
 - b. Need for return to OR
4. **Pain control**

- a. Sedation considerations
 - b. Multimodal analgesia
 - c. Regional anesthesia for cardiac surgical patients
 - d. Ultrasound anatomy for chest wall nerve blocks
5. **Neurologic**
- a. Delayed emergency (e.g., stroke, seizure)
 - b. Postoperative cognitive dysfunction
 - c. Delirium

L. Other Topics

1. **Research methodology/statistical analysis**
 - a. Fundamentals of research design and conduct
 - b. Interpretation and presentation of data
2. **Practice management**
 - a. Costs of medical/anesthesia care
 - i. Understanding principles of healthcare funding and payment
 - ii. Cost-conscious practice
 - b. Efficient OR staffing and scheduling
 - i. Subspecialization issues: pediatrics, cardiac, regional, obstetric coverage
 - ii. Anesthesia care team and scope of practice
 - c. Population health: perioperative surgical home and enhanced recovery
 - i. Population based health determinants, resources to improve access
 - ii. Health care disparities between populations
 - d. Clinical informatics
 - i. Electronic medical record systems: costs and benefits
 - ii. Artificial intelligence and machine learning
 - e. Documentation, coding, and billing
 - i. Compliance with documentation requirements
 - ii. Accuracy, clarity, specificity of medical records
 - iii. Coding integrity, audits, and insurance denials
3. **Quality Improvement and patient safety**
 - a. Definitions
 - i. Medical error, adverse events, sentinel events, misuse of medications and technology
 - ii. Human factors and mindfulness
 - iii. Systems thinking and technology design
 - b. Medication errors: assessment and prevention
 - i. Medication reconciliation
 - ii. Information technology to reduce medication errors
 - c. Crisis management and teamwork
 - i. Simulation training
 - ii. Crisis manuals and other cognitive aids
 - iii. Teamwork training
 - iv. Handoff communication
 - v. Preoperative and procedural checklists
 - d. Quality Improvement (QI) basics
 - i. Design, analysis, and implementation of QI projects
 - ii. Data collection
 - iii. QI metrics
 - iv. Patient satisfaction measurement
 - v. Value-based care incentives, pay-for-performance

- e. Performance assessment
 - i. Individual benchmarking
 - ii. Group and facility scorecards
 - iii. Public reporting
 - 1. Federal Quality Payment Program
 - 2. Anesthesia registries
 - iv. Change management methods
 - 1. Peer review and morbidity and mortality Conferences
 - 2. Lean Six Sigma
 - 3. QI and the 5S process
 - 4. Value stream mapping
 - 5. Failure mode and effects analysis
 - 6. Root cause analysis
 - v. Barriers to QI
- 4. **Diversity, Equity and Inclusion (DEI) in health care**
 - a. Surgical outcomes
 - b. Barriers
 - i. Systematic racism, colorism/shadeism, sexism, discrimination against orientation, gender identity, language, national origin, ethnicity, religion, immigration/citizenship status, age, familial status, and disability
 - ii. Bias; Implicit bias, microaggression, stereotype threat
 - c. Approaches to improvement; interventions at individual, inter-personal, community, organizational and policy levels; cultural and gender competency, upstander vs. bystander, allyship vs. performative action, tokenism vs representation, assortativity vs. homophily
 - d. DEI in the workplace
 - e. DEI in academia
 - i. Leadership
 - ii. Scholarship; Representation of diversity and race related topics in research, Importance of language in reports discussing racial inequities
- 5. **Healthcare disparities**
 - a. Social determinants of health considerations in assessment and management of patients – race, language, education status, religion, housing, nutrition, geographic location, rural vs. urban, access to and quality of care, health coverage
 - b. Maternal healthcare disparities; Maternal mortality and morbidity, Pain management
 - c. ICU disparities and outcomes
- 6. **Ethics and medico-legal issues**
 - a. Professionalism: definitions and teaching
 - i. Disclosure of errors or adverse events
 - ii. Professional behavior: honesty, integrity, compassion, respect, altruism, conflicts of interest, response to marketing
 - iii. Recognizing limitations in expertise and need to seek guidance
 - iv. Personal role in reporting unsafe conditions and fitness for work
 - v. Recognizing and responding to unprofessional behavior
 - vi. Evidence-based practice
 - b. Patient autonomy and decision making
 - i. Principles of informed consent and shared decision making
 - ii. Advance directives, Do Not Resuscitate (DNR) orders, medical orders for life-sustaining treatment

- iii. Health care proxy laws and limitations
- iv. Patients refusing transfusion or other treatments
- c. Legal and regulatory issues
 - i. Elements of medical malpractice: duty, breach of duty, causation, damages
 - ii. Legal actions and consequences, National Practitioner Data Bank, Closed Claims findings, professional liability insurance
 - iii. Understanding laws related to controlled substances, including opioids and cannabinoids
 - iv. Patient privacy issues: principles of confidentiality, access to records, protected health information
 - v. The Health Insurance Portability and Accountability Act (HIPAA)
- d. Primary certification, recertification, maintenance of certification and related issues (Professional Standing, Lifelong Learning, Cognitive Knowledge, Clinical Practice Assessment, Systems-Based Practice)
- e. Research ethics
 - i. Principles of justice, autonomy, beneficence, non-maleficence
 - ii. Ethical standards in research design: scientific validity, fair subject selection, favorable risk-benefit profile
 - iii. Review and implementation of trials, the institutional review board
 - iv. Informed consent in research
 - v. Conflicts of interest and financial disclosure
- f. Clinician wellness and self-care
 - i. Diagnosis and treatment of burnout
 - ii. Sleep deprivation
 - iii. Adaptations for clinical disability
 - iv. Substance abuse