

THE AMERICAN BOARD OF PEDIATRICS®

CONTENT OUTLINE

Pediatric Critical Care Medicine

**Subspecialty In-Training, Certification, and
Maintenance of Certification (MOC) Examinations**

INTRODUCTION

This document was prepared by the American Board of Pediatrics Subboard of Pediatric Critical Care Medicine for the purpose of developing in-training, certification, and maintenance of certification examinations. The outline defines the body of knowledge from which the Subboard samples to prepare its examinations. The content specification statements located under each category of the outline are used by item writers to develop questions for the examinations; they broadly address the specific elements of knowledge within each section of the outline.

Pediatric Critical Care Medicine

Each Pediatric Critical Care Medicine exam is built to the same specifications, also known as the blueprint. This blueprint is used to ensure that, for the initial certification and in-training exams, each exam measures the same depth and breadth of content knowledge. Similarly, the blueprint ensures that the same is true for each Maintenance of Certification exam form. The table below shows the percentage of questions from each of the content domains that will appear on an exam. Please note that the percentages are approximate; actual content may vary.

	Content Categories	Initial Certification and In-Training	Maintenance of Certification (MOC)
1.	Cardiovascular	15%	16%
2.	Respiration	15%	16%
3.	Neurology and Neuromuscular	10%	11%
4.	Infectious Disease, Immunology, and Inflammation	7%	7%
5.	Renal and Electrolytes	7%	7%
6.	Metabolism and Endocrinology	4%	4%
7.	Hematology/Oncology	5%	5%
8.	Gastroenterology and Nutrition	5%	5%
9.	Poisonings, Toxins, and Overdoses	4%	4%
10.	Trauma and Burns	5%	5%
11.	Pharmacology	5%	5%
12.	Anesthesiology, Perioperative Care, and Procedural Sedation	5%	5%
13.	Technical Procedures	2%	2%
14.	Principles of Monitoring	3%	3%
15.	Special Critical Care Issues	3%	3%
16.	Core Knowledge in Scholarly Activities	5%	2%

Critical Care

1. Cardiovascular

A. Development, structure, and physiology of the cardiovascular system

1. Anatomy

- a. Know the anatomy of the heart
- b. Know the anatomy of the circulation of the heart
- c. Understand the determinants of blood flow across the ductus arteriosus before and after birth
- d. Anatomically differentiate between right and left ventricles
- e. Understand the failures in normal developmental embryology of the heart that occur in congenital heart disease
- f. Know the recognizable developmental abnormalities of the heart

2. Myocardial mechanics

a. Sarcomere function

1. Excitation-contraction coupling

- a. Understand calcium flux in excitation-contraction coupling
- b. Identify the types of receptors on the myocyte and their functions
- c. Understand the role of actin, myosin, troponin, tropomyosin, calcium, and sarcoplasmic reticulum in contraction

2. Length-tension relationship

- a. Understand the structural basis and characteristics of the sarcomere length-tension relationship

b. Integrated muscle function

1. Pressure-volume relationship

- a. Interpret pressure-volume relationships

2. Ventricular function curve

- a. Interpret ventricular function curves
- b. Understand the effects of afterload, contractility, and preload on the ventricular function curve

3. Venous return curve

- a. Recognize the venous return curve and factors that alter its slope, intercept, and inflection point

4. Determinants of function

a. Inter-relationship

1. Recognize the inter-relationship between the determinants of cardiac function

b. Preload

1. Understand how preload affects ventricular stroke volume
2. Recognize the conditions that alter ventricular preload

c. Afterload

1. Understand how afterload affects ventricular stroke volume
2. Understand the concept of afterload and factors that affect afterload (Laplace equation)
3. Understand the concept of wall stress and its effect on stroke volume

d. Contractility

1. Understand how contractility affects ventricular stroke volume
 2. Understand how to quantitate contractility (slope of pressure-volume curves)
 - e. Heart rate
 1. Understand how heart rate affects cardiac output
 5. Neural control
 - a. Understand neural effects on myocardial function
 - b. Understand the effects of heart denervation on cardiac function
 - c. Understand the role of carotid and aortic baroreceptors
 6. Cardiac response to hormonal and pharmacologic influences
 - a. Beta-adrenergic agonists and antagonists
 1. Understand beta-adrenergic effects on myocardial function
 - b. Alpha-adrenergic agonists and antagonists
 1. Understand alpha-adrenergic effects on myocardial function
 - c. Calcium
 1. Understand effects of calcium on myocardial function
 - d. Cardiac glycosides
 1. Understand the effects of cardiac glycosides on myocardial function
 - e. Bipyridines (amrinone, etc)
 1. Understand the effects of phosphodiesterase III inhibitors on myocardial function
 - f. Natriuretic peptides
 1. Understand the effects of natriuretic peptides on myocardial function
 - g. Nitrates
 1. Understand the effects of nitrates on myocardial function
 7. Developmental changes
 - a. Know the changes in myocardial function that occur with postnatal development
 - b. Know the changes in adrenergic myocardial receptors that occur with postnatal development
 - c. Understand the age-related signs and symptoms of congenital heart disease
 - c. Mechanical dysfunction
 1. Systolic dysfunction
 - a. Understand how to evaluate systolic dysfunction
 - b. Identify the clinical disorders associated with systolic dysfunction
 - c. Understand the mechanisms of systolic dysfunction
 2. Diastolic dysfunction
 - a. Understand how to evaluate diastolic dysfunction
 - b. Identify the factors that influence diastolic ventricular function
 - c. Know the clinical disorders associated with diastolic dysfunction
- B. Electrophysiology
1. Impulse formation
 - a. Normal mechanism
 1. Understand the normal mechanisms for impulse formation
 2. Understand the roles of sodium current, calcium current, and potassium current in normal impulse formation

- b. Neural influences
 - 1. Understand how neural function influences impulse formation
- c. Humoral influences
 - 1. Know the humoral influences on impulse formation
- d. Effects on drugs
 - 1. Differentiate the effects of various classes of drugs on impulse formation
- e. Effects on electrolyte abnormalities
 - 1. Recognize the effects of electrolyte abnormalities on impulse formation
- 2. Impulse conduction
 - a. Normal mechanism
 - 1. Understand the normal pathways of impulse conduction
 - 2. Understand the mechanism of impulse conduction
 - 3. Recognize the differences in depolarization pattern between pacemaker cell and other cardiac cells
 - b. Neural influences
 - 1. Understand how neural factors influence impulse conduction
 - c. Humoral influences
 - 1. Know which humoral factors influence impulse conduction
 - d. Effects of drugs
 - 1. Differentiate the effects of various classes of drugs on impulse conduction
 - e. Effects of electrolyte abnormalities
 - 1. Understand the effects of electrolyte abnormalities on impulse conduction
 - f. Developmental changes
 - 1. Understand how atrioventricular conduction pathways mature after birth
- 3. Rhythm disturbances
 - a. Disorders of impulse formation
 - 1. Know how to differentiate disorders of impulse formation
 - 2. Understand the pathogenesis of disorders of impulse formation
 - 3. Know the treatment of disorders of impulse formation
 - b. Disorders of impulse conduction
 - 1. Know how to differentiate disorders of impulse conduction
 - 2. Understand the pathogenesis of disorders of impulse conduction
 - 3. Know the treatment of disorders of impulse conduction
 - c. Specific disorders of impulse formation, conduction
 - 1. Supraventricular re-entrant tachycardia
 - a. Understand the pathogenesis of supraventricular re-entrant tachycardia
 - b. Know the treatment of supraventricular re-entrant tachycardia
 - 2. Junctional ectopic tachycardia
 - a. Understand the pathogenesis of junctional ectopic tachycardia
 - b. Plan the management of a patient with junctional ectopic tachycardia
 - 3. Ventricular tachycardia
 - a. Understand the pathogenesis of ventricular tachycardia
 - b. Plan the management of a patient with ventricular tachycardia
 - 4. Heart block
 - a. Understand the pathogenesis of heart block
 - b. Plan the management of a patient with heart block

C. Myocardial metabolism and blood flow

1. Normal myocardial metabolism
 - a. Aerobic myocardial metabolism
 1. Understand myocardial energy metabolism
 2. Understand the use of energy substrates by the myocardium
 - b. Determinants of myocardial oxygen consumption
 1. Identify the factors that determine the relationship between myocardial metabolic rate and blood flow
 2. Understand the effects of PCO₂ and PO₂ on myocardial blood flow regulation
 3. Understand autoregulation of myocardial blood flow
 4. Understand the mechanical factors that influence myocardial blood flow
 5. Recognize settings in which myocardial oxygen demand exceeds potential supply
 6. Recognize the conditions and drugs that increase coronary blood flow
 7. Recognize the relationship between oxygen demand and preload, afterload, and contractility
 8. Know which drugs increase myocardial oxygen demand
 9. Understand the relationship between oxygen supply and demand, both functionally and anatomically (eg, subendocardium, myocardial muscle mass, blood flow)
 10. Understand the neural regulation of myocardial blood flow
 - c. Hormonal influences on myocardial metabolism
 1. Recognize hormonal effects on myocardial metabolism
2. Effects of abnormal metabolism on myocardium
 - a. Hypoxia/ischemia
 1. Understand the effects of hypoxia/ischemia on myocardium
 - b. Acid-base imbalance
 1. Understand how pH alters myocardial function
 2. Understand how pH alters myocardial responses to drugs
 - c. Other primary metabolic disturbances
 1. Recognize the effects of metabolic disturbances and inborn errors of metabolism on myocardial function
3. Regional circulations
 - a. Blood flow and perfusion
 1. General
 - a. Understand the structure of the microcirculatory vascular beds
 - b. Understand the relationship between intravascular volume and pressure and organ blood flow
 2. Autoregulation
 - a. Recognize normal and disrupted autoregulation
 - b. Understand the concept of blood flow autoregulation
 - c. Understand the contribution of autoregulation to cardiac output
 3. Neural influences
 - a. Understand how neural input influences tissue blood flow
 4. Humoral influences
 - a. Know which humoral factors influence tissue blood flow

5. Responses to hypoxia
 - a. Understand the effects of hypoxemia on systemic vascular resistance
6. Responses to acid-base imbalance
 - a. Understand how acidosis affects tissue perfusion
 - b. Understand how alkalosis affects tissue perfusion
7. Local regulation of vascular tone
 - a. Understand how prostanoids, platelet-activating factor, and other inflammatory mediators affect tissue perfusion
 - b. Understand the role of endothelium-dependent factors in regulation of tissue perfusion, particularly constitutive and inducible nitric oxide synthase
- b. Local regulation and modulation of regional blood flow
 1. Brain (see III.A.10)
 2. Myocardium (see I.C.1)
 3. Liver (see VIII.A.10)
 4. Kidney (see V.A.3)
 5. Gut (see VIII.A.10)
 6. Skeletal muscle
 - a. Recognize the factors affecting blood flow to skeletal muscle
 7. Lung (see II.B.3)
- c. Control of blood pressure (see V.E)
- d. Systemic oxygen supply and demand
 1. Understand the determinants of oxygen content and delivery
 2. Understand the factors that increase systemic oxygen consumption
 3. Understand tissue and systemic responses to acute and chronic oxygen deprivation
 4. Know how to estimate the adequacy of oxygen delivery
 5. Understand the concept of delivery-dependent oxygen consumption
- e. Mechanisms of transcapillary fluid flux
 1. Understand the factors affecting transcapillary fluid flux (Starling equation)
 2. Understand the factors that lead to the development of systemic edema
- D. Interactions with other systems
 1. Cardiopulmonary interactions
 - a. Recognize the major forms of interaction between heart and lungs
 - b. Understand the effect of inspiration on right ventricular preload
 - c. Recognize the effects of increased lung volumes on left ventricular preload
 - d. Understand the effects of lung volume and breathing on right ventricular afterload
 - e. Understand the effects of lung volume and breathing on left ventricular afterload
 - f. Understand features of large or small airway obstruction that may contribute to development of pulmonary edema
 - g. Understand the pathophysiologic processes associated with pulsus paradoxus
 2. Effects of systemic venous congestion
 - a. Know the signs, pathogenesis, and effects of systemic venous congestion
 3. Effects of pulmonary venous congestion
 - a. Know the signs, pathogenesis, and effects of pulmonary venous congestion
 4. Cardioendocrine relations
 - a. Understand the endocrine responses to impaired circulation

- b. Understand the role of the cardiovascular system in water-sodium homeostasis
- E. Assessment of structure, function, and dysfunction
 1. Physical examination
 - a. Differentiate cardiovascular diseases by physical examination
 2. Radiographic evaluation
 - a. Differentiate cardiovascular diseases by radiographic evaluation
 - b. Know the type of information that can be collected by cardiac catheterization
 3. Electrocardiography
 - a. Recognize Wolff-Parkinson-White syndrome by ECG
 - b. Interpret ventricular hypertrophy on ECG
 - c. Interpret cardiac rhythm disturbances by ECG
 - d. Appreciate the age dependence of ventricular forces seen on ECG
 - e. Recognize artifacts on ECG tracings
 - f. Recognize myocardial infarction by ECG
 - g. Recognize ST changes on ECG
 - h. Recognize T changes on ECG
 - i. Recognize ventricular dysrhythmias on ECG
 - j. Recognize supraventricular dysrhythmias on ECG
 - k. Recognize conduction disturbances on ECG
 - l. Recognize abnormalities in cardiac axes on ECG
 4. Echocardiography and Doppler flowmetry
 - a. Know the indications and limitations of echocardiography, including Doppler flowmetry, for evaluating cardiovascular disease
 - b. Recognize abnormalities of cardiac function on echocardiography
 - c. Recognize depressed myocardial function based on echocardiographic findings
 - d. Understand the limitations of diagnosis of pulmonary hypertension by echocardiography
 5. Measurement of vascular pressures, resistances
 - a. Interpret vascular pressures
 - b. Understand invasive techniques for measurement of vascular pressure
 - c. Know the potential complications of invasive vascular pressure monitoring
 6. Quantitation of cardiac output and blood flow
 - a. Invasive techniques
 1. Understand invasive methods for the evaluation of cardiac output and blood flow
 2. Thermodilution
 - a. Understand thermodilution measurement of blood flow
 3. Fick technique
 - a. Understand the Fick principle for calculation of blood flow
 - b. Noninvasive techniques
 1. Understand noninvasive techniques for the evaluation of cardiac output and blood flow
 2. Echocardiography (see I.E.4)
 3. Doppler flowmetry (see I.E.4)
 7. Quantitation and detection of shunts
 - a. Thermodilution

1. Know qualitative effects of left-to-right and right-to-left shunts on thermodilution cardiac output determination
 - b. Fick technique
 1. Know how to quantify shunt flow using the Fick principle
 2. Understand how to calculate systemic blood flow in the presence of a left-to-right shunt
 - c. Contrast echocardiography
 1. Know how shunts are visualized by contrast echocardiography
 - d. Doppler flowmetry
 1. Know how shunts are visualized by color Doppler flowmetry
 8. Biomarkers
 - a. Understand the use of brain natriuretic peptide as a diagnostic test for cardiac dysfunction
 - b. Understand the use of troponin, creatine kinase, and free myoglobin as markers of myocardial cell injury
- F. Cardiac disease
1. Cardiac malformations
 - a. General
 1. Identify other congenital anomalies or diseases associated with congenital heart malformations
 2. Recognize asplenia/polysplenia syndromes
 - b. Acyanotic obstruction of left heart
 1. Understand the pathophysiology of left heart obstruction
 2. Know the signs and findings of left heart obstruction
 3. Know the initial medical therapy for critical left heart obstruction
 4. Know the effects of systemic hypertension on obstructive lesions on the left side of the heart
 5. Know and recognize specific disorders causing left heart obstruction
 - c. Acyanotic obstruction of right heart
 1. Understand the pathophysiology of right heart obstruction
 2. Recognize the signs and findings of right heart obstruction
 3. Know the initial medical therapy for critical right heart obstruction
 4. Know and recognize specific disorders causing right heart obstruction
 - d. Left-to-right shunt lesions
 1. Understand the pathophysiology of left-to-right shunt lesions
 2. Recognize the signs and findings of left-to-right shunt lesions
 3. Know the medical therapy for management of large left-to-right shunt lesions
 4. Understand the use and toxicity of drugs that can be employed to manipulate the ductus arteriosus (prostaglandin E1, indomethacin)
 5. Know and recognize specific disorders causing left-to-right shunt lesions
 - e. Right-to-left shunt lesions
 1. Understand the pathophysiology of right-to-left shunt lesions
 2. Know the signs and findings of right-to-left shunt lesions
 3. Know the medical therapy for management of critical hypoxemia with right-to-left shunt lesions
 4. Know and recognize specific disorders causing right-to-left shunt lesions

- f. Admixture lesions
 - 1. Understand the pathophysiology, signs, and findings of transposition of the great arteries
 - 2. Understand the pathophysiology, signs, and findings of total anomalous pulmonary venous connection
- g. Valvar regurgitation
 - 1. Understand the pathophysiology of valvar regurgitation
 - 2. Know the signs of valvar regurgitation
 - 3. Know the medical therapy for management of an unstable patient with valvar regurgitation
- h. Single ventricles
 - 1. Understand the pathophysiology, signs, and findings of tricuspid atresia
 - 2. Plan the medical management (including preoperative care) for a patient with a single ventricle
 - 3. Plan the preoperative preparation of a patient with truncus arteriosus
 - 4. Understand the preoperative support and surgical options required for a patient with pulmonary atresia
 - 5. Understand the pathophysiology of right or left single ventricle
- 2. Vascular malformations (see II.D.1.a)
- 3. Shock (see also IV.B.3)
 - a. General
 - 1. Know the epidemiology, complications and sequelae of circulatory shock
 - 2. Recognize the signs of perfusion failure, including altered mental status
 - 3. Differentiate between the various types of shock
 - b. Hypovolemic shock
 - 1. Recognize the signs of hypovolemic shock
 - 2. Know how to investigate causes of hypovolemic shock
 - 3. Understand the treatment of hypovolemic shock
 - 4. Understand the pathophysiology of hypovolemic shock
 - 5. Know the prognosis associated with hypovolemic shock
 - c. Obstructive shock
 - 1. Recognize the signs of obstructive shock
 - 2. Know how to investigate causes of obstructive shock
 - 3. Understand the treatment of obstructive shock
 - 4. Understand the pathophysiology of obstructive shock
 - 5. Know the prognosis associated with obstructive shock
 - d. Cardiogenic shock
 - 1. Recognize the signs of cardiogenic shock
 - 2. Know how to investigate causes of cardiogenic shock
 - 3. Understand the treatment of cardiogenic shock
 - 4. Understand the pathophysiology of cardiogenic shock
 - 5. Know the prognosis associated with cardiogenic shock
 - e. Distributive shock
 - 1. Recognize the signs of distributive shock
 - 2. Know how to investigate causes of distributive shock
 - 3. Understand the treatment of distributive shock

4. Understand the pathophysiology of distributive shock
5. Know the prognosis associated with distributive shock
- f. Septic shock
 1. Recognize the signs of septic shock
 2. Know how to investigate the causes of septic shock
 3. Understand the treatment of septic shock
 4. Understand the pathophysiology of septic shock
 5. Know the prognosis associated with septic shock
4. Congestive heart failure (see also II.B.6)
 - a. Understand the pathogenesis of congestive heart failure
 - b. Understand the pathophysiology of congestive heart failure
 - c. Know the differential diagnosis of congestive heart failure
 - d. Plan medical therapy for a patient with congestive heart failure
 - e. Understand the effect of mechanical ventilatory strategies in congestive heart failure
5. Systemic hypertension (see V.E)
6. Tamponade
 - a. Recognize pericardial tamponade and understand its pathogenesis
 - b. Understand the pathophysiology of tamponade
 - c. Know the differential diagnosis of tamponade
 - d. Plan medical therapy for a patient with tamponade
7. Cardiopulmonary arrest (see also XIII.F)
 - a. Recognize and understand events leading to cardiac arrest
 - b. Understand the principles of resuscitation for cardiac arrest
 - c. Know the prognosis associated with in-hospital and out-of-hospital cardiac arrest
 - d. Know how to evaluate neurologic status after cardiac arrest
8. Myocardial infection
 - a. Understand the pathogenesis of myocarditis
 - b. Know how to diagnose myocardial infection
 - c. Plan medical therapy for a patient with myocardial infection
9. Pericardial infection
 - a. Understand the pathogenesis of pericardial infection
 - b. Understand the pathophysiology of pericardial infection
 - c. Know how to investigate the etiology of pericardial infection
 - d. Plan medical therapy for a patient with pericardial infection
10. Endocardial infection
 - a. Understand the pathogenesis of endocardial infection
 - b. Understand the pathophysiology and natural history of endocardial infection
 - c. Know how to investigate the etiology of endocardial infection
 - d. Know the prophylaxis and medical therapy for endocardial infection
 - e. Recognize endocardial infection as a cause of persistent bacteremia
 - f. Recognize the complications of endocardial infection
11. Traumatic cardiac injury (see also X.B.5)
 - a. Understand the pathogenesis of cardiac injury in trauma
 - b. Understand the pathophysiology of cardiac injury in trauma
 - c. Know how to diagnose traumatic cardiac injury

- d. Know the therapy (including indications for surgery) of cardiac injury in trauma
- 12. Cardiac hypoxia, asphyxia (limited DO₂) (see also I.C)
 - a. Recognize myocardial asphyxia and its manifestations
 - b. Understand the pathogenesis of cardiac hypoxia and asphyxia (limited DO₂)
 - c. Understand the pathophysiology of cardiac hypoxia and asphyxia (limited DO₂)
 - d. Plan medical therapy for a patient with cardiac hypoxia and asphyxia (limited DO₂)
- 13. Cardiomyopathy (see also I.C)
 - a. Understand the pathogenesis of cardiomyopathy
 - b. Understand the pathophysiology of cardiomyopathy
 - c. Know how to investigate the etiology of cardiomyopathy
 - d. Plan medical therapy for a patient with cardiomyopathy
- 14. Myocardial infarction (see also I.C)
 - a. Recognize the causes of myocardial ischemia and infarction in children
 - b. Understand the pathogenesis of myocardial ischemia and infarction
 - c. Know the appropriate therapy for patients with myocardial ischemia and infarction
- 15. The heart in systemic disease
 - a. Muscular dystrophies (see also III.D)
 - 1. Recognize the muscular dystrophies associated with impaired myocardial function
 - 2. Recognize the effect of restrictive lung disease on myocardial function in children with muscular dystrophies
 - b. Marfan syndrome and homocystinuria
 - 1. Recognize the structural cardiac abnormalities associated with Marfan syndrome
 - 2. Recognize the structural cardiac abnormalities associated with homocystinuria
 - c. Mitochondrial and glycogen storage diseases (see also VI.F)
 - 1. Understand the spectrum of mitochondrial disease and its impact on cardiovascular function
 - 2. Understand how myocardial function is altered in glycogen storage diseases
 - d. Carnitine deficiency and long-chain fatty acid disorders
 - 1. Understand the role of long-chain fatty acids in heart disease
 - 2. Recognize the indications for carnitine administration in heart disease
- G. Heart, lung, and heart/lung transplantation
 - 1. Indications and contraindications
 - a. Know the indications and contraindications for heart, lung, and heart/lung transplantation
 - 2. Postoperative intensive care
 - a. Recognize postoperative complications from heart, lung, and heart/lung transplantation
 - b. Plan postoperative management of heart and lung transplantation
 - c. Recognize the common forms of rejection in heart and lung transplantation
- H. Cardiac surgery
 - 1. Indications and contraindications
 - a. Know the indications and contraindications for cardiac surgery

- b. Recognize and interpret important data in the preoperative evaluation of a patient scheduled for cardiac surgery
- 2. Surgical
 - a. Know the anatomic relationship of the ductus arteriosus to adjacent structures such as the recurrent laryngeal nerve
 - b. Know the common techniques and indications for the repair/palliation of congenital cardiac diseases
- 3. Postoperative care
 - a. Recognize the setting of mesenteric arteritis after repair of coarctation of the aorta
 - b. Diagnose mesenteric arteritis on the basis of clinical and laboratory findings in a child with hypertension after repair of coarctation of the aorta
 - c. Recognize that control of postcoarctectomy hypertension prevents mesenteric arteritis
 - d. Understand the complications and risks of cardiac surgery including bypass, cardioplegia, cross-clamp, hypothermia, and circulatory arrest
 - e. Understand and plan the management of common complications following closure of ventricular septal defects
 - f. Understand and plan the management of common complications following systemic to pulmonary shunts
 - g. Understand and plan the management of common complications following the Fontan procedure
 - h. Understand and plan the management of common complications following cardiac valve replacement
 - i. Understand and plan the management of common complications following first-stage surgery for single ventricles
 - j. Understand common and plan the management of complications following atrioventricular canal repair
 - k. Understand and plan the management of common complications following repair of tetralogy of Fallot
 - l. Understand and plan the management of common complications following the arterial switch procedure
 - m. Understand the use of cardiac pacemakers after cardiac surgery
 - n. Understand the indications for preload versus inotropy versus afterload reduction following cardiac surgery
 - o. Recognize and plan the management of postpericardiotomy syndrome
 - p. Recognize and plan the management of diaphragmatic paralysis following cardiac surgery
 - q. Recognize and plan the management of chylothorax following cardiac surgery
 - r. Recognize and plan the management of protein-losing enteropathy following cardiac surgery
 - s. Understand and plan the management of common complications following the bidirectional Glenn procedure
 - t. Understand the etiology and therapy of renal impairment following cardiac surgery
 - u. Understand alterations in hepatic function following cardiac surgery
 - v. Recognize and diagnose myocardial ischemia following cardiac surgery

- w. Understand ventilator management following cardiac and cardio-pulmonary bypass surgery
- x. Understand the pathogenesis of restrictive lung disease following cardiac surgery
- y. Understand and plan the management of the syndrome of low cardiac output following complex congenital heart disease surgery

2. **Respiration**

A. Development and Functional Anatomy

1. Development of the respiratory system
 - a. Understand how prenatal alterations in lung development lead to specific diseases or conditions in infancy
 - b. Understand the main processes involved in fetal maturation of the lungs and the transition to air breathing
 - c. Understand the anatomic and functional changes experienced by the airways, pulmonary vessels, and lungs during postnatal development
 - d. Understand the anatomic and functional changes experienced by the chest wall during postnatal development
2. Functional anatomy of the conducting airways
 - a. Understand the pathophysiology and manifestations of laryngeal nerve palsies
 - b. Understand the ultrastructure and function of the bronchial cilia
 - c. Know the anatomy and function of the pharynx
 - d. Know the anatomy of the laryngeal cartilages and muscles
 - e. Know the anatomy of the trachea
 - f. Know the anatomic and functional differences between bronchi and bronchioles
 - g. Know the cranial nerves responsible for sensory and motor innervation of the upper and lower airways
 - h. Know the anatomic differences between the airways of infants and adolescents
3. Functional anatomy of the acinus
 - a. Know the structure of the alveolar-capillary unit and pulmonary interstitium
 - b. Identify the structural and ultrastructural characteristics and function of type I pneumocytes, type II pneumocytes, and alveolar macrophages
 - c. Know the anatomy of the acinus
4. Functional anatomy of the pulmonary vessels
 - a. Know the anatomy and relationships of the pulmonary and bronchial circulations
 - b. Understand the anatomic changes involved in the normal and abnormal postnatal remodeling of the pulmonary vessels
 - c. Understand the processes involved in the adaptation of the fetal pulmonary vessels to extrauterine life

B. Physiology

1. Mechanics of breathing
 - a. Understand how spontaneous and positive-pressure breathing influence the caliber of the extrathoracic and intrathoracic airways
 - b. Understand the components of the work of breathing
 - c. Know the factors that determine the depth and frequency of breathing
 - d. Know the forces generated during breathing
 - e. Know how changes in gas viscosity and density influence gas movement in the central and peripheral airways

- f. Understand the relationships between airway opening pressure, alveolar pressure, and pleural pressure during breathing
 - g. Understand the concept and determinants of transpulmonary pressure
 - h. Understand the concepts of lung and chest wall compliance
 - i. Understand the concepts of airway and lung tissue resistance to air flow
 - j. Know the muscles of breathing and their function in health and disease
 - k. Understand the basic factors that determine energy supply utilization by the respiratory muscles in health and disease
 - l. Understand how changes in lung and chest wall compliance affect the volume-pressure relationships of the lungs and chest wall
 - m. Understand how changes in airway resistance affect the volume-pressure relationships of the lungs
 - n. Understand the mechanisms that determine the volume of the lungs in health and disease
 - o. Understand the factors that influence the rate of emptying of the lungs during expiration
 - p. Understand the concept of time constant as it applies to both lung inflation and deflation
 - q. Understand the concept of gas flow limitation and its applicability to pulmonary function testing
 - r. Interpret physiologic and pathologic variations in flow-volume relationships during tidal breathing and maximal forced expiration
 - s. Understand age-related developmental differences in respiratory physiologic function
2. Surface tension and pulmonary surfactant
 - a. Know the indications for and the use of surfactant replacement therapy
 - b. Understand the concept of surface tension and its implications for alveolar stability
 - c. Know the principal components of pulmonary surfactant
 - d. Know the cellular processes involved in surfactant production and recycling
 - e. Understand the biologic functions of the surfactant apoproteins
 - f. Understand how surfactant influences the volume dependence of surface tension in the pulmonary air spaces
3. Pulmonary circulation
 - a. Know the effects of pH, PCO₂, and PO₂ on pulmonary vascular tone
 - b. Know the effects of gravity on the distribution of blood flow in the lungs
 - c. Understand the concept and calculation of pulmonary vascular resistance
 - d. Understand the effects of blood viscosity and vascular caliber on pulmonary vascular resistance
 - e. Know the contributions of pulmonary arteries, capillaries, and veins to pulmonary vascular resistance
 - f. Understand the influence of lung volume and alveolar pressure on the resistance of alveolar wall capillaries
 - g. Understand the influence of lung volume and airway pressure on the resistance of extra-alveolar arteries and veins
 4. Fluid filtration in the lungs

- a. Understand the basic forces that determine net water flux across pulmonary capillary walls in health and disease
 - b. Understand the forces implicated in Starling's law for fluid flux in the lung
 - c. Know the anatomy and function of the pulmonary lymphatics
 - d. Understand how lung volume and surface tension influence fluid filtration in pulmonary vessels
 - e. Understand how changes in pulmonary arterial and venous caliber influence fluid filtration in pulmonary vessels
 - f. Know the mechanisms of fluid removal from the alveoli and pulmonary interstitium
 - g. Understand how changes in systemic venous pressure influence fluid balance in the lungs and pleural space
 - h. Understand the mechanisms of fluid filtration and removal from the pleural space
5. Pulmonary gas exchange
- a. Understand the mechanisms that match ventilation and perfusion in the normal lung
 - b. Understand the factors that govern the equilibration of alveolar gas and pulmonary capillary blood
 - c. Know the mechanisms involved in oxygen uptake by the blood
 - d. Know the mechanisms by which carbon dioxide is transported in the blood and the relationship between carbon dioxide content and PCO₂
 - e. Know the concept and calculation of the respiratory quotient
 - f. Understand the factors that determine the relationship between oxygen content and PO₂
 - g. Understand the concept and calculation of pulmonary shunt and venous admixture
 - h. Understand the concept and calculation of dead space in the lungs
 - i. Know how PO₂ influences carbon dioxide transport and how PCO₂ influences oxygen transport by the blood
 - j. Know the factors that determine alveolar PO₂
 - k. Know the concept and calculation of oxygen uptake by the lungs
 - l. Know the concept and calculation of whole body carbon dioxide production
 - m. Understand the concept and calculation of blood oxygen content
 - n. Understand the mechanisms involved in the release of carbon dioxide by the venous blood in the lungs
 - o. Understand the concept and estimation of ventilation-perfusion mismatch
 - p. Understand the mechanisms that disturb ventilation-perfusion matching in the lungs
 - q. Know how abnormalities in ventilation, diffusion, perfusion and ventilation-perfusion ratios affect gas exchange in the lungs
 - r. Know the effects of decreased consciousness and posture on pulmonary gas exchange
 - s. Understand the mechanisms that increase the alveolar-arterial PO₂ difference
6. Cardiopulmonary interactions (see also I.C and I.D)
- a. Understand the effects of breathing (spontaneous or mechanical) on arterial blood pressure and heart rate

- b. Understand the differential effects of spontaneous and positive airway pressure breathing on the transmural pressure of the intrathoracic vessels and heart chambers
 - c. Understand the differential effects of spontaneous and positive airway pressure breathing on pulmonary and systemic arterial blood flow
- 7. Control of breathing
 - a. Understand the chemoreceptor mechanisms that maintain arterial PO₂ and PCO₂ constant
 - b. Know how lung and chest wall mechanoreceptors influence tidal volume and breathing rate
 - c. Know the neuroanatomic structures involved in the coordination of upper airway tone and ventilation
 - d. Know the factors that influence the tone of the upper airway muscles
- 8. Immunological responses of the lungs and airways
 - a. Understand the mechanical defenses of the respiratory system against invasion by microorganisms
 - b. Understand the role of immunoglobulins in pulmonary host defense
 - c. Understand the role of macrophages in immune defense of the lung
 - d. Demonstrate understanding of the mechanisms involved in lung hypersensitivity reactions
- 9. The role of the lung in acid-base balance regulation
 - a. Understand the role of ventilation in the acid buffering system
 - b. Know the pathophysiology and treatment of respiratory acidosis
 - c. Understand the mechanisms of adaptation to chronic hypercapnia
 - d. Know the principal causes, pathophysiology, and treatment of respiratory alkalosis
- C. Pharmacology and developmental pharmacology
 - 1. Upper airway
 - a. Know the pharmacologic therapy for the treatment or prevention of laryngeal and subglottic edema
 - b. Know the effects of sedatives on pharyngeal tone
 - 2. Lung
 - a. Understand the pharmacology of the airway smooth muscle
 - b. Know the effects of diuretics on lung water
 - 3. Pulmonary circulation
 - a. Understand the effects of vasoactive drugs on pulmonary circulation
 - b. Understand the effects of nitric oxide on the pulmonary circulation
 - 4. Control of respiration
 - a. Know the drugs used to stimulate respiratory effort in infants susceptible to apnea or hypoventilation
- D. Respiratory disorders
 - 1. Upper airway
 - a. Congenital malformations of the airway itself
 - 1. Understand the pathophysiology and presentation of upper airway malformations in neonates
 - 2. Plan treatment for upper airway malformation in a neonate
 - b. Vascular compression of airways

1. Recognize vascular compression of airways
2. Understand the embryology and pathophysiology of the various syndromes of vascular compression of the airways
3. Plan treatment for vascular compression of airways
- c. Acquired narrowing of the airway
 1. Know the factors that predispose to subglottic stenosis
 2. Recognize acquired narrowing of the airway
 3. Understand the pathophysiology of acquired narrowing of the airway
 4. Plan treatment for a patient with acquired narrowing of the airway
- d. Paralysis of the vocal cords
 1. Know the most frequent causes of vocal cord paralysis
 2. Recognize and diagnose paralysis of the vocal cords
 3. Plan treatment for a patient with paralysis of the vocal cords
- e. Infection
 1. Croup
 - a. Know how to diagnose croup
 - b. Understand the pathophysiology of croup
 - c. Plan treatment for a patient with croup
 2. Epiglottitis
 - a. Know the acute evaluation and management of epiglottitis
 - b. Understand the pathophysiology of epiglottitis
 3. Tracheitis
 - a. Understand the acute treatment of bacterial tracheitis
 - b. Understand the pathophysiology of tracheitis
 - c. Know how to diagnose and evaluate tracheitis
 4. Peritonsillar/retropharyngeal abscess
 - a. Know how to diagnose peritonsillar or retropharyngeal abscess
 - b. Plan treatment for a patient with retropharyngeal or peritonsillar abscess
 - c. Know the life-threatening complications of peritonsillar or retropharyngeal abscess
 - d. Identify the organisms commonly associated with retropharyngeal or peritonsillar abscess
- f. Tracheomalacia
 1. Recognize the clinical features of tracheomalacia
 2. Understand the pathophysiologic effects of tracheomalacia
 3. Plan treatment for a patient with tracheomalacia and respiratory distress
- g. Obstructive sleep apnea
 1. Know how to diagnose and evaluate obstructive sleep apnea
 2. Plan perioperative management for a patient with obstructive sleep apnea
2. Lung
 - a. Disorders of the bronchi
 1. Malformations of the bronchial system
 - a. Understand the pathophysiology of malformations of the bronchial system
 - b. Plan treatment for malformations of the bronchi
 - c. Know how to diagnose and evaluate malformations of the bronchi
 2. Disorders of the bronchial system

- a. Bronchiolitis
 - 1. Recognize the clinical features of bronchiolitis
 - 2. Know the organisms that commonly cause bronchiolitis
 - 3. Plan the management of a patient with bronchiolitis
- b. Bronchial hyperreactivity/asthma
 - 1. Understand the pathogenesis of the mechanical and gas exchange abnormalities associated with asthma
 - 2. Know how to diagnose disorders characterized by bronchial hyperreactivity
 - 3. Understand the pathophysiology of disorders characterized by bronchial hyperreactivity
 - 4. Know the treatment of disorders characterized by bronchial hyperreactivity
 - 5. Understand the use of various drug therapies for the treatment of asthma
 - 6. Know which drugs are contraindicated (relative and absolute) in a patient with asthma
 - 7. Understand the principles of gas emptying in an intubated patient with asthma
 - 8. Understand the effects of positive-pressure (noninvasive and invasive) therapy in a patient with severe asthma
 - 9. Plan mechanical ventilation for a patient with respiratory failure secondary to asthma
- b. Disorders of the alveolar-capillary unit
 - 1. Pulmonary edema and inflammation
 - a. General
 - 1. Understand the factors that lead to the development of pulmonary edema
 - 2. Understand the differential mechanisms of cardiogenic and noncardiogenic pulmonary edema
 - 3. Understand mechanisms and scenarios associated with the development of postobstructive pulmonary edema
 - b. Acute respiratory distress syndrome
 - 1. Know the epidemiologic risk factors for acute respiratory distress syndrome
 - 2. Understand the pathogenesis of lung dysfunction in acute respiratory distress syndrome
 - 3. Know how to diagnose acute respiratory distress syndrome
 - 4. Understand the pathophysiologic mechanisms underlying acute respiratory distress syndrome
 - 5. Know the principles of medical management for acute respiratory distress syndrome
 - 6. Understand the principles of open lung strategy for ventilation in patients with acute lung injury
 - 7. Know the general principles of ventilator management in the setting of acute respiratory distress syndrome
 - 8. Understand potential implications of fluid management in acute respiratory distress syndrome

- c. Cardiogenic or hydrostatic pulmonary edema
 - 1. Understand the pathogenesis of pulmonary edema in congestive cardiac failure
 - 2. Know how to diagnose hemodynamic pulmonary edema
 - 3. Understand the pathophysiology of hydrostatic pulmonary edema
 - 4. Plan treatment for a patient with hydrostatic pulmonary edema
 - 2. Neonatal respiratory distress syndromes
 - a. Neonatal pneumonia
 - 1. Know how to diagnose neonatal pneumonia
 - 2. Understand the pathophysiology of neonatal pneumonia
 - 3. Plan treatment for a patient with neonatal pneumonia
 - 4. Know the pathogens that can cause neonatal pneumonia
 - 3. Ventilation-perfusion mismatching
 - a. Know the treatment of ventilation-perfusion mismatching
 - b. Differentiate among the causes of hypoxia
 - c. Differentiate among the causes of hypercapnia
 - 4. Pneumonitis
 - a. Infectious pneumonitis (see also IV.B.2)
 - 1. Understand the pathophysiology and pathogenesis of infectious pneumonitis
 - b. Chemical pneumonitis
 - 1. Know how to diagnose chemical pneumonitis
 - 2. Understand the pathophysiology of chemical pneumonitis
 - 3. Plan treatment for a patient with chemical pneumonitis
 - 4. Know which agents cause chemical pneumonitis
 - 5. Plan treatment for a patient with aspiration pneumonitis
- c. Global respiratory disorders
 - 1. Bronchopulmonary dysplasia
 - a. Recognize and diagnose bronchopulmonary dysplasia
 - b. Understand the pathogenesis and pathophysiology of bronchopulmonary dysplasia
 - c. Know the treatment of acute pulmonary decompensation in a patient with bronchopulmonary dysplasia
 - 2. Oxygen toxicity
 - a. Understand the mechanisms involved in oxygen- and oxygen radical-mediated lung injury
 - b. Understand the role of antioxidant enzymes
 - c. Know mechanisms for detoxifying intracellular oxygen radicals
 - 3. Pulmonary hemorrhage
 - a. Know how to diagnose pulmonary hemorrhage
 - b. Understand the pathophysiology of pulmonary hemorrhage
 - c. Plan treatment for a patient with pulmonary hemorrhage
 - d. Know the diseases associated with pulmonary hemorrhage
- 3. Mechanical abnormalities of pulmonary function
 - a. Thoracic cage dystrophy or dysfunction
 - 1. Understand the pathophysiology of thoracic cage dystrophy or dysfunction

2. Plan treatment for a patient with thoracic cage dystrophy or dysfunction
3. Know how to evaluate the severity of thoracic cage dystrophy or dysfunction
4. Understand the pathogenesis of respiratory failure in patients with thoracic cage dystrophy
- b. Diaphragmatic dysfunction
 1. Know how to diagnose diaphragmatic dysfunction
 2. Understand the pathophysiology of diaphragmatic dysfunction
 3. Plan treatment for a patient with diaphragmatic dysfunction
 4. Recognize diaphragmatic dysfunction in the differential diagnosis of respiratory failure
 5. Know the causes of phrenic nerve injury (birth trauma, surgical trauma)
 6. Plan the management of a patient with diaphragmatic paralysis
4. Pulmonary circulation
 - a. Malformations of pulmonary circulation
 1. Know how to diagnose malformations of pulmonary circulation
 2. Understand the pathophysiology of malformations of pulmonary circulation
 3. Know the treatment of malformations of pulmonary circulation
 - b. Pulmonary embolism
 1. Know how to diagnose pulmonary embolism
 2. Understand the pathophysiology of pulmonary embolism
 3. Recognize recurrent pulmonary embolism in the differential diagnosis of pulmonary hypertension
 4. Understand the pathophysiology of the blood gas abnormalities associated with pulmonary embolism
 5. Plan treatment for a patient with acute pulmonary embolism
 6. Identify the risk factors for pulmonary embolism
 - c. Pulmonary hypertension
 1. Know how to diagnose persistent pulmonary hypertension of the newborn
 2. Plan treatment for a patient with persistent pulmonary hypertension of the newborn
 3. Recognize primary pulmonary hypertension
 4. Evaluate the severity of primary pulmonary hypertension
 5. Plan treatment for a patient with primary pulmonary hypertension
 6. Recognize risks factors for secondary pulmonary hypertension in a child with chronic lung disease
 7. Plan the management of a patient with secondary pulmonary hypertension
5. Disorders of blood oxygen and carbon dioxide transport
 - a. Know how to diagnose disorders of blood oxygen and carbon dioxide transport
 - b. Understand the pathophysiology of disorders of blood oxygen and carbon dioxide transport
 - c. Know the treatment of disorders of blood oxygen and carbon dioxide transport
 - d. Know the physiologic effects of anemia
 - e. Understand the toxic and pharmacologic causes of abnormal oxygen transport
6. Disorders of control of respiration
 - a. Recognize disorders of the control of respiration in the differential diagnosis of hypercapnia

- b. Know how to diagnose disorders of control of respiration
- c. Understand the pathophysiology of disorders of control of respiration
- d. Know the treatment of disorders of control of respiration
- 7. Disorders of pleura and lymphatics
 - a. Differentiate among the causes of pleural effusion
 - b. Plan the management for a patient with complicated parapneumonic effusion
 - c. Know the pathogenesis of chylous effusion
 - d. Plan treatment for a patient with chylous effusion
- 8. Lung disorders in immune dysfunction
 - a. Know the differential diagnosis of pneumonitis in a patient with immune deficiency
 - b. Evaluate a patient with acute respiratory failure and immune deficiency
 - c. Plan treatment for a patient with an opportunistic lung infection
- 9. Lung injury in thoracic trauma (see also X.B.5)
 - a. Know the physical findings of pulmonary contusion
 - b. Know how to diagnose lung injury in thoracic trauma
 - c. Understand the pathophysiology of lung injury in thoracic trauma
 - d. Know the treatment of lung injury in thoracic trauma
- E. Respiratory diagnostic modalities
 - 1. Physical examination
 - a. Know the physical findings of respiratory failure in the spontaneously breathing child
 - b. Differentiate between the various causes of respiratory distress by physical examination
 - 2. Imaging studies
 - a. Use imaging studies to differentiate among the various causes of respiratory distress in infants and children
 - b. Assess airway obstruction by radiography
 - c. Recognize the radiographic findings characteristic of atelectasis, pulmonary infiltrates, pneumothoraces, and pleural effusions
 - 3. Blood gas examination and end-tidal gas analysis
 - a. Recognize the limitations inherent in using end-tidal gas as a sample of alveolar air in the abnormal lung
 - b. Distinguish acute from chronic hypercapnia using arterial and end-tidal gas analysis
 - c. Distinguish hypoventilation from ventilation-perfusion mismatch using arterial and end-tidal gas analysis
 - d. Determine the pathogenesis of hypoxemia by blood gas analysis
 - 4. Bronchoscopy and bronchoalveolar lavage
 - a. Know the indications for bronchoscopy
 - b. Know the acute complications associated with bronchoscopy
 - c. Know the indications for bronchoalveolar lavage
 - d. Know the acute complications associated with bronchoalveolar lavage
 - e. Know the constituents of normal bronchoalveolar lavage fluid
 - 5. Pulmonary function testing for extubation
 - a. Assess readiness for extubation in a patient recovering from acute lung disease

- b. Assess readiness for extubation in a patient with weakness due to neuromuscular disease
 - c. Assess readiness for extubation in a patient recovering from anesthesia
 - d. Assess readiness for extubation in a patient with long-standing lung disease
 - e. Know how to use tests of mechanics of breathing such as negative inspiratory force or forced vital capacity to predict extubation
6. Indirect calorimetry
- a. Understand the principles of indirect calorimetry
 - b. Know the limitations of indirect calorimetry
- F. Therapy
1. Manipulation of metabolic demand
- a. Understand the relation of nutrient intake to respiratory quotient and carbon dioxide production
 - b. Understand the relation of work of breathing to oxygen demand in respiratory failure
2. Principles of respiratory stabilization and support
- a. Understand the principles involved in selecting initial ventilator settings for the patient with respiratory failure
 - b. Understand the physiologic effects of positive-pressure breathing
 - c. Understand the potential use of different maneuvers of chest physiotherapy and positioning
3. Principles of postoperative respiratory care
- a. Understand the principles of mechanical ventilation as a means to stabilize the patient after major or prolonged surgery
 - b. Plan the postoperative approach to mechanical ventilation of a patient with abnormal preoperative lung function, upper airway abnormalities, or thoracic dystrophy
4. Modes of mechanical and assisted ventilation
- a. Standard mechanical ventilation
 - 1. Understand the principles and applications of the various modes of volume-controlled mechanical ventilation
 - 2. Know the advantages and limitations of the various modes of pressure-controlled mechanical ventilation
 - 3. Recognize that problems with temperature control of humidifiers may lead to hypothermia or hyperthermia
 - 4. Understand the effects of decreased pulmonary compliance on mechanical ventilation
 - 5. Know the effects of patterns of gas flow during mechanical ventilation oxygenation
 - 6. Understand the devices used for humidification of respiratory gases
 - 7. Understand the principles and applications of the various modes of pressure-controlled mechanical ventilation
 - 8. Know the advantages and limitations of the various modes of volume-controlled mechanical ventilation
 - 9. Understand the components of mean airway pressure that can be manipulated to improve oxygenation

10. Understand the effects of high airways resistance on mechanical ventilation
11. Understand the problems of mechanical ventilation presented by asymmetrical lung disease
12. Understand the appropriate application and benefits of CPAP/PEEP
13. Understand the potential deleterious effects of CPAP/PEEP
14. Understand the effects of the ventilator circuit on gas exchange
- b. High-frequency ventilation/oscillation
 1. Understand the principles underlying the use of high-frequency oscillatory ventilation
 2. Know the advantages and limitations of high-frequency/oscillatory ventilation
 3. Identify the clinical situations where high-frequency/oscillatory ventilation is useful
 4. Adjust parameters of high-frequency/oscillatory mechanical ventilation to maintain gas exchange
 5. Understand the mechanism of action of airway pressure release ventilation
 6. Understand the potential indications for airway pressure release ventilation
 7. Understand the parameters for titration of airway pressure release ventilation
- c. Noninvasive ventilation
 1. Noninvasive negative-pressure ventilation
 - a. Know the principles underlying the use of negative-pressure mechanical ventilation
 - b. Know the advantages and disadvantages of negative-pressure mechanical ventilation
 - c. Know the appropriate settings for the use of negative-pressure mechanical ventilation
 2. Noninvasive positive-pressure mechanical ventilation (NIPPV)
 - a. Know the principles underlying the use of NIPPV
 - b. Know the advantages and disadvantages of NIPPV
 - c. Understand the specific subtypes of NIPPV:CPAP, bilevel positive airway pressure, high-flow nasal cannula delivery
 - d. Know the clinical settings for the use of NIPPV
- d. Application of exogenous gases and other adjuncts
 1. Understand the indications for and applications and complications of helium-oxygen therapy
 2. Understand the indications for and mechanisms of the delivery of nitric oxide via a ventilator
 3. Understand the indications for and mechanisms of the delivery of surfactant in the mechanically ventilated patient
 4. Understand the indications for and mechanisms of the application of inhaled carbon dioxide or nitrogen to control pulmonary blood flow in the mechanically ventilated patient
 5. Understand the indications for and application and complications of hyperbaric oxygen therapy
 6. Understand how to administer aerosol therapy in the mechanically ventilated patient and limitations to medication delivery
5. Weaning from mechanical ventilation

- a. Understand the principles of weaning patients from mechanical ventilation
- b. Understand factors that support or discourage patient liberation from the ventilator and extubation
- 6. Complications of mechanical ventilation (see also IV.B.8.b.(3))
 - a. Know the complications resulting from mechanical ventilation
 - b. Know the factors associated with mechanical ventilation that contribute to lung injury
 - c. Understand the concepts of tension, stress, and strain in mechanical ventilation
 - d. Recognize, diagnose, and plan treatment for a tension pneumothorax
- 7. Tracheostomy
 - a. Know how to manage accidental decannulation of a tracheostomy
 - b. Know the immediate and long-term postoperative complications of tracheostomy
- G. Gas therapy and physics
 - 1. Delivery
 - a. Understand the advantages and limitations of the various manual ventilation devices (eg, self-inflating vs flow-inflating bag)
 - b. Calculate the availability of adequate gas flow in the use of anesthetic gas cylinders
 - c. Calculate the approximate oxygen concentration delivery of nasal cannula flow in an infant
 - d. Understand the determinants and limitations of oxygen delivery via various oxygen masks (eg, simple masks, non-breathing masks, Venturi masks)
 - e. Understand the principles of the use of a nonrebreathing mask
 - 2. Physics
 - a. Know the effect of altitude on partial pressure of gases in the alveolus
 - b. Utilize the alveolar gas equation
 - c. Understand the importance of gas density and viscosity in airway resistance
- 3. **Neurology and Neuromuscular**
 - A. Anatomic, functional, and physiologic development
 - 1. Major central nervous system components
 - a. Identify the major arterial and venous blood vessels and the regions of their supply and drainage
 - b. Know the structural components of the brain
 - c. Know the role of cell types within the central nervous system
 - d. Understand the susceptibility of central nervous system cell types to different types of injury: traumatic, hypoxic, metabolic, inflammatory
 - e. Understand the function of and consequences of injury to specific regions of the central nervous system, including the cerebral cortex, basal ganglia, cerebellum, regions of the brain stem, cranial nerves, and major tracts of the spinal cord
 - f. Know the relative volume of the principal intracranial compartments
 - g. Identify normal intracranial structures on CT and MRI of the central nervous system
 - 2. Postnatal neuromuscular development
 - a. Understand the developmental changes of the postnatal brain and central nervous system
 - 3. Sympathetic nervous system
 - a. Understand the functions of the sympathetic nervous system

- b. Know the anatomy of the sympathetic nervous system
 - c. Know the transmitters of the sympathetic nervous system
 - d. Understand the consequences of disruption of elements of the sympathetic nervous system
 - e. Understand the baroreceptor response
 - f. Know the systemic consequences of excess sympathetic activity
4. Parasympathetic nervous system
- a. Understand the functions of the parasympathetic nervous system
 - b. Know the anatomy of the parasympathetic nervous system
 - c. Know the transmitters of the parasympathetic nervous system
 - d. Know the consequences of parasympathetic blockade
 - e. Know the consequences of excess parasympathetic activity
5. Blood-brain barrier
- a. Understand the physiologic basis of the blood-brain barrier
 - b. Know that the capillary endothelium forms the principal component of the blood-brain barrier
 - c. Identify the causes of blood-brain barrier disruption
 - d. Know the anatomic features of the blood-brain barrier
6. Neuromuscular junction
- a. Know the structure of the neuromuscular junction
 - b. Understand the electrical and biochemical mechanism of muscular contraction
 - c. Understand competitive and noncompetitive inhibition of the neuromuscular junction
 - d. Know the causes and consequences of critical illness-induced neuropathy or myopathy
7. Major central nervous system neurotransmitters
- a. Know the localization of the major central nervous system neurotransmitters
 - b. Understand the function of the major central nervous system neurotransmitters
8. Metabolic requirements
- a. Know the oxygen consumption of gray matter, white matter, and whole brain
 - b. Understand the methods of measuring cerebral metabolic rate for oxygen
 - c. Understand the regional differences of the metabolic rates within the brain
 - d. Know the preferred fuels of the brain
 - e. Understand how metabolic derangements can cause brain injury
9. Cerebral blood flow, regulation, and modulation (see also XIV.B.6.e/f)
- a. Understand the effects of hypoxia on cerebral vascular resistance
 - b. Understand the effects of blood carbon dioxide concentration on cerebral vascular resistance and cerebral blood flow regulation
 - c. Understand cerebral autoregulation
 - d. Know the effects of various classes of vasodilators on cerebral vascular resistance
 - e. Know that alpha-adrenergic drugs have little effect on cerebral vascular resistance
 - f. Differentiate between the effects of pH and PCO₂ on cerebral blood flow
 - g. Know that jugular venous pressure or intracranial pressure may serve as the outflow pressure of the cerebral circulation
 - h. Recognize the cerebral complications of severe hypertension
10. Cerebrospinal fluid

- a. Know the basic physiology of cerebrospinal fluid production, absorption, and circulation
- B. Neurologic evaluation
 - 1. Assessment of mental status
 - a. Know the components of the Glasgow Coma Scale
 - b. Understand the use of the Glasgow Coma Scale
 - c. Know the pediatric modifications to the Glasgow Coma Scale
 - d. Know the differential diagnosis of altered mental status in different age groups
 - e. Understand the significance of rate of progression in changes in mental status
 - 2. Ocular abnormalities
 - a. Pupillary responses
 - 1. Know that pupillary innervation is by the third cranial nerve as well as by adrenergic and cholinergic nerves
 - 2. Recognize and differentiate among the causes of unilateral dilated or constricted pupils
 - 3. Recognize and differentiate among the causes of bilateral dilated or constricted pupils
 - 4. Understand the ciliospinal reflex
 - 5. Understand the significance of abnormal pupillary reactions, other than dilated or constricted pupils
 - b. Extraocular movement
 - 1. Understand the response of the vestibular apparatus to cold water in the comatose and awake patient
 - 2. Understand the effects of brain stem tumor on oculomotor findings
 - 3. Know the oculomotor findings associated with neuroblastoma
 - 4. Know the ocular findings associated with third cranial nerve palsy
 - 5. Know the ocular findings associated with sixth cranial nerve palsy
 - 6. Know the cranial nerves that control eye movements
 - 7. Interpret results of the oculocephalic and oculovestibular reflexes
 - 8. Differentiate between the causes of various gaze abnormalities
 - c. Retinal exam
 - 1. Recognize the fundusoscopic appearance of papilledema
 - 2. Recognize the fundusoscopic appearance of recent and old retinal hemorrhages
 - 3. Recognize the fundusoscopic appearance of systemic fungemia
 - 3. Neuromuscular function
 - a. Evaluate the significance of hyperactive tendon reflexes
 - b. Evaluate the significance of absent tendon reflexes
 - c. Evaluate the significance of changes in muscle strength
 - d. Understand the important components of a comprehensive neurologic examination
 - 4. Electroencephalography
 - a. Recognize the following EEG patterns: spike and wave, burst-suppression, slow wave activity, isoelectric EEG, ECG artifact
 - b. Know the EEG findings associated with herpes encephalitis
 - c. Know the significance of the following EEG patterns: spike and wave, burst-suppression, slow wave activity, isoelectric EEG, ECG artifact
 - d. Know the indications for continuous EEG monitoring

5. Electromyography/nerve conduction
 - a. Recognize the diagnostic importance of electromyography/nerve conduction studies in Guillain-Barré syndrome and myasthenia gravis
 - b. Recognize the clinical situations in which electromyography and nerve conduction studies might be useful in patients with critical illness
6. Cerebrospinal fluid
 - a. Differentiate among the causes of decreased cerebrospinal fluid glucose concentration
 - b. Understand the pathophysiology and consequences of decreased cerebrospinal fluid glucose concentration
 - c. Understand the pathophysiology of increased cerebrospinal fluid protein concentration
 - d. Understand the pathophysiology of an abnormal cerebrospinal fluid cell count
 - e. Use cerebrospinal fluid cell count and leukocyte differential cell count to distinguish among bacterial infection, fungal infection, viral infection, and malignancy
 - f. Differentiate among the causes of increased cerebrospinal fluid protein concentration
 - g. Know the differential diagnosis of erythrocytes in the cerebrospinal fluid
7. Imaging studies
 - a. Recognize communicating and noncommunicating hydrocephalus on CT or MRI of the head
 - b. Recognize intracranial hemorrhage on CT or MRI of the head
 - c. Recognize a mass lesion on CT or MRI of the head
 - d. Recognize herpes encephalitis on CT or MRI of the head
 - e. Recognize herniation on CT or MRI of the head
 - f. Recognize cerebral edema on CT or MRI of the head
 - g. Recognize cerebral ischemia or infarction on CT or MRI of the head
 - h. Know the indications for and limitations of MR spectroscopy, MR angiography, and MR venography
8. Evoked potentials
 - a. Know the significance and limitations of evoked potentials
 - b. Know the indications for ordering auditory, visual, and somatosensory-evoked potentials
9. Cerebral blood flow
 - a. Understand the methods for assessing cerebral blood flow in the clinical setting
 - b. Know the physiologic basis, limitations, indications, and interpretation of near-infrared spectroscopy (NIRS) monitoring in the ICU
 - c. Understand the differences between NIRS monitoring and global cerebral blood flow measurements in critically ill patients
- C. Pathophysiology and management of acute neurologic disorders
 1. Cellular mechanisms of neuronal and glial injury
 - a. Understand the association of lactic acidosis, glucose, calcium, and excitatory amino acids with neuronal injury in stroke, traumatic brain injury, meningitis, encephalitis, status epilepticus, and other disorders

- b. Understand the role and the underlying mechanisms of inflammatory changes leading to secondary brain injury
- c. Understand how vulnerability to neuronal or glial injury changes with age
- 2. Central nervous system aspects of metabolic disorders
 - a. Electrolyte disturbances
 - 1. Know the electrolyte disturbances that cause metabolic encephalopathy
 - 2. Recognize the electrolyte disorders that cause seizures, including hypomagnesemia, hypocalcemia, and hyponatremia
 - 3. Plan the management of seizures caused by electrolyte disorders
 - b. Inborn errors of metabolism (see also VI.F.2)
 - 1. Carbohydrate
 - a. Recognize Pompe disease (glycogen storage disease type II) as a cause of cardiomyopathy and hypotonia
 - b. Recognize galactosemia as a cause of acute neurologic disease
 - c. Identify the disorders of carbohydrate metabolism that cause neurologic dysfunction
 - d. Identify the disorders of lipid metabolism that cause neurologic dysfunction
 - e. Recognize the neurologic manifestations of carbohydrate disorders
 - 2. Protein/amino acid
 - a. Distinguish disorders of amino acid formation or degradation from other causes of metabolic encephalopathy
 - b. Recognize the neurologic manifestations of protein/amino acid disorders
 - 3. Urea cycle
 - a. Recognize urea cycle disorders in patients with coma
 - b. Recognize the neurologic manifestations of urea cycle disorders
 - 4. Mitochondrial
 - a. Recognize mitochondrial disorders that might present as metabolic causes of brain dysfunction (causing seizures or encephalopathy)
 - b. Recognize the neurologic manifestations of mitochondrial disorders
 - c. Hepatic encephalopathy (see also VIII.D.9.a.(5))
 - 1. Understand the pathophysiology, clinical features, and stages of hepatic encephalopathy
 - 2. Recognize and treat the central nervous system complications of hepatic failure
- 3. Neurologic aspects of CNS infection (see also IV.B.1)
 - a. Recognize the life-threatening consequences of subdural empyema
 - b. Recognize nerve palsies as a complication of bacterial meningitis
 - c. Recognize the clinical features of viral, bacterial, fungal, or parasitic forms of encephalitis
 - d. Know the etiology and epidemiology of viral encephalitis
 - e. Know that increased intracranial pressure may complicate central nervous system infection
 - f. Plan the management of increased intracranial pressure in a patient with a central nervous system infection
 - g. Know that bacterial shunt infections can lead to ventriculitis and encephalitis
- 4. Vascular diseases and disorders of cerebral circulation
 - a. Vasculitis

1. Recognize cerebral vasculitis as a possible explanation for seizures, stroke, or altered mental status
2. Recognize the association of cerebral vasculitis with collagen vascular disease (eg, lupus, dermatomyositis, moyamoya disease)
3. Understand the pathogenesis and pathophysiology of cerebral vasculitis
4. Plan treatment for a patient with cerebral vasculitis
- b. Aneurysm/arteriovenous malformation
 1. Recognize aneurysm as a cause of subarachnoid and intracranial hemorrhage
 2. Recognize arteriovenous malformation as a cause of focal seizures, subarachnoid hemorrhage, and intracranial hemorrhage
 3. Plan therapy for a patient with subarachnoid hemorrhage
 4. Recognize spinal cord arteriovenous malformation as a cause of acute neurologic deficit
 5. Recognize spinal epidural hematoma as a cause of acute neurologic deficit
- c. Stroke
 1. Understand the causes and pathophysiology of stroke in children
 2. Know the differential diagnosis of embolic and thrombotic stroke in children
 3. Recognize the clinical and radiographic signs of venous sinus thrombosis
 4. Plan therapy for a patient with thrombotic stroke
 5. Know the anatomic and functional patterns and clinical course of stroke (eg, middle cerebral artery infarction, brain stem infarction)
 6. Identify the clinical settings in which venous sinus thrombosis is most likely
 7. Know the association between stroke and systemic diseases (eg, hypercoagulable disorders, iron deficiency, sickle cell anemia)
 8. Know the clinical features of sickle cell disease leading to stroke
 9. Plan treatment for a patient with sickle cell disease and stroke
5. Hypoxic-ischemic encephalopathy
 - a. Pathophysiology
 1. Understand the pathophysiology and developmental aspects of hypoxic-ischemic encephalopathy
 2. Understand the neurologic implications of asphyxia-induced cardio-pulmonary arrest versus ventricular fibrillation-induced cardio-pulmonary arrest
 3. Understand the differences in pathophysiology between hypoxic and ischemic neurologic injury
 4. Understand the concept of a threshold for damage in relationship to cerebral blood flow
 5. Know the regions of the brain that are especially vulnerable to hypoxic injury (eg, hippocampus, cerebral cortex, basal ganglia)
 6. Understand the pathogenesis and pathophysiology of cerebral edema after a hypoxic/ischemic episode
 - b. Treatment
 1. Plan therapy for a patient with hypoxic-ischemic encephalopathy
 2. Recognize that the treatment of hypoxic/ischemic brain injury is largely supportive
 3. Recognize that hyperthermia may exacerbate hypoxic/ischemic injury
 4. Know the role of therapeutic hypothermia in treating hypoxic-ischemic injury

6. Central nervous system and neoplasm
 - a. Posterior fossa
 1. Identify the common posterior fossa tumors that cause posterior fossa compression (eg, medulloblastoma, astrocytoma)
 2. Recognize the signs of a posterior fossa tumor
 3. Know the predominant tumors of the posterior fossa
 4. Plan the pre-operative and post-operative management of a patient with posterior fossa tumor resection
 - b. Hemispheric and third ventricle
 1. Recognize the signs of a tumor of the hemispheres and third ventricle
 2. Know the predominant tumors of the hemispheres and third ventricle
 3. Know the complications (endocrine, hemorrhagic, etc) of tumors in the cerebral hemispheres and third ventricle
 - c. Spinal cord and brain stem tumors
 1. Recognize spinal cord tumor as a cause of acute spinal cord dysfunction
 2. Know the clinical features and complications of brain stem tumors
 - d. Central nervous system complications of cancer chemotherapy
 1. Understand that central nervous system tumor necrosis and effects of chemotherapy and radiation therapy may cause increased intracranial pressure
 2. Recognize leukoencephalopathy caused by methotrexate therapy
 3. Recognize inappropriate secretion of antidiuretic hormone as a complication of cancer chemotherapy and tumor resection
 4. Recognize seizures as a complication of cancer chemotherapy
 - e. Central nervous system complications of transplantation
 1. Know the opportunistic central nervous system infections that are associated with transplantation
 2. Recognize and evaluate the contribution of immunosuppressive therapy to seizures and metabolic encephalopathy
 3. Understand the central nervous system effects of graft-versus-host disease
7. Head and spinal cord trauma
 - a. Patterns of injury/physical examination
 1. Recognize the clinical findings of frontal and temporal lobe contusion
 2. Recognize the effects of shearing of axons in the corpus callosum, cerebral and cerebellar peduncles, and the brain-stem
 3. Recognize the clinical findings and patterns of injury leading to different types of intracranial hemorrhage (parenchymal, intraventricular, subarachnoid, subdural, epidural)
 4. Recognize clinical correlates of anterior spinal artery syndrome
 5. Understand the pathogenesis and pathophysiology of traumatic intracranial hemorrhage
 6. Assess the severity of neurologic dysfunction after head trauma
 7. Understand the pathogenesis and pathophysiology of shaken impact injury
 8. Recognize the typical physical findings in a patient with shaken impact injury
 9. Recognize the syndrome of spinal cord injury without radiologic abnormalities (SCIWORA)
 10. Recognize the characteristic clinical presentations of spinal cord injury

11. Recognize disruption of sympathetic chain in high cervical trauma
- b. Imaging patterns of injury
 1. Distinguish between focal contusion, focal hemorrhage, and atrophy as sequelae of trauma on CT scan of the head
 2. Interpret CT scan of the head showing traumatic epidural hemorrhage
 3. Recognize lateral neck, CT, and MRI images suggestive of spinal cord injury
 4. Recognize new versus old bleeding on imaging studies
- c. Pathophysiology
 1. Recognize contusion and shearing as primary brain injuries
 2. Recognize hypoxia-ischemia as a secondary mechanism of traumatic brain injury
 3. Recognize cerebral edema as a secondary cause of brain injury after head trauma
- d. Treatment
 1. Head trauma (see also XIII.A.1.c.(1).(5))
 - a. Plan the treatment of a patient with epidural hematoma
 - b. Know the effects of ventilation in patients with head trauma
 - c. Know the value/risks of neuromuscular blockade in patients with head trauma
 - d. Know emergency airway management following head trauma
 - e. Plan the emergency airway management of a patient with basilar skull fracture, including the avoidance of nasal intubation
 - f. Plan basic supportive care for patients with head trauma, including management of increased intracranial pressure and acute loss of consciousness
 - g. Know the role of drainage of cerebrospinal fluid and airway management in the treatment of acute increases in intracranial pressure
 - h. Know the mechanism of action of osmotic diuretics: decreased viscosity, decreased intravascular volume, and cellular dehydration
 - i. Know that hyperventilation following head trauma may compromise blood flow to ischemic areas of the brain
 - j. Know that prolonged hyperventilation for head trauma is associated with loss of cerebrospinal fluid buffer and increased sensitivity to hypercapnia
 - k. Plan the management of a patient with refractory intracranial hypertension (eg, barbiturate coma, decompressive craniectomy) and know the associated prognosis
 - l. Understand the rationale of using cerebral perfusion pressure to guide therapy in patients with head injury
 2. Spinal cord injury
 - a. Plan basic supportive care for patients with spinal cord injury
 - b. Understand the physiologic changes associated with spinal shock
8. Increased intracranial pressure (see also XIV.B.6)
 - a. Hydrocephalus
 1. Distinguish between communicating and noncommunicating hydrocephalus
 2. Recognize that increased cerebrospinal fluid production and decreased reabsorption can both cause hydrocephalus

3. Recognize hydrocephalus as a complication of central nervous system infection, infestation, hemorrhage, or tumor
4. Know the medical and surgical treatments of hydrocephalus
5. Recognize several causes of noncommunicating hydrocephalus
6. Plan treatment for a patient with noncommunicating hydrocephalus
7. Recognize the clinical signs of Arnold-Chiari malformation
- b. Pseudotumor cerebri
 1. Recognize pseudotumor cerebri as a cause of increased intracranial pressure
 2. Recognize causes of pseudotumor cerebri (eg, endocrine imbalance, sinus thrombosis, tetracycline, vitamin A, CNS infection)
 3. Know the treatment of pseudotumor cerebri (eg, corticosteroids, acetazolamide, drainage)
- c. Cerebral edema
 1. Distinguish between the causes of cytotoxic, vasogenic, osmotic, and interstitial types of cerebral edema
 2. Recognize the differences in the treatment appropriate for vasogenic and cytotoxic edema
 3. Know that corticosteroid therapy for cerebral edema has proven benefit only in the setting of brain tumor
 4. Know the physiology of cerebrospinal fluid drainage for the treatment of increased intracranial pressure
 5. Know the physiology of head positioning for the treatment of cerebral edema
 6. Know the physiology of hyperventilation for the treatment of cerebral edema
 7. Know that topical lidocaine has an effect on intubated patients with cerebral edema during suctioning
 8. Know the mechanism of action of barbiturates in the treatment of head injury
 9. Know the physiology of osmolar therapy in the management of cerebral edema
 10. Understand the risk factors for post-traumatic seizures and the effect of seizures on brain metabolic rate
 11. Know the physiology and limitations of therapeutic hypothermia in the management of cerebral edema
 12. Know the potential surgical options for the management of refractory cerebral edema
 13. Know the potential risks of the therapies for cerebral edema
9. Herniation
 - a. Diagnosis
 1. Recognize the syndromes of transtentorial, subfalcine, foramen magnum, and extracranial herniation
 2. Recognize that uncal herniation is a subset of descending transtentorial herniation
 3. Recognize the clinical signs and imaging features of the various herniation syndromes
 4. Differentiate between the clinical findings and imaging signs of ascending and descending transtentorial herniation
 - b. Pathogenesis
 1. Understand the pathogenesis of the various herniation syndromes

2. Know the changes in cranial nerve function and cerebral blood flow associated with various herniation syndromes
 - c. Treatment
 1. Plan treatment for patients with the various herniation syndromes
 2. Evaluate the efficacy of medical and surgical interventions for the various types of herniation
10. Seizure disorders
- a. Classification
 1. Know the basic classification of seizure disorders
 2. Recognize tonic-clonic seizures
 3. Recognize myoclonic seizures
 4. Recognize simple partial (or focal) seizures
 5. Recognize partial complex seizures
 6. Know the definition of and the differing management for early and late post-traumatic seizures
 - b. Neonatal seizures
 1. Know the causes of neonatal seizures
 2. Plan the evaluation and treatment of neonatal seizures
 - c. Febrile seizures
 1. Know the definition of a simple febrile seizure
 2. Understand the characteristics of complex febrile seizures and their significance (duration > 20 min, focality, underlying CNS disorder, family history, higher risk of epilepsy)
 3. Know the prognosis and long-term outcomes associated with febrile seizures
 - d. Status epilepticus
 1. Plan the treatment of a patient with status epilepticus
 2. Know several mechanisms of injury to the brain from status epilepticus
 3. Recognize that neuronal injury can occur during seizures even with normal systemic perfusion and oxygenation
 4. Recognize the causes of status epilepticus (eg, hypoxia-ischemia, drug withdrawal, infection, drug-induced)
 5. Understand the role of specific anticonvulsants in the treatment of status epilepticus
 6. Know the physiologic changes (systemic, neurologic) associated with status epilepticus
 7. Plan the diagnosis and treatment of patients with refractory status epilepticus
 8. Recognize the potential implications of nonconvulsive status epilepticus
- D. Neuromuscular disorders
1. Motor neuron diseases
 - a. Spinal muscular atrophy
 1. Understand the pathophysiology of spinal muscular atrophy
 2. Recognize the clinical features and plan the diagnostic evaluation of spinal muscular atrophy
 3. Know the natural history of spinal muscular atrophy
 4. Understand the causes of respiratory insufficiency in spinal muscular atrophy (weakness, spinal deformity)

- b. Tetanus
 - 1. Recognize and plan the treatment for tetanus
 - 2. Understand the risk factors for tetanus
- 2. Guillain-Barré syndrome
 - a. Pathogenesis
 - 1. Understand the pathogenesis of Guillain-Barré syndrome
 - 2. Know the association of Guillain-Barré syndrome with influenza and other respiratory viruses
 - b. Diagnosis
 - 1. Recognize the clinical signs of Guillain-Barré syndrome (paresthesia in arms and legs, proximal ascending weakness and respiratory failure closely associated with loss of gag reflex)
 - 2. Know the cerebrospinal fluid findings compatible with the diagnosis of Guillain-Barré syndrome
 - 3. Recognize the Miller-Fisher variant of Guillain-Barré syndrome
 - c. Treatment
 - 1. Know the criteria for elective intubation in patients with Guillain-Barré syndrome
 - 2. Know the appropriate treatment for Guillain-Barré syndrome
 - 3. Know that the patterns of response to treatment are related to the long-term prognosis of patients with Guillain-Barré syndrome
- 3. Neuromuscular junction
 - a. Infant botulism
 - 1. Recognize that infant botulism may be a cause of neuromuscular paralysis
 - 2. Understand the pathophysiology of infant botulism
 - 3. Know the clinical course of infant botulism
 - 4. Know the life-threatening complications of infant botulism
 - 5. Plan treatment for a patient with infant botulism
 - b. Botulism
 - 1. Recognize the differences between infant botulism and botulism in older patients
 - 2. Know the clinical course of botulism in older patients
 - c. Myasthenia gravis
 - 1. Distinguish between myasthenia gravis and other neuromuscular disorders causing neuromuscular paralysis
 - 2. Know that myasthenia gravis is characterized by progressive fatigue, bulbar weakness, and hoarseness
 - 3. Know that myasthenia gravis may be exacerbated by aminoglycosides and surgery
 - 4. Know that myasthenia gravis is characterized by decremental repetitive nerve conductions and a positive response to neostigmine
 - 5. Know the pathophysiologic basis of myasthenia gravis
 - 6. Plan the management of a patient with myasthenia gravis
- 4. Myopathies
 - a. Chronic

1. Know that Duchenne muscular dystrophy is characterized by progressive respiratory failure and cardiomyopathy
 2. Recognize the importance of muscle biopsy and electromyography in the diagnosis of chronic myopathies
 3. Understand supportive therapies for patients with progressive respiratory insufficiency associated with myopathy
 4. Know the genetic defect causing Duchenne muscular dystrophy
 - b. Inflammatory (see IV.D.3)
 - c. Metabolic
 1. Recognize the occurrence of metabolic myopathies
 - d. Rhabdomyolysis
 1. Know the causes of rhabdomyolysis
 2. Recognize the clinical signs and laboratory findings consistent with the diagnosis of rhabdomyolysis
 3. Understand the complications of rhabdomyolysis
 4. Plan treatment for a patient with rhabdomyolysis
 5. Demyelinating disorders
 - a. Recognize the clinical presentation of postinfectious encephalomyelitis
 - b. Recognize acute demyelinating disorder as an etiology of seizures
 - c. Recognize demyelinating disorder as an etiology of coma
 6. Toxic nervous system disorders
 - a. Heavy metal toxicity
 1. Recognize acute lead encephalopathy
 - b. Tick paralysis
 1. Recognize tick paralysis as a cause of ascending neuromuscular paralysis
4. **Infectious Disease, Immunology, and Inflammation**
- A. Structure, function, and development
 1. Host defenses
 - a. General
 1. Distinguish among the specific immune functions performed by the components of the innate immune system and the acquired immune system
 2. Know the importance of endothelial/epithelial barriers as defense against infection
 3. Know the structure and development of the components of the immune/inflammation system
 4. Understand the biochemistry of inducible nitric oxide
 5. Understand the production and effects of inducible nitric oxide
 6. Understand disseminated intravascular coagulation as a component of the innate immune response
 7. Understand the role of toll-like receptors in the initiation of the innate immune response
 8. Understand the role of the transcription factor NF- κ B in the initiation and amplification of the immune response
 9. Understand the importance of the circulating proteins of the innate immune system (eg, lectins, C3, LPS-binding proteins, acute phase reactants, etc)

10. Understand the importance of the cellular components of the innate immune system (eg, phagocytes, natural killer cells)
11. Understand the role of endothelial cells in the innate immune response
- b. Phagocytic system
 1. Understand the function of the phagocytic system
 2. Understand the role of oxygen metabolites in killing by phagocytes
 3. Understand the mechanisms by which endothelium and phagocytic cells interact
 4. Understand the functions of macrophages, neutrophils, eosinophils, and basophils
- c. Reticuloendothelial system (see VIII.B.4)
- d. Understand the role of the reticuloendothelial system
- e. Lymphocytic system
 1. Know the immune function of the B-cell system
 2. Know the immune function of the T-cell system
 3. Know the immune function of the immunoglobulins
- f. Platelets
 1. Know that activated platelets produce the vasoconstrictor thromboxane A₂
 2. Understand the role of platelets in the immune system
- g. Humoral immune/inflammatory system
 1. Understand the role of the complement system
 2. Know that the membrane lipids are a source for eicosanoids and platelet-activating factor
 3. Know the lipid-derived mediators of inflammation and their effects
 4. Understand the role of cytokines in inflammation
 5. Understand the role of oxyradicals in inflammation
 6. Understand the role of nitric oxide in inflammation
 7. Understand the role of adhesive glycoproteins in inflammation
 8. Know the signs of inflammation
 9. Understand the role of cytokines in stimulating leukocyte growth
2. Immune dysfunction
 - a. General
 1. Recognize manifestations of dysfunction of the several components of the normal immune system
 2. Know how to evaluate a patient for specific immune deficiencies
 - b. Iatrogenic
 1. Know iatrogenic causes of immune system dysfunction including anesthetic agents, trauma, and surgery
 - c. Nutritional
 1. Recognize the relationship between malnutrition and immune dysfunction
 - d. Infectious immune depression
 1. Recognize the patient at risk for immune suppression secondary to an infectious disease
 - e. Integument
 1. Know the pathogens that typically infect defective or injured integument
 2. Know the life-threatening complications of skin infection

- f. Endothelial barriers
 1. Recognize endothelial barrier failure as a possible cause of sepsis
 2. Recognize gastrointestinal endothelial injury/translocation as a cause of sepsis/inflammation
- g. B-cell system/immunoglobulins
 1. Recognize the manifestations of B-cell dysfunction in an acutely ill patient
 2. Identify the pathogens to which a patient with B-cell deficiency is susceptible
 3. Identify the disorders associated with B-cell deficiency
 4. Recognize immunoglobulin deficiency
- h. T-cell system
 1. Identify the pathogens to which a patient with T-cell deficiency is susceptible
 2. Recognize the manifestations of severe combined immunodeficiency syndrome
 3. Identify the disorders associated with T-cell deficiency
- i. Phagocytic system
 1. Recognize the manifestations of dysfunctional or deficient phagocytosis in an acutely ill patient
 2. Identify the pathogens to which a patient with defective or deficient phagocytosis is susceptible
 3. Recognize the clinical features of chronic granulomatous disease
 4. Identify the pathogens to which patients with chronic granulomatous disease are particularly susceptible
 5. Identify the disorders associated with phagocytic system dysfunction
 6. Understand the pathogenesis of chronic granulomatous disease
- j. Complement system
 1. Recognize the manifestations of deficient complement activity
- k. Reticuloendothelial system
 1. Recognize the manifestations of dysfunction of the reticuloendothelial system in an acutely ill patient
 2. Identify the pathogens to which a child with defective or deficient reticuloendothelial function is susceptible
 3. Know the disorders that cause defective or deficient reticuloendothelial function
- l. Acquired immunodeficiency syndrome (AIDS)
 1. Pathophysiology
 - a. Understand the pathophysiology of AIDS
 2. Clinical course
 - a. Know the natural history of pediatric AIDS
 - b. Know the natural history of congenital infection with HIV type 1
 - c. Understand how human immunodeficiency virus (HIV) is acquired
 3. Diagnosis
 - a. Recognize the common clinical presentations of HIV type 1 infection in children
 - b. Understand the interpretation of laboratory tests used in the diagnosis of HIV type 1 infection
 4. Life-threatening complications
 - a. Recognize the manifestations of life-threatening complications of AIDS

- b. Identify the bacterial pathogens to which a child with AIDS is particularly susceptible
 - c. Know the common causes of respiratory failure in a child with AIDS
 - d. Identify the viral pathogens to which a child with AIDS is particularly susceptible
 - e. Identify the other pathogens (not viral or bacterial) to which a child with AIDS is particularly susceptible
 - 5. Treatment
 - a. Plan appropriate management for critically ill patients with AIDS
 - b. Know the potentially life-threatening complications of antiretroviral therapy
 - 6. Risk factors
 - a. Plan appropriate procedures and techniques to minimize exposure of hospital staff to the risk of acquiring HIV infection from patients
 - b. Know which factors increase the risk of acquired HIV infection
- B. Specific disorders
 - 1. Central nervous system infections (see also III.C.3)
 - a. General
 - 1. Differentiate the types of meningeal infection by clinical and laboratory features
 - 2. Differentiate among the manifestations of meningitis, encephalitis, and encephalopathy
 - 3. Know the major causes of central nervous system bacterial infections and the predominant patient age-groups with which they are associated
 - 4. Understand the penetrance of antimicrobial drugs into the cerebrospinal fluid compartment
 - b. Meningitis
 - 1. Understand the pathogenesis and pathophysiology of meningitis
 - 2. Know the clinical course of untreated, partially treated, and treated meningitis
 - 3. Recognize the manifestations of life-threatening complications of bacterial meningitis
 - 4. Know the appropriate interventions for the life-threatening complications of bacterial meningitis
 - 5. Plan appropriate medical treatment for a patient with suspected bacterial meningitis
 - 6. Plan appropriate comprehensive therapy for a patient with proven bacterial meningitis
 - 7. Judge the efficacy of treatment for bacterial meningitis
 - 8. Know the bacterial agents that cause epidemics of meningitis and the circumstances with which they are associated
 - 9. Know the prognosis and long-term sequelae of bacterial meningitis
 - 10. Know the prognosis and long-term sequelae of viral meningitis
 - 11. Know drug prophylaxis against *Neisseria meningitidis*
 - 12. Understand the impact of immunization on childhood meningitis
 - 13. Know the common viral etiologies of meningitis
 - 14. Plan the management of a child with severe viral meningitis
 - c. Encephalitis

1. Understand the pathogenesis and pathophysiology of encephalitis
 2. Know the clinical manifestations of encephalitis
 3. Know the clinical course of encephalitis
 4. Differentiate among the various types of encephalitis by clinical and laboratory features
 5. Recognize the manifestations of life-threatening complications of encephalitis
 6. Know the appropriate interventions for the life-threatening complications of encephalitis
 7. Plan appropriate medical treatment for a patient with encephalitis
 8. Know the CSF findings associated with herpes encephalitis
 9. Know the common viral etiologies of encephalitis
 10. Know the appropriate diagnostic testing for suspected herpes encephalitis
- d. Brain abscess
 1. Plan appropriate treatment for a patient with a brain abscess
 2. Recognize the causes of brain abscess, including right-to-left shunt, otitis media, sinusitis, and penetrating trauma
 3. Understand the pathogenesis and pathophysiology of brain abscess
 4. Know the clinical manifestations of brain abscess
 5. Know the clinical course of brain abscess
 6. Recognize the manifestations of life-threatening complications of brain abscess
 7. Know the appropriate interventions for the life-threatening complications of brain abscess
 8. Know the common bacterial etiologies of brain abscess
 - e. Fungal infection
 1. Recognize the clinical signs and symptoms and laboratory findings characteristic of fungal central nervous system infections
 2. Plan the treatment for a patient with a fungal central nervous system infection
 3. Know the factors associated with an increased risk of fungal central nervous system infection
 - f. Parasitic infection
 1. Recognize the clinical and laboratory findings characteristic of parasitic central nervous system infection
 2. Plan the treatment for a patient with a parasitic central nervous system infection
 3. Know the factors associated with an increased risk for parasitic central nervous system infection
2. Parenchymal pulmonary infections
 - a. Bacterial
 1. Identify the most likely bacterial etiologies of pneumonia in children of various ages
 2. Identify the most likely bacterial etiologies of pneumonia in children with immune dysfunction
 3. Identify the most likely bacterial etiologies of nosocomially acquired pneumonia
 4. Evaluate a patient with bacterial pneumonia to determine etiology and appropriate treatment
 5. Recognize the life-threatening complications of bacterial pneumonia

6. Know the appropriate therapy for bacterial pneumonia in children of various ages and with various underlying disease
 7. Differentiate between pneumonia and bacterial colonization in an intubated patient or a patient with a tracheostomy
 8. Evaluate a patient with pulmonary abscess to determine etiology and appropriate treatment
 9. Evaluate a patient with pleural space empyema to determine etiology and appropriate treatment
 10. Evaluate a patient with ventilator-associated pneumonia to determine etiology and appropriate treatment
- b. Viral
1. Know the epidemiologic mode of transmission of respiratory syncytial virus
 2. Identify the most likely viral etiologies of pneumonia in children of various ages
 3. Understand the pathophysiology and pathogenesis of viral pneumonia
 4. Know the clinical and laboratory manifestations of viral pneumonia
 5. Know the clinical course of viral pneumonia
 6. Differentiate among the various types of viral pneumonia using clinical and laboratory findings
 7. Recognize the life-threatening complications of viral pneumonia
 8. Know the subgroups of patients at high risk for the life-threatening complications of respiratory syncytial virus
 9. Know the isolation procedures for respiratory viral infections in the intensive care unit
 10. Know the specific pharmacologic therapies for viral pneumonias
 11. Know the indications for prophylaxis against respiratory syncytial virus
- c. Fungal and opportunistic organisms
1. Understand the pathogenesis and pathophysiology of fungal and opportunistic pneumonias
 2. Recognize the clinical manifestations of fungal and opportunistic pneumonias
 3. Know the clinical course of fungal and opportunistic pneumonias
 4. Plan the appropriate evaluation of a child with suspected fungal or opportunistic pneumonia
 5. Recognize the life-threatening sequelae of fungal or opportunistic pneumonias
 6. Know the appropriate therapy for a child with fungal or opportunistic pneumonia
 7. Recognize a patient at risk for fungal or opportunistic infection
3. Sepsis
- a. Multiple organ system failure
1. Understand the relation of sepsis and perfusion failure to the development of multiple organ system failure
 2. Know the pathogenesis and pathophysiology of myocardial dysfunction in a child with multiple organ system failure due to sepsis
 3. Understand the treatment of the failing heart in a child with multiple organ system failure

4. Understand the general principles of support for a patient with multiple organ system failure
5. Understand the use of clinical scoring systems in predicting outcome of groups of patients with multiple organ system failure
6. Recognize that hypermetabolism is a key component of septic shock and multiple organ failure
- b. Bacterial
 1. Know the etiology and pathogenesis of bacterial sepsis in children of various ages
 2. Understand the pathophysiologic response to bacterial sepsis
 3. Know the clinical manifestations and course of bacterial sepsis
 4. Distinguish among possible etiologic agents causing sepsis on the basis of clinical and laboratory features
 5. Recognize the manifestations of life-threatening complications of bacterial sepsis
 6. Plan appropriate therapy for a child with bacterial sepsis
 7. Understand the role of teichoic acid in gram-positive sepsis
 8. Understand the role of endotoxin in gram-negative sepsis
- c. Viral
 1. Understand the pathogenesis and pathophysiology of disseminated viral infection with shock
 2. Recognize the clinical manifestations of disseminated viral infection with shock
 3. Differentiate among the disseminated viral infections that cause shock in infants and children
 4. Recognize the life-threatening complications of disseminated viral infection with shock
 5. Know the specific pharmacologic treatments of disseminated viral infections
 6. Recognize the clinical manifestations of viral hemorrhagic fevers
4. Systemic inflammatory response syndrome (SIRS)
 - a. Recognize the relationship of multiple organ system failure with activation of the systemic inflammatory response syndrome
 - b. Understand the concept of the systemic inflammatory response syndrome
 - c. Understand the role of innate immunity in the development of the systemic inflammatory response syndrome
5. Infection-associated syndromes
 - a. Toxic shock syndrome
 1. Know the etiology of toxic shock syndrome
 2. Recognize the manifestations of streptococcal and staphylococcal toxic shock syndrome
 3. Know the diagnostic clinical and laboratory features of toxic shock syndrome
 4. Recognize the manifestations of the life-threatening complications of toxic shock syndrome
 5. Plan management for a patient with toxic shock syndrome
 6. Judge the efficacy of therapy for toxic shock syndrome
 7. Recognize the risk factors associated with staphylococcal and streptococcal toxic shock syndrome

8. Understand the pathophysiologic mechanisms involved in superantigen stimulation of the T cell receptor
- b. Kawasaki disease
 1. Understand the pathophysiology of myocardial dysfunction in Kawasaki disease
 2. Recognize typical and atypical Kawasaki disease by its clinical and diagnostic features
 3. Know the life-threatening sequelae of Kawasaki disease
 4. Plan treatment for a patient with Kawasaki disease
 5. Plan the evaluation of a patient with atypical Kawasaki disease
- c. Rheumatic fever
 1. Know the pathogenesis and pathophysiology of rheumatic fever
 2. Recognize acute rheumatic fever as a cause of cardiac dysfunction in children
 3. Recognize the patient at risk for the life-threatening complications of rheumatic fever
 4. Know the association of rheumatic fever and bacterial endocarditis
- d. Hemorrhagic shock encephalopathy
 1. Understand the pathophysiology of hemorrhagic shock encephalopathy
 2. Plan treatment for a patient with hemorrhagic shock encephalopathy
- e. Rocky Mountain spotted fever
 1. Understand the pathophysiology of Rocky Mountain spotted fever
 2. Know the clinical features and manifestations of Rocky Mountain spotted fever
 3. Plan treatment for a patient with Rocky Mountain spotted fever
- f. Ehrlichiosis
 1. Understand the pathophysiology of ehrlichiosis
 2. Know the clinical features and manifestations of human monocytic versus granulocytic ehrlichiosis
- g. Parasitic infections
 1. Recognize the clinical features and manifestations of severe parasitic infection, including malaria, amebiasis, and toxoplasmosis
 2. Plan the treatment for a patient with parasitic infection
6. Other infections encountered in the PICU
 - a. Urosepsis pyelonephritis
 1. Understand the pathophysiology and clinical features of pyelonephritis
 2. Plan the management of a patient with pyelonephritis
 - b. Peritonitis, abdominal abscess
 1. Understand the pathophysiology and clinical features of peritonitis and abdominal abscess
 2. Plan the management of a patient with peritonitis and abdominal abscess
 - c. Necrotizing fasciitis
 1. Understand the pathophysiology and clinical features of necrotizing fasciitis and myonecrosis
 2. Plan the management of a patient with necrotizing fasciitis and myonecrosis
 3. Know the prognosis for patients with necrotizing fasciitis and myonecrosis
 - d. Lemierre syndrome
 1. Understand the pathophysiology and clinical features of Lemierre syndrome

2. Plan the management of a patient with Lemierre syndrome
- e. Viral-associated hemophagocytic syndrome
 1. Recognize the clinical manifestation of viral-associated hemophagocytic syndrome
 2. Plan the evaluation of a patient with viral-associated hemophagocytic syndrome
- f. Methicillin-resistant staphylococcus aureus infection
 1. Recognize the risk factors for methicillin-resistant staphylococcus aureus (MRSA) colonization and invasive infection
 2. Plan the evaluation and treatment of a patient with possible MRSA infection
- g. Mediastinitis
 1. Understand the pathophysiology and clinical features of mediastinitis
 2. Plan the management of a patient with mediastinitis
- h. Sinusitis
 1. Understand the pathophysiology and clinical features of sinusitis
 2. Plan the management of a patient with sinusitis
7. Opportunistic infection and immunodeficiency
 - a. Oncology patient
 1. Recognize the oncology patient at risk for opportunistic infection
 2. Know the natural history of opportunistic infection in the oncology patient
 3. Plan appropriate evaluation for suspected opportunistic infection in an oncology patient
 4. Plan appropriate therapy for suspected opportunistic infection in the oncology patient
 - b. Hematopoietic stem cell transplant patient (see also VII.C)
 1. Recognize the hematopoietic stem cell transplant patient at risk for opportunistic infection
 2. Know the natural history of opportunistic infection in a hematopoietic stem cell transplant patient
 3. Plan appropriate evaluation for suspected opportunistic infection in a hematopoietic stem cell transplant patient
 4. Plan appropriate therapy for suspected opportunistic infection in a hematopoietic stem cell transplant patient
 5. Identify the pathogens to which the hematopoietic stem cell transplant recipient is especially susceptible
 - c. Solid organ transplant recipient
 1. Recognize the solid organ transplant recipient at risk for opportunistic infection
 2. Know the natural history of opportunistic infection in a solid organ transplant recipient
 3. Plan appropriate evaluation for suspected opportunistic infection in a solid organ transplant recipient
 4. Plan appropriate therapy for suspected opportunistic infection in a solid organ transplant recipient
 5. Identify the pathogens to which a solid organ transplant recipient is particularly susceptible
 6. Recognize the common infectious complications of solid organ transplantation
 - d. Immunosuppressive effects of drug therapy

1. Recognize the infectious complications of immunosuppressive therapy
- e. Infectious agents
 1. Cytomegalovirus
 - a. Recognize the life-threatening manifestations of cytomegalovirus infection in the immunodeficient patient
 - b. Plan appropriate therapy for the life-threatening manifestations of cytomegalovirus infection
 2. Herpesvirus
 - a. Recognize the life-threatening manifestations of herpesvirus infection in the neonate
 - b. Plan appropriate therapy for the life-threatening manifestations of herpesvirus infection
 3. Varicella
 - a. Recognize varicella as an important opportunistic pathogen in the immunosuppressed patient
 - b. Know the available therapy for varicella infection in the immunocompromised patient
 - c. Recognize that nonimmune ICU contacts of the varicella patient may be protected by administration of zoster immune globulin
 - d. Recognize the life-threatening manifestations of varicella infection
 - e. Plan appropriate therapy for the life-threatening manifestations of varicella infection
 4. Pneumocystis jirovecii
 - a. Recognize Pneumocystis jirovecii as an important opportunistic pathogen in AIDS and immunosuppressed patients
 - b. Plan the appropriate evaluation of a patient with suspected Pneumocystis jirovecii infection
 - c. Recognize the life-threatening manifestations of Pneumocystis jirovecii infection
 - d. Plan appropriate therapy for the life-threatening manifestations of Pneumocystis jirovecii infection
 - e. Plan appropriate treatment for a patient with Pneumocystis jirovecii infection
 5. Epstein-Barr virus
 - a. Recognize Epstein-Barr virus as a potential pathogen in the immunosuppressed or immunocompromised patient
 - b. Recognize the life-threatening manifestations of Epstein-Barr virus infection
 - c. Plan appropriate therapy for the life-threatening manifestations of Epstein-Barr virus infection
 6. Aspergillus
 - a. Recognize the common manifestations of allergic bronchopulmonary aspergillosis
 - b. Recognize the common clinical manifestations of invasive Aspergillus infection
 - c. Plan treatment for a patient with Aspergillus infection
8. Infectious complications of invasive monitoring

- a. Foley catheter
 - 1. Understand the natural history of infectious complications associated with the use of a Foley catheter
 - 2. Know the appropriate evaluation for suspected infectious complications associated with the use of a Foley catheter
 - 3. Know the appropriate treatment for infectious complications associated with the use of a Foley catheter
 - b. Endotracheal tube (see also XIII.A.1)
 - 1. Sinusitis
 - a. Recognize the relationship between nasotracheal intubation and sinusitis
 - 2. Otitis
 - a. Recognize the relationship between endotracheal intubation and otitis
 - 3. Pneumonia
 - a. Recognize ventilator-associated pneumonia as a potential complication of intubation
 - b. Know the pathogenesis of ventilator-associated pneumonia in a patient receiving mechanical ventilation
 - c. Know how to diagnose ventilator-associated pneumonia in a patient receiving mechanical ventilation
 - d. Plan appropriate therapy for a patient receiving mechanical ventilation who has suspected ventilator-associated pneumonia
 - e. Know the strategies to decrease the incidence of ventilator-associated pneumonia in a patient receiving mechanical ventilation
 - c. Vascular catheter (see also XIII.B)
 - 1. Know the strategies to decrease the incidence of bacterial infections associated with the use of vascular catheters
 - 2. Recognize the manifestations of infectious complications associated with the use of vascular catheters
 - 3. Know the diagnostic features of vascular catheter infection
 - 4. Plan management for the infectious complications associated with the use of vascular catheters
 - d. Intracranial catheters and pressure monitors (see also XIV.B.6)
 - 1. Know the strategies to decrease the incidence of infectious complications resulting from devices used to measure intracranial pressure
 - 2. Know the appropriate evaluation for suspected infectious complications resulting from devices used to measure intracranial pressure
 - 3. Know the appropriate treatment of infectious complications resulting from devices used to measure intracranial pressure
 - 4. Plan the management of the infectious complications associated with the use of indwelling ventricular drainage catheters
- C. Isolation techniques
- 1. Universal precautions
 - a. Understand the rationale for universal precaution isolation techniques
 - 2. Specific isolation precautions
 - a. Differentiate key procedures that characterize isolation protocols for herpesvirus infections

- b. Know the key procedures that characterize isolation protocols for varicella infections
 - c. Know the key procedures that characterize isolation protocols for cytomegalovirus infections
 - d. Know the key procedures that characterize isolation protocols for hepatitis and enteric viral infections
 - e. Know the key procedures that characterize isolation protocols for meningitis infections
 - f. Know the key procedures that characterize isolation protocols for tuberculosis
 - g. Know the key procedures that characterize isolation protocols for wound and skin infections
 - h. Know the key procedures that characterize isolation protocols for respiratory infections
 - i. Know the means of transmission for common pathogens
3. Reverse isolation
- a. Understand the rationale for the reverse isolation technique
 - b. Know the features of protective isolation
- D. Collagen vascular disease
1. Systemic lupus erythematosus
- a. Know the pathophysiology and pathogenesis of systemic lupus erythematosus
 - b. Know the clinical features and clinical course of systemic lupus erythematosus
 - c. Know the diagnostic clinical and laboratory features of systemic lupus erythematosus
 - d. Recognize the manifestations of life-threatening complications of systemic lupus erythematosus
 - e. Plan treatment for the life-threatening manifestations of systemic lupus erythematosus
 - f. Recognize that macrophage activation syndrome can complicate systemic lupus erythematosus
2. Juvenile rheumatoid (idiopathic) arthritis
- a. Recognize the manifestations and life-threatening complications of juvenile rheumatoid (idiopathic) arthritis
 - b. Know signs and symptoms of macrophage activation syndrome and laboratory evaluation
3. Dermatomyositis
- a. Recognize the manifestations and life-threatening complications of dermatomyositis
 - b. Know the laboratory findings associated with dermatomyositis
4. Vasculitis
- a. Understand the pathogenesis and pathophysiology of the different types of vasculitis
 - b. Know how to investigate the etiology of the different types of vasculitis
 - c. Know the medical therapy for the different types of vasculitis
- E. Anaphylaxis
- 1. Know the natural history of anaphylaxis
 - 2. Recognize the manifestations of anaphylaxis

3. Plan appropriate therapy for the life-threatening complications of anaphylaxis
 4. Recognize the causes of anaphylaxis
 5. Understand the pathophysiology of anaphylaxis
- F. Antimicrobials
1. Sensitivities
 - a. Know the clinical significance of the laboratory determination of infectious agent susceptibility to antimicrobial/antifungal drugs
 - b. Understand the use of serum concentration determinations in planning antimicrobial treatment regimens
 - c. Plan appropriate therapy for infection with beta-lactamase producing, coagulase-negative staphylococci
 - d. Know the characteristics and spectrum of activity of aminoglycoside antibiotics
 - e. Know the characteristics and spectrum of activity of commonly used cephalosporins
 - f. Know the characteristics and spectrum of activity of semisynthetic penicillins
 - g. Know the characteristics and spectrum of activity of the macrolide antibiotics
 - h. Know the characteristics, spectrum of activity, and appropriate use of vancomycin
 - i. Know the characteristics and spectrum of activity of carbapenems and monobactams
 - j. Know the characteristics and spectrum of activity of quinolones
 - k. Know the characteristics and spectrum of activity of the different classes of commonly used antifungal agents
 - l. Understand the principles behind the choice of antimicrobials
 - m. Understand the principles behind combining antimicrobials
 - n. Understand the concept of emerging resistance to antibiotics
 - o. Know the characteristics and spectrum of activity of the different classes of commonly used antiviral agents
 - p. Know the characteristics and spectrum of activity of the different classes of commonly used antiparasitic agents
 2. Metabolism and excretion
 - a. Understand the particular problems associated with the use of hepatically metabolized and renally excreted antimicrobial/ antifungal drugs (including antibacterials/antifungals/antivirals/ antiparasitics) in critically ill patients
 3. Mode of action
 - a. Understand the relationship between antimicrobial (including antibacterial/antifungal/antiviral/antiparasitic) drug penetration into tissues and efficacy in critically ill patients
 4. Adverse effects
 - a. Know the adverse effects associated with commonly used antibiotics
 - b. Recognize the manifestations of adverse effects associated with the use of aminoglycoside antibiotics in critically ill children
 - c. Recognize the manifestations of adverse effects associated with the use of common cephalosporins in critically ill children
 - d. Recognize the manifestations of adverse effects associated with the use of semisynthetic penicillins in critically ill children

- e. Recognize the manifestations of adverse effects associated with the use of the macrolide antibiotics in critically ill children
- f. Recognize the manifestations of adverse effects associated with the use of vancomycin in critically ill children
- g. Recognize the manifestations of adverse effects associated with the use of carbapenems and monobactams in critically ill children
- h. Recognize the manifestations of adverse effects associated with the use of quinolones in critically ill children
- i. Recognize the manifestations of adverse effects associated with the use of the different classes of common antifungal agents in critically ill children
- j. Recognize the manifestations of adverse effects associated with the use of the different classes of common antiviral drugs in critically ill children
- k. Recognize the manifestations of adverse effects associated with the use of the different classes of common antiparasitic drugs in critically ill children

5. Renal and Electrolytes

A. Structure and function

- 1. Anatomy
 - a. Know the anatomy of the circulation of the kidneys
 - b. Know the structure and function of the nephron
- 2. Physiologic principles
 - a. Know how to estimate excretion and clearance of endogenous waste products
 - b. Understand the concept of renal clearance
 - c. Understand the developmental changes in glomerular filtration rate during the first year after birth
 - d. Know the clinical factors that modulate glomerular filtration rate
 - e. Know the mechanisms of glomerular injury
 - f. Know the mechanisms of tubular injury
- 3. Renal circulation
 - a. Understand the factors that control renal vascular resistance, renal blood flow, and glomerular filtration rate
 - b. Know the effects of vasoactive drugs on renal vascular resistance, renal blood flow, and glomerular filtration rate
 - c. Understand neural influences on renal blood flow
 - d. Understand local humoral influences on renal blood flow
- 4. Hormone effects
 - a. Know the effects of circulating hormones on renal function
 - b. Know the effect of endogenous and synthetic natriuretic hormones on renal function
 - c. Know which conditions are associated with release of atrial natriuretic hormone
 - d. Know the effects of vasopressin on renal function
 - e. Know the effects of parathyroid hormone on the kidney
- 5. Assessment
 - a. Interpret the results of urinalysis (chemistry, microscopic)
 - b. Know appropriate radiologic evaluation of renal function
 - c. Understand how to calculate creatinine clearance and how it is used in the assessment of renal function

- d. Calculate serum osmolarity
 - e. Calculate and interpret fractional excretion of sodium
 - f. Calculate and interpret fractional excretion of urea
- B. Fluid and electrolyte balance
- 1. General
 - a. Understand the effects of diarrhea on fluid balance
 - b. Understand the effects of diuretics on fluid and electrolyte balance
 - c. Interpret serum electrolyte concentrations and identify sources of error
 - 2. Electrolyte disorders
 - a. Hyperkalemia
 - 1. Understand the pathogenesis of hyperkalemia in renal failure
 - 2. Recognize hyperkalemia as a manifestation of adrenal insufficiency
 - 3. Understand the effects of hyperkalemia on the heart
 - 4. Recognize the clinical, laboratory, and electrocardiographic manifestations of hyperkalemia
 - 5. Plan appropriate management for a patient with life-threatening hyperkalemia
 - 6. Understand the association of acidosis and hyperkalemia
 - b. Hypokalemia
 - 1. Recognize the clinical, laboratory, and electrocardiographic manifestations of severe hypokalemia
 - 2. Understand the relation of hypokalemia to alkalosis
 - 3. Recognize the implications of hypokalemia in the patient treated with digoxin
 - 4. Plan appropriate therapy for the life-threatening complications of hypokalemia
 - 5. Know the normal requirement for potassium and the principles of potassium replacement therapy
 - 6. Know causes of hypokalemia without total body potassium deficit
 - 7. Know causes of hypokalemia with associated total body potassium deficit
 - c. Hypercalcemia
 - 1. Understand the various causes of hypercalcemia
 - 2. Know the clinical, laboratory, and electrocardiographic manifestations of hypercalcemia
 - 3. Plan appropriate therapy for a patient with severe hypercalcemia
 - d. Hypocalcemia
 - 1. Understand the physiologic effects of hypocalcemia
 - 2. Recognize the clinical, laboratory, and electrocardiographic manifestations of hypocalcemia
 - 3. Understand the relation of ionized calcium to total calcium and the significance of ionized hypocalcemia
 - 4. Understand the interaction of calcium and phosphate, and the relation of hypocalcemia to hyperphosphatemia
 - 5. Plan appropriate therapy for complications of hypocalcemia
 - 6. Distinguish among the causes of hypocalcemia
 - e. Hyponatremia
 - 1. Recognize diabetes insipidus as a cause of hyponatremia
 - 2. Recognize salt poisoning as a cause of hyponatremia

3. Recognize water loss as an iatrogenic cause of hypernatremia as in therapy with mannitol, sorbitol, lactulose, etc
4. Recognize the occurrence of hypernatremia in diarrheal dehydration
5. Recognize the clinical manifestations of hypernatremia
6. Recognize the life-threatening complications of hypernatremia, including subdural hemorrhage
7. Plan appropriate treatment of hypernatremia
8. Understand the complications of rapid correction of hypernatremia
- f. Hyponatremia (see also VI.D.2/3)
 1. Distinguish hyponatremia caused by water intoxication from inappropriate secretion of antidiuretic hormone
 2. Recognize the manifestations of life-threatening hyponatremia
 3. Recognize the iatrogenic causes of hyponatremia
 4. Understand the complications of rapid correction of hyponatremia
 5. Know causes of hyponatremia with decreased total body sodium
 6. Know causes of hyponatremia with normal total body sodium
 7. Know causes of hyponatremia with increased total body sodium
 8. Plan treatment for a patient with hyponatremia
- g. Disorders of magnesium homeostasis
 1. Recognize the manifestations of hypomagnesemia
 2. Know the causes of hypomagnesemia
 3. Know the causes of hypermagnesemia
 4. Recognize the manifestations of hypermagnesemia
 5. Plan treatment for a patient with hypomagnesemia
 6. Plan treatment for a patient with hypermagnesemia
- h. Disorders of phosphorus homeostasis
 1. Know the causes of hypophosphatemia
 2. Know the causes of hyperphosphatemia
 3. Recognize the clinical signs of hypophosphatemia
 4. Plan treatment for a patient with hypophosphatemia
 5. Plan treatment for a patient with hyperphosphatemia
 6. Recognize the clinical signs of hyperphosphatemia
3. Dehydration
 - a. Understand the pathophysiology of water and electrolyte loss that occur in severe dehydration in infants and children
 - b. Recognize the manifestations and life-threatening complications of severe dehydration
 - c. Plan management for a child with severe dehydration
 - d. Recognize that vascular volume expansion is the first priority in dehydration with shock and know how to accomplish it
 - e. Know the mechanisms and sites for water absorption
 - f. Calculate free water replacement in a patient with hypernatremic dehydration
4. Acid-base balance (see also II.B.9)
 - a. Acid-base
 1. Know the role of the kidney in acid-base balance

2. Distinguish disorders of acid-base homeostasis, including primary, compensatory, and mixed disturbances
 3. Know the management of acid-base disorders
 - b. Acidosis
 1. Understand the mechanisms of lactic acidosis
 2. Understand the consequences of acidosis and hypoglycemia
 3. Distinguish between causes of metabolic acidosis
 4. Understand the difference between anion- and nonanion-gap metabolic acidosis
 - c. Alkalosis
 1. Know how to treat metabolic alkalosis
 2. Know the causes of metabolic alkalosis
- C. Renal failure
1. General
 - a. Know the life-threatening complications of acute kidney injury
 - b. Understand the implications of fractional excretion of sodium in categorizing renal failure as pre-, intra-, or post-renal
 - c. Understand that creatinine and urine output are used in categorizing renal function according to RIFLE criteria
 - d. Recognize the clinical manifestations of hepatorenal syndrome
 - e. Plan fluid management for a patient with renal failure
 2. Disorders of renal circulation
 - a. Vascular disease
 1. Understand the pathophysiologic response to alterations in renal blood flow that occur during renal vascular disease
 - b. Ischemia
 1. Prerenal azotemia
 - a. Distinguish the clinical and laboratory manifestations of prerenal azotemia from those of renal parenchymal disease
 - b. Understand the pathophysiology of oliguria in a child with prerenal azotemia
 - c. Plan treatment for a patient with prerenal azotemia
 2. Acute tubular necrosis
 - a. Understand the pathophysiology of acute tubular necrosis secondary to shock
 - b. Understand the principles of treatment of renal failure in the context of circulatory shock
 - c. Recognize the clinical and laboratory manifestations of acute tubular necrosis
 - d. Recognize the patient at risk for acute tubular necrosis
 - e. Know the natural history of acute tubular necrosis
 - f. Recognize the life-threatening complications of acute tubular necrosis
 - g. Plan treatment for a patient with acute tubular necrosis
 3. Acute cortical necrosis
 - a. Understand the pathogenesis and pathophysiology of acute cortical necrosis of the kidney
 - b. Know the clinical course of acute cortical necrosis of the kidney

- c. Renal vein thrombosis
 - 1. Understand the pathogenesis and pathophysiology of renal vein thrombosis
 - 2. Recognize the clinical and laboratory manifestations of renal vein thrombosis
 - 3. Plan treatment for a patient with renal vein thrombosis
- d. Abdominal compartment syndrome (see also X.B.6.)
 - 1. Understand the pathogenesis of abdominal compartment syndrome in children
 - 2. Recognize renal failure caused by abdominal compartment syndrome
 - 3. Plan treatment for renal failure caused by abdominal compartment syndrome
- 3. Glomerulonephritis
 - a. Differentiate acute glomerulonephritis from other causes of renal failure on the basis of its clinical and laboratory features
 - b. Understand the pathogenesis and pathophysiology of glomerulonephritis
 - c. Know the causes of glomerulonephritis
 - d. Recognize the manifestations and life-threatening complications of glomerulonephritis
 - e. Plan treatment for a patient with glomerulonephritis
- 4. Nephrotic syndrome
 - a. Know the pathogenesis and pathophysiology of nephrotic syndrome
 - b. Recognize the clinical manifestations and life-threatening complications of nephrotic syndrome
 - c. Plan treatment for the life-threatening complications of nephrotic syndrome
- 5. Hemolytic-uremic syndrome
 - a. Know the pathogenesis and pathophysiology of hemolytic-uremic syndrome
 - b. Know the features and clinical course of hemolytic-uremic syndrome
 - c. Recognize the manifestations and life-threatening complications of hemolytic-uremic syndrome
 - d. Plan treatment for a patient with hemolytic-uremic syndrome
 - e. Know the infectious causes of hemolytic-uremic syndromes
 - f. Recognize non-infectious hemolytic-uremic syndrome
 - g. Know the long-term complications associated with hemolytic-uremic syndrome
- 6. Aplasia/dysplasia
 - a. Understand the clinical course of renal failure and hypertension in renal dysplasia
 - b. Recognize the manifestations of severe renal aplasia/dysplasia in the newborn infant
- 7. Toxic
 - a. Recognize the manifestations of drug-induced acute kidney injury
 - b. Recognize tumor lysis syndrome
 - c. Plan treatment for a patient with pigment nephropathy
 - d. Understand the mechanisms of NSAID-induced renal dysfunction
 - e. Plan the management of a patient with tumor lysis syndrome
 - f. Recognize renal toxicity associated with calcineurin inhibitors
 - g. Recognize renal failure from acetaminophen toxicity
- 8. Obstructive
 - a. Recognize the manifestations of renal failure secondary to severe urethral obstruction
 - b. Know the causes of urinary tract obstruction

D. Renal replacement therapy

1. Hemodialysis
 - a. Recognize the complications of hemodialysis
 - b. Know the appropriate clinical application for hemodialysis in a patient with renal failure
 - c. Know the (relative) contraindications to hemodialysis
 - d. Understand how hemodialysis affects the clearance of medications
2. Peritoneal dialysis
 - a. Recognize the complications of peritoneal dialysis
 - b. Recognize the respiratory/gas exchange complications of peritoneal dialysis
 - c. Know the appropriate clinical application for peritoneal dialysis in a patient with renal failure
 - d. Know the (relative) contraindications to peritoneal dialysis
 - e. Understand how peritoneal dialysis affects the clearance of medications
3. Continuous renal replacement therapy
 - a. Recognize the complications of continuous renal replacement therapy
 - b. Know the appropriate clinical application for continuous renal replacement therapy
 - c. Understand the principles of water and electrolyte balance in a patient undergoing continuous renal replacement therapy
 - d. Understand how continuous renal replacement therapies affect the clearance of medications

E. Hypertension

1. Pathophysiology
 - a. Understand neural influences on systemic blood pressure
 - b. Understand humoral regulation of blood pressure
 - c. Understand the developmental changes in systemic blood pressure
 - d. Understand the pathophysiology of systemic hypertension
 - e. Recognize the effect of acute and chronic hypertension on cerebral autoregulation
 - f. Know the acute and chronic renal disorders associated with hypertension
 - g. Know which tumors are associated with hypertension
 - h. Know the endocrine causes of hypertension
 - i. Know which drugs can cause hypertension
2. Clinical course
 - a. Know the clinical course of hypertension in the disorders that cause it
3. Diagnosis
 - a. Know how to evaluate the etiology and severity of hypertension in infants and children
4. Complications
 - a. Recognize the manifestations and life-threatening complications of acute hypertension
 - b. Recognize the manifestations and life-threatening complications of acute exacerbation of long-standing hypertension
 - c. Recognize hypertensive encephalopathy
5. Treatment
 - a. Understand the normal mechanisms for blood pressure control
 - b. Plan medical therapy for a patient with systemic hypertension

- c. Plan initial therapy for a patient with acute severe hypertension
- d. Plan the management of hypertension in a child with chronic renal disease
- e. Know the mechanism of action of commonly used antihypertensive drugs
- f. Know contraindications to the use of antihypertensive drugs
- g. Know the adverse effects and toxicities associated with the use of various antihypertensive agents

F. Renal transplantation

- 1. Differentiate among the causes of acute renal failure following renal transplantation
- 2. Understand the concepts of fluid management following renal transplantation
- 3. Recognize the life-threatening complications that may occur following renal transplantation

6. **Metabolism and Endocrinology**

A. Adrenal

1. Steroid function

- a. Know the classes of steroids synthesized by the adrenal cortex and their function
- b. Understand the mechanisms of steroid action in the cardiovascular system
- c. Understand the mechanisms of steroid action in the immune system
- d. Understand the mechanisms of steroid action in the endocrine system
- e. Know the genetic or acquired abnormalities of steroid biosynthesis resulting in critical illness
- f. Understand the mechanisms of steroid action in the central nervous system

2. Adrenal insufficiency

a. Acquired adrenal insufficiency

1. Pathophysiology

- a. Understand the pathogenesis and pathophysiology of acquired adrenal insufficiency
- b. Know the causes and clinical features of hypoadrenal disorders associated with increased ACTH concentrations
- c. Know the causes and clinical features of hypoadrenal disorders associated with decreased ACTH concentrations

2. Clinical course

- a. Recognize acquired adrenal insufficiency as a complication of infection or sepsis syndrome
- b. Know the clinical and laboratory manifestations of acquired adrenal insufficiency
- c. Know how to diagnose acquired adrenal insufficiency
- d. Know the importance of bound versus free cortisol concentrations
- e. Recognize acquired adrenal insufficiency during critical illness
- f. Know the drugs that may cause acquired adrenal insufficiency

3. Treatment

- a. Plan the treatment of a patient with possible acquired adrenal insufficiency
- b. Know the clinical features of corticosteroid resistance

b. Congenital adrenal insufficiency

1. Pathophysiology

- a. Understand the pathogenesis and pathophysiology of congenital adrenal insufficiency

2. Clinical course
 - a. Recognize the manifestations of congenital adrenal insufficiency
 - b. Distinguish the clinical presentation of a 2-week-old infant with congenital adrenal insufficiency from one with sepsis
3. Treatment
 - a. Plan the acute treatment of an infant with shock due to congenital adrenal insufficiency
3. Hyperadrenalism
 - a. Cushing disease
 1. Know the manifestations and life-threatening complications of Cushing disease
 - b. Corticosteroid toxicity
 1. Know the acute and chronic adverse effects of corticosteroids
 - c. Anabolic steroid toxicity
 1. Recognize the signs of and understand the pathophysiologic effects of anabolic steroid abuse
4. Pheochromocytoma
 - a. Recognize the clinical and laboratory manifestations of pheochromocytomas, and differentiate them from those of the serotonin syndrome
 - b. Identify the underlying conditions associated with pheochromocytomas
 - c. Plan treatment for a child with pheochromocytoma prior to surgery
 - d. Anticipate the postoperative complications following surgery in a child with pheochromocytoma
- B. Thyroid
 1. General
 - a. Know the role of thyroid hormones in regulating energy metabolism
 - b. Know the role of thyroid hormones in modulating catecholamine effects
 - c. Know which drugs may interfere with the normal thyroid hormone axis
 2. Thyroid storm
 - a. Pathophysiology
 1. Understand the pathogenesis and pathophysiology of thyroid storm in a child with thyrotoxicosis
 - b. Clinical course
 1. Recognize the manifestations of thyroid storm
 - c. Diagnosis
 1. Distinguish thyroid storm from acute psychosis and other disorders
 2. Know that comorbidities such as diabetic ketoacidosis and adrenal insufficiency may be associated with thyroid storm
 - d. Treatment
 1. Plan the treatment of a child with acute thyroid storm
 2. Know the risks of hepatic injury associated with treatment for thyrotoxicosis
 3. Hypothyroidism
 - a. Pathophysiology
 1. Understand the association between acquired hypothyroidism and the use of specific drugs (eg, amiodarone) or specific conditions (eg, trisomy 21)
 - b. Clinical course
 1. Recognize the manifestations of congenital hypothyroidism

2. Recognize the manifestations of acquired hypothyroidism
 4. Sick euthyroid syndrome
 - a. Recognize the laboratory manifestations of sick euthyroid syndrome
 - b. Know that thyroid supplementation is not indicated for patients with sick euthyroid syndrome
- C. Endocrine pancreas
 1. General
 - a. Know the alterations in insulin and glucagon secretion caused by critical illness
 2. Diabetes mellitus
 - a. Pathophysiology
 1. Understand the pathophysiology of diabetic ketoacidosis
 2. Understand the factors associated with the development of cerebral edema complicating diabetic ketoacidosis
 3. Understand the pathophysiology of non-ketotic hyperosmolar hyperglycemia
 - b. Life-threatening complications
 1. Recognize a patient with diabetic ketoacidosis with cerebral edema
 2. Recognize diabetes mellitus as a cause of coma
 3. Recognize insulin overdose as a cause of coma
 - c. Treatment
 1. Plan the initial management of a child with diabetic ketoacidosis
 2. Plan the management of cerebral edema occurring during diabetic ketoacidosis
 3. Plan the conversion from intravenous to subcutaneous insulin therapy in a patient with diabetic ketoacidosis
 3. Acute or episodic hyperinsulinism
 - a. Recognize the manifestations of acute insulin overdose
 - b. Know the cellular effects of insulin and glucagon
- D. Antidiuretic hormone and the renin-angiotensin-aldosterone axis
 1. General
 - a. Understand the physiology of the renin-angiotensin-aldosterone axis
 - b. Recognize conditions characterized by increased activity of the renin-angiotensin-aldosterone system
 - c. Understand the actions of the renin-angiotensin-aldosterone and antidiuretic hormone systems during dehydration and positive-pressure ventilation
 2. SIADH
 - a. Pathophysiology
 1. Recognize SIADH as a cause of hyponatremia
 2. Understand the mechanism of hyponatremia during SIADH
 3. Understand the pathophysiology of sodium and water balance in a patient with SIADH
 - b. Clinical course
 1. Know how to establish the diagnosis of SIADH and how to differentiate it from cerebral salt wasting, diuretic therapy, and water intoxication
 2. Recognize the instability of the antidiuretic hormone function after head injury
 3. Differentiate between SIADH and other causes of increased total body water
 - c. Life-threatening complications

1. Plan appropriate therapy for the life-threatening complications of hyponatremia due to SIADH
2. Recognize seizure as a complication of SIADH
- d. Treatment
 1. Plan acute treatment for a child with SIADH after head injury
3. Cerebral salt wasting
 - a. Pathophysiology
 1. Recognize cerebral salt wasting as a cause of hyponatremia
 - b. Clinical course
 1. Know how to diagnose cerebral salt wasting and distinguish it from SIADH and water intoxication
 - c. Treatment
 1. Plan the management of a patient with cerebral salt wasting
4. Central diabetes insipidus
 - a. Pathophysiology
 1. Understand the variable course of diabetes insipidus following brain injury
 2. Know the causes of diabetes insipidus
 - b. Clinical course
 1. Recognize the clinical and laboratory manifestations of diabetes insipidus and differentiate from nephrogenic diabetes insipidus
 - c. Life-threatening complications
 1. Know the life-threatening complications of diabetes insipidus
 - d. Treatment
 1. Plan the acute management of a child with diabetes insipidus
- E. Endocrine disorders of calcium homeostasis
 1. Parathyroid hormone
 - a. Deficiency
 1. Pathophysiology
 - a. Understand the pathogenesis and pathophysiology of hypoparathyroidism
 2. Clinical course
 - a. Know the clinical and laboratory manifestations of hypoparathyroidism
 - b. Recognize the association of congenital Hypoparathyroidism and T-cell immunodeficiency (DiGeorge syndrome)
 3. Diagnosis
 - a. Understand the possibility of hypoparathyroidism in an infant with refractory hypocalcemia
 - b. Plan the diagnostic evaluation of a patient with presumed hypoparathyroidism
 4. Life-threatening complications
 - a. Know the life-threatening complications of hypoparathyroidism
 5. Treatment
 - a. Understand the acute management of an infant or child with symptomatic hypocalcemia due to hypoparathyroidism
 - b. Excess
 1. Pathophysiology

- a. Understand the pathogenesis and pathophysiology of hyperparathyroidism in the patient with chronic renal failure
- b. Understand the causes and manifestations of primary, secondary, and tertiary hyperparathyroidism
- 2. Treatment
 - a. Know the treatment of hypercalcemia due to hyperparathyroidism

F. Metabolism

- 1. Normal metabolism
 - a. Know the sources of ATP in energy metabolism
 - b. Aerobic and anaerobic metabolism
 - 1. Understand the relationship between anaerobic and aerobic metabolism
 - 2. Understand anaerobic metabolism
 - 3. Identify which cell types require aerobic metabolism
 - c. Cori cycle or lactic acid cycle
 - 1. Know the role of the Cori cycle
 - d. Gluconeogenesis
 - 1. Understand the role of gluconeogenesis in energy homeostasis
 - 2. Identify the enzymes and substrates for rate-limiting steps in gluconeogenesis
- 2. Inborn errors of metabolism (see III.C.2.b for CNS manifestations)
 - a. Carbohydrate
 - 1. Recognize genetic abnormalities in carbohydrate metabolism
 - 2. Recognize the clinical manifestations and life-threatening complications of abnormal carbohydrate metabolism
 - 3. Recognize glycogen storage disease as a cause of hypoglycemia
 - b. Protein/amino acid
 - 1. Know how to diagnose inborn errors of amino acid metabolism
 - 2. Recognize the importance of withholding dietary protein in the initial management of acidosis due to errors of amino acid metabolism
 - 3. Plan supportive management for specific amino acid disorders
 - 4. Understand the life-threatening complications of inborn errors of amino acid metabolism
 - c. Organic acid
 - 1. Recognize inherited diseases that might produce metabolic acidosis (eg, Leigh disease, methylmalonic aciduria, pyruvate dehydrogenase complex abnormalities)
 - 2. Know the clinical and laboratory manifestations and the course of the organic acidurias
 - 3. Know the life-threatening complications of the organic acidurias
 - d. Urea cycle
 - 1. Recognize urea cycle disorders
 - 2. Understand the roles of dialysis, administration of arginine, phenylacetate and benzoate in the treatment of urea cycle disorders
 - 3. Recognize defects in the urea cycle as potential causes of hyperammonemia
 - 4. Understand the emergency management of patients with urea cycle disorders, especially hyperammonemia in the neonatal period

5. Know the utility of sodium phenylbutyrate to create alternate pathways for nitrogen excretion
 - e. Fatty acid
 1. Recognize disorders of fatty acid metabolism
 2. Plan the management of a patient with a disorder of fatty acid metabolism
 - f. Mitochondrial
 1. Recognize the manifestations of mitochondrial disorders
 2. Plan the management of a patient with a mitochondrial disorder
- G. Glucose and critical illness
1. Neonatal hypoglycemia (excluding hyperinsulinism)
 - a. Pathophysiology
 1. Understand the mechanisms of hypoglycemia other than hyperinsulinism in the neonate
 - b. Clinical course
 1. Know the clinical manifestations and outcome of neonatal hypoglycemia of various causes other than hyperinsulinism
 - c. Diagnosis
 1. Differentiate among the causes of neonatal hypoglycemia (other than hyperinsulinism)
 - d. Treatment
 1. Know the treatment of hypoglycemia (other than hyperinsulinism) and its complications in the neonate
 2. Non-neonatal hypoglycemia
 - a. Pathophysiology and diagnosis
 1. Understand the causes and mechanisms of hypoglycemia in infants, children, and adolescents
 - b. Clinical course and treatment
 1. Know the clinical course and treatment of hypoglycemia in infants, children, and adolescents
 3. Hyperglycemia
 - a. Pathophysiology
 1. Understand the causes of hyperglycemia in critically ill patients without diabetes
 2. Understand the adverse effects on patient outcome associated with hyperglycemia
 3. Know the detrimental association of hyperglycemia and the outcomes of critical illness
 - b. Treatment
 1. Plan the management of hyperglycemia in a critically ill patient
 2. Understand the rationale and algorithms for controlling hyperglycemia in patients undergoing surgery
7. **Hematology/Oncology**
- A. Structure, function, and development
 1. Hematopoietic system
 - a. Understand the development of the hematopoietic system
 - b. Know the colony-stimulating factors and their uses

2. Erythrocyte
 - a. Know the nutritional requirements for erythrocyte precursors
 - b. Understand the function of erythropoietin
 - c. Understand the life cycle of erythrocytes
 3. Neutrophil
 - a. Know the role of the neutrophil in host defense
 - b. Know the effects of drugs and stress on neutrophil concentrations
 - c. Know the role of the neutrophil in the inflammatory response
 - d. Know the kinetics of polymorphonuclear leukocytes in the circulation
 4. Macrophage
 - a. Know the role of the tissue macrophage
 - b. Know the role of the macrophage in antigen presentation
 5. Platelet
 - a. Know the development of the platelet
 - b. Know the role of platelets in coagulation
 6. Lymphocytes
 - a. Know the role of the lymphocyte in host defense
 - b. Understand the role of the various lymphocyte classes
 7. Spleen
 - a. Know the functions of the spleen
 - b. Know the clinical and laboratory manifestations of altered/absent splenic function
- B. Specific disorders
1. Anemia
 - a. General
 1. Distinguish among the various causes of anemia
 - b. Nutrient deficiency
 1. Recognize the clinical and laboratory manifestations of anemia caused by chronic bleeding and/or iron deficiency
 2. Recognize anemia caused by nutrient deficiency
 - c. Hemolytic
 1. Understand the pathogenesis, pathophysiology, and clinical manifestations of hemolytic disease due to various causes
 2. Plan treatment for a child with severe acute hemolytic anemia
 3. Differentiate among the causes of hemolytic anemia
 - d. Aplastic disorders
 1. Plan medical management for a patient with aplastic anemia
 2. Know the manifestations of aplastic anemia
 3. Understand the pathogenesis and pathophysiology of aplastic anemia
 4. Know the clinical manifestations and clinical course of drug-induced aplastic anemia
 5. Distinguish aplastic from hemolytic anemia on the basis of clinical and laboratory features
 - e. Hemoglobinopathy
 1. Know the pathogenesis and pathophysiology of sickle cell crisis
 2. Recognize the clinical and laboratory manifestations of vaso-occlusive sickle cell crisis

3. Recognize the life-threatening complications of sickle cell disease
4. Plan treatment for a patient with sickle cell crisis
5. Recognize the clinical and laboratory manifestations of acute chest syndrome
6. Recognize the clinical and laboratory manifestations of acute sequestration crisis
7. Recognize the clinical and laboratory manifestations of acute aplastic crisis
8. Recognize the signs and symptoms associated with methemoglobinemia
9. Plan the treatment for a patient with methemoglobinemia
- f. Hemorrhagic disorders
 1. Know the pathophysiology of hemorrhagic shock
 2. Understand the pathophysiology of ischemia-reperfusion injury
 3. Recognize the common factor deficiencies associated with hemorrhagic disorders
 4. Plan initial management of a patient with hemorrhagic shock
 5. Understand the appropriate use of exogenous factor replacement in critically ill patients
2. Polycythemia
 - a. Understand the causes of polycythemia
 - b. Understand the adverse effects of polycythemia
 - c. Plan the management of a patient with polycythemia
3. Thrombocytopenia
 - a. General
 1. Know the causes of thrombocytopenia
 2. Know the complications of thrombocytopenia
 3. Distinguish among the causes of thrombocytopenia (dilutional loss, impaired production, destruction)
 - b. Immunologic
 1. Understand the pathogenesis of immune thrombocytopenia
 2. Recognize the clinical and laboratory manifestations of idiopathic thrombocytopenia purpura
 3. Understand the principles of treatment of idiopathic thrombocytopenia purpura
 4. Recognize the bleeding and thrombotic diatheses of the patient with infection/sepsis and purpura
 5. Understand how to diagnose heparin-induced thrombocytopenia
 6. Know how to treat heparin-induced thrombocytopenia
 7. Understand the pathogenesis of thrombotic thrombocytopenic purpura
 - c. Disseminated intravascular coagulation
 1. Understand the pathogenesis and pathophysiology of disseminated intravascular coagulation
 2. Understand the clinical and laboratory manifestations of disseminated intravascular coagulation
 3. Know the clinical disorders associated with disseminated intravascular coagulation
 4. Recognize infarction as a complication of thrombotic intravascular coagulation
 5. Plan appropriate replacement therapy for a patient with disseminated intravascular coagulation

4. Thrombocytosis
 - a. Understand the causes of thrombocytosis
 - b. Understand the complications of thrombocytosis
 5. Neutropenia
 - a. Understand the pathogenesis and pathophysiology of neutropenia
 - b. Understand the infectious risks of neutropenia
 - c. Recognize neutropenia as a manifestation of overwhelming infection
 - d. Recognize the risk factors for and clinical manifestations of infection in the neutropenic patient
 - e. Recognize the life-threatening complications of neutropenia, including sepsis
 6. Coagulopathies
 - a. Recognize intracranial hemorrhage as a risk of clotting factor deficiency
 - b. Know the effects of hepatocellular disease on clotting factors
 - c. Know the effects of disseminated intravascular coagulation on clotting factors
 - d. Know the effects of heparin administration on clotting factors
 - e. Understand the pathogenesis and treatment of drug-induced coagulopathies
 - f. Interpret the results of coagulation studies
 - g. Understand the risks of warfarin therapy and methods to reverse effects of warfarin
 - h. Know the indications and contraindications for the use of protamine and other heparin antagonists
 - i. Know the indications and contraindications for the use of anti-fibrinolytics, such as aminocaproic acid and tranexamic acid
 - j. Know that anticoagulants used outside the body (EDTA, citrate, oxalate) may be administered via blood products or as additives with other therapies
 - k. Know the indications for various blood products, component therapy, and medications to enhance coagulation
 - l. Know the indications and contraindications for the use of specific coagulation factors for the treatment of bleeding disorders
 7. Thrombosis
 - a. Understand the indications and contraindications for thrombolytic therapy
 - b. Understand the mechanism of action of commonly used anticoagulant drugs: heparin and low-molecular-weight heparin, other heparin-like glycosaminoglycans, vitamin K antagonists, direct thrombin inhibitors
 - c. Understand the mechanism of action of commonly used thrombolytic drugs
 - d. Plan the evaluation of a patient with thrombosis
 - e. Understand how a blood clot is formed
 - f. Plan the management of a patient with an arterial thrombosis (eg, gangrene in a limb or digit, cerebrovascular stroke, myocardial infarction)
 - g. Know the indications and contraindications for the use of antiplatelet drugs
 - h. Know the indications and contraindications for the use of fibrinolytic inhibitors
 - i. Plan the management of a patient with venous thrombosis (deep vein thrombosis, venous limb gangrene, pulmonary embolism, cerebral sinus thrombosis, venous stroke)
- C. Hematopoietic stem cell transplantation (see also IV.B.7.b)
1. Know the expected clinical course of a hematopoietic stem cell transplant and differences by graft source (eg, autologous, peripheral blood stem cells, cord blood)

2. Recognize graft-versus-host disease after hematopoietic stem cell transplantation and know treatment options and their toxicities
3. Recognize complications resulting from hematopoietic stem cell transplantation (eg, sinusoidal obstruction syndrome, engraftment syndrome, lymphoproliferative disease)
4. Recognize toxicities and drug interactions with common immunosuppressants
5. Recognize the difference in rates of various complications during the phases after hematopoietic stem cell transplantation (pre-engraftment, post-engraftment, > 100 days)
6. Understand the etiologies of respiratory failure after hematopoietic stem cell transplantation and differences by timing of presentation
7. Understand the prognosis of respiratory failure after hematopoietic stem cell transplantation

D. Malignancies

1. Recognize the life-threatening complications of pediatric malignancies at initial presentation, including hyperleukocytosis, tumor lysis syndrome, and airway compression
2. Recognize the common side effects associated with various chemotherapeutic agents used for pediatric malignancies
3. Recognize the complications associated with the initial treatment of pediatric malignancies
4. Plan the treatment of life-threatening complications associated with pediatric malignancies, including hyperleukocytosis, tumor lysis syndrome, and airway compression
5. Recognize the life-threatening complications of treatment of pediatric malignancies, including sinusoidal obstructive syndrome, sepsis, and acute kidney injury
6. Plan the treatment of life-threatening complications of treatment of pediatric malignancies

E. Immune activation/inflammatory syndromes

1. Hemophagocytic lymphohistiocytosis
 - a. Recognize primary and secondary hemophagocytic lymphohistiocytosis
 - b. Recognize the complications of hemophagocytic lymphohistiocytosis
 - c. Plan treatment for a patient with primary hemophagocytic lymphohistiocytosis
 - d. Plan the treatment of secondary hemophagocytic lymphohistiocytosis
2. Macrophage activation syndrome
 - a. Recognize macrophage activation syndrome
 - b. Recognize the illnesses that incite macrophage activation syndrome
 - c. Plan treatment for a patient with macrophage activation syndrome

F. Blood banking and blood component transfusion

1. Recognize the clinical and laboratory manifestations of transfusion reaction
2. Understand the principles of component transfusion
3. Know what screening is routinely performed on donor blood prior to release from the blood bank
4. Understand the potential hazards of blood component transfusions
5. Know the specific indications for the use of irradiated erythrocytes
6. Know the complications of a massive blood transfusion
7. Know what constitutes compatible blood products for transfusion

8. Plan therapy for complications of transfusion
9. Know the indications for and complications of platelet transfusions
10. Know which mechanisms reduce the risk of cytomegalovirus infection resulting from blood transfusion
11. Know the risks and advantages of directed donor transfusion
12. Know the alternatives to blood transfusion
13. Understand the indications for erythrocyte transfusion in various disease states (ie, cyanotic congenital heart disease, severe respiratory failure, severe dehydration)
14. Know the indications for plasma and cryoprecipitate transfusion
15. Know the indications for plasmapheresis

8. **Gastroenterology and Nutrition**

A. Structure, function, and physiologic development

1. Nutritional requirements
 - a. Know the caloric requirements of normal infants and children
 - b. Understand the factors that influence caloric requirements
 - c. Know the nitrogen requirements of normal infants and children
 - d. Know the signs of fatty acid deficiency
2. Chewing and swallowing
 - a. Recognize the role of intact neural function in airway protection during swallowing
 - b. Know the anatomic and functional characteristics of swallowing
3. Gastrointestinal motility
 - a. Identify the conditions that increase gastric emptying time
 - b. Understand the effects of decreased gastrointestinal motility
 - c. Identify the conditions that decrease gastric emptying time
4. Digestion and exocrine function
 - a. Salivary
 1. Understand the methods for decreasing salivary volume
 2. Understand the role of salivary secretions in the digestive process
 3. Understand the role of salivary enzymes (lysozyme and peroxidase) in defense against bacterial invasion
 4. Understand the role of mouth care in preventing ventilator-associated pneumonia
 - b. Gastric
 1. Understand the role of the stomach in the digestive process
 2. Understand the regulation of gastric pH
 3. Understand the effect of pH on gastrointestinal flora
 4. Know the gastric digestive enzymes and their regulation
 5. Understand the role of gastric proteases in the digestive process
 - c. Hepatic
 1. Understand the synthetic functions of the liver
 2. Understand the storage functions of the liver
 3. Understand the role of bile salts in digestion
 4. Understand the role of the liver in xenobiotic metabolism
 - d. Pancreatic
 1. Know the types and function of pancreatic enzymes
 - e. Intestinal

1. Understand the physiology of the brush border of the small intestine
2. Know the effects of damage to the small bowel epithelium on digestion
3. Identify the causes of decreased intestinal surface area
5. Gastrointestinal neuroendocrine function
 - a. Understand the role of gastrointestinal peptides in gastric acid secretion
 - b. Understand the mechanisms that control the release of the gastrointestinal peptides
 - c. Understand the role of gastrointestinal peptides in glucose metabolism
 - d. Understand the role of gastrointestinal peptides in gastrointestinal motility
6. Hepatic structure and function
 - a. Nutrients
 1. Recognize the role of hepatic metabolism in the clearance of ammonia during protein catabolism
 2. Recognize the role of hepatic metabolism in bilirubin elimination
 - b. Pharmacologic agents
 1. Know the role of hepatic metabolism in drug metabolism/detoxification
 2. Recognize drug-induced alterations in hepatic metabolism as a mechanism of drug-drug interaction
 - c. Structure
 1. Understand the anatomy of the liver
 2. Understand the role of hepatic vascular structure on function
7. Gastrointestinal absorption and secretion
 - a. Water
 1. Know the principles of gastrointestinal water handling
 2. Understand the causes of impaired gastrointestinal water handling
 - b. Nutrients
 1. Know the principles of gastrointestinal handling of carbohydrates
 2. Understand the effect of decreased intestinal surface area on fluid and nutrient handling
 3. Recognize the causes of malabsorption
 4. Know the principles of gastrointestinal handling of proteins
 5. Recognize that some peptides/proteins may be adsorbed intact
 6. Understand the principles of gastrointestinal handling of fats
 7. Understand the principles of vitamin absorption
 - c. Acid and base
 1. Know the acid/base characteristics of gastrointestinal secretions and the effects of these secretions on systemic acid-base balance
 - d. Electrolytes and minerals
 1. Know the role of the gastrointestinal tract in the regulation of serum calcium and phosphorus
 2. Know the effect of decreased intestinal surface area on electrolyte balance
8. Cellular nutrient absorption and metabolism
 - a. Know the principles of cellular nutrient absorption and metabolism
 - b. Understand the role of lipid metabolism in energy production
9. Gastrointestinal lymphatics
 - a. Know the function and significance of gastrointestinal lymph flow
 - b. Recognize the causes and effects of impaired gastrointestinal lymph flow

10. Gastrointestinal circulation
 - a. Understand the factors affecting hepatic blood flow
 - b. Understand the pathophysiology of portal hypertension
 - c. Know that hepatic blood flow may influence drug metabolism
 - d. Understand the factors affecting gastrointestinal blood flow and know high-risk sites for ischemia
 - e. Know that gastrointestinal blood flow is affected by feeding
 - f. Know the vascular response of the gut to hypotension
 - g. Know the anatomy of the circulation of the gastrointestinal system
 - h. Know the principles of enterohepatic circulation
 - i. Know the anatomy and physiology of the hepatic/portal circulation
 - j. Understand the mechanisms of ascites formation
 - k. Know the effect of gastrointestinal hormones on intestinal vascular tone
 - l. Know the effect of vasoactive drugs on gastrointestinal blood flow
 - m. Know the effect of vasopressin on gastrointestinal blood flow
11. Gastrointestinal pharmacology
 - a. Know the pharmacology of pH regulation in the gastrointestinal tract
 - b. Know the drugs that decrease gastrointestinal motility and their clinical importance
 - c. Know the drugs that increase gastrointestinal motility and their clinical importance
 - d. Identify the drugs that increase or decrease lower esophageal sphincter tone
 - e. Understand the importance of delivering drugs to the appropriate location in the gastrointestinal tract (eg, drugs dependent on an acid milieu)
- B. Interactions with other organ systems
 1. With airway and lungs
 - a. Reflux and aspiration
 1. Understand gastric emptying time and its impact on the risk of aspiration
 2. Know the contribution of salivary secretion volume and pharyngeal coordination to the risk of aspiration
 3. Know the effect of pH of gastric secretions on damage due to aspiration
 4. Understand the pathophysiologic effects of aspirated gastric contents on airway and lung parenchyma
 5. Recognize the relation of reflux to aspiration in infancy
 6. Recognize the relationship between esophageal motility and aspiration
 7. Recognize H-type tracheoesophageal fistula as a cause of recurrent aspiration
 8. Recognize the symptoms and signs associated with reflux (vomiting, wheezing, apnea, recurrent pneumonia, etc)
 9. Plan treatment for a patient with gastrointestinal reflux
 10. Know techniques for decreasing the aspiration of saliva
 11. Recognize esophageal foreign body as a cause of respiratory distress
 12. Recognize gastroesophageal reflux and aspiration as a possible cause of acute life-threatening event in infancy
 - b. Chylous effusion (see II.D.7)
 - c. Elevated diaphragms due to abdominal distension
 1. Understand the effect of elevated diaphragms on respiratory function
 - d. Nutrition and respiratory musculature
 1. Know the effect of reduced caloric intake on respiratory muscle function

2. With mediastinum (eg, esophageal perforation)
 - a. Recognize the conditions associated with an increased risk for esophageal perforation
 - b. Know the signs of mediastinitis
 3. With peritoneum
 - a. Recognize peritonitis as a cause of sepsis
 - b. Recognize free air in the abdomen as an indication of gastrointestinal perforation
 4. With reticuloendothelial system
 - a. Understand the interrelationship of gut ischemia and sepsis
 - b. Recognize the contributions of the gastrointestinal system to host defense: salivary immunoglobulins, gastric acid, normal gut motility, physical barriers (mucin, etc)
 - c. Understand the gastrointestinal factors that increase bacterial translocation
 5. With acid/base balance
 - a. Know the effects of systemic alterations in acid-base homeostasis on gastrointestinal electrolyte absorption
 6. With cardiovascular system
 - a. Congenital heart disease
 1. Recognize that certain gastrointestinal malformations occur more commonly with certain forms of congenital heart disease
 2. Recognize the special nutritional issues associated with surgical repair of congenital heart disease
 3. Recognize failure to thrive due to increased nutritional requirements and decreased intake as a consequence of congestive heart failure in infancy
 - b. With hemodynamics (eg, fluid shifts)
 - c. Understand the hemodynamic significance of intraperitoneal or intraenteric fluid accumulation
 7. With central nervous system
 - a. Understand the conditions (eg, TBI, hypoxic encephalopathy, etc) in which a patient should undergo evaluation of suck-swallow mechanisms prior to attempts at oral feeding
 - b. Understand the risks associated with chronic nasogastric tube feeding in a patient with impaired airway protective reflexes
- C. Functional and nutritional assessment
1. Consumption
 - a. Plan a parenteral nutrition regimen
 - b. Recognize enteral feeding limitations in critically ill patients (by oral, gastric and jejunal routes)
 - c. Calculate caloric and nutrient intake in parenteral nutrition
 - d. Calculate caloric and nutrient intake in enteral nutrition
 - e. Understand the role of specialized formulas to treat malabsorption in critically ill children
 - f. Know the advantages and disadvantages of enteral feeding in critically ill patients
 - g. Know the side effects and/or complications of parenteral nutrition
 - h. Understand the clinical situations in which caloric and nutrient requirements are altered

- i. Understand the role of specialized formulas to treat specific clinical conditions (eg, pulmonary or renal failure) in critically ill patients
 - 2. Absorption
 - a. Understand the effects of critical illness on gastrointestinal absorption
 - b. Know how to assess a patient for fat, protein, and carbohydrate malabsorption
 - 3. Laboratory
 - a. Gastric and esophageal pH
 - 1. Understand the significance of gastric and esophageal pH
 - 2. Recognize esophageal pH monitoring as a means of correlating reflux and other life-threatening events (bronchospasm, apnea, etc)
 - b. Stool
 - 1. Evaluate and put into context stool laboratory findings (eg, occult blood, fat, leukocytes, reducing substances)
 - c. Endoscopy
 - 1. Recognize the therapeutic indications for endoscopy
 - 2. Recognize the diagnostic indications for endoscopy
 - 3. Recognize the potential complications of endoscopy
 - d. Laryngoscopy and bronchoscopy
 - 1. Identify the bronchoscopic approach to the diagnosis of reflux and aspiration (eg, appearance of supraglottic tissue, presence of lipid-laden macrophages)
 - e. Radiographic assessment
 - 1. Differentiate mechanical obstruction from ileus by radiographic assessment
 - 2. Recognize free air on flat-plate x-ray study of the abdomen
 - 3. Recognize the radiographic findings associated with necrotizing enterocolitis (ie, pneumatosis and biliary air on plain x-ray study of the abdomen)
 - f. Abdominal ultrasonography
 - 1. Recognize the indications for abdominal ultrasonography
 - 2. Recognize the indications and limitations of FAST (focused abdominal sonography for trauma) versus formal abdominal ultrasonography in children
 - g. Abdominal CT scan
 - 1. Recognize the indications for and limitations of abdominal CT scan
 - h. Radionuclide scans
 - 1. Know the role of radionuclide scans in the diagnosis of Meckel diverticulum, hepatobiliary disease, gastrointestinal bleeding, etc
 - i. Assessment of nutritional status
 - 1. Know the proper assessment studies to evaluate nutritional status
 - 2. Understand the use of indirect calorimetry in nutritional assessment
 - 3. Know the plasma proteins useful in nutritional assessment
- D. Specific disorders of the gastrointestinal tract
 - 1. Ulceration
 - a. Pathophysiology
 - 1. Understand the pathophysiology of gastric and duodenal ulceration
 - 2. Recognize the conditions that contribute to stress gastritis
 - b. Diagnosis
 - 1. Evaluate ulceration of gastrointestinal tract organs

2. Recognize the life-threatening complications of gastric/duodenal ulceration (hemorrhage, perforation, etc)
- c. Treatment
 1. Plan the treatment of a patient with gastritis or ulceration
 2. Understand the role and mode of action of antacids, proton pump inhibitors, lavage, and somatostatin in the treatment of ulceration
 3. Know the indications for antibiotic therapy in a patient with *Helicobacter pylori* infection
2. Gastrointestinal burns
 - a. Pathophysiology
 1. Know the acute and long-term course of esophageal burns
 2. Know the substances that can cause esophageal burns
 3. Understand the mechanism of gastroesophageal injury by caustic substances
 - b. Diagnosis
 1. Understand the significance of mouth burns in predicting esophageal injury
 2. Understand the appropriate timing of endoscopic evaluation in a patient with suspected esophageal burns
 - c. Treatment
 1. Plan supportive care for a patient with gastrointestinal burns
3. Perforation
 - a. Pathophysiology
 1. Know the causes of hollow viscous perforation
 - b. Diagnosis
 1. Recognize perforation of the gastrointestinal tract
 - c. Treatment
 1. Know the surgical and medical treatment for gastrointestinal perforation
4. Hemorrhage
 - a. Pathophysiology
 1. Understand the causes of upper gastrointestinal bleeding
 2. Understand the causes of lower gastrointestinal bleeding
 3. Understand the role of portal hypertension in gastrointestinal bleeding
 - b. Diagnosis
 1. Evaluate the significance of gastrointestinal bleeding
 2. Recognize the various types of gastrointestinal bleeding and their likely origins (hematemesis, hematochezia, hematemesis, melena, decreasing hematocrit)
 3. Understand the methods of identification of a gastrointestinal bleeding site
 - c. Treatment
 1. Understand the principles of management of upper gastrointestinal tract hemorrhage
 2. Understand the principles of management of lower gastrointestinal hemorrhage
 3. Know the role and side effects of somatostatin in the treatment of gastrointestinal hemorrhage
5. Inflammatory bowel disease
 - a. Ulcerative colitis
 1. Diagnosis
 - a. Know the life-threatening complications of ulcerative colitis

- b. Recognize the colonic perforation in ulcerative colitis as a cause of peritonitis
 - c. Recognize the history and physical findings associated with ulcerative colitis
 - 2. Treatment
 - a. Plan the treatment of a patient with ulcerative colitis who is critically ill
 - b. Regional enteritis
 - 1. Diagnosis
 - a. Recognize the risk of sepsis in a patient with regional enteritis
 - b. Recognize the life-threatening complications of regional enteritis
 - 2. Treatment
 - a. Plan treatment for a patient with sepsis due to regional enteritis
- 6. Ileus
 - a. Pathophysiology
 - 1. Understand the different etiologies of ileus in the critically ill patient
 - b. Diagnosis
 - 1. Know how to diagnose ileus
 - c. Treatment
 - 1. Plan treatment for a patient with ileus
- 7. Obstruction
 - a. Neonate and infant
 - 1. Pathophysiology
 - a. Understand the anatomic derangements of congenital bowel obstruction
 - b. Recognize the causes of bowel obstruction in the neonate and infant
 - 2. Diagnosis
 - a. Recognize the signs and symptoms of bowel obstruction in the neonate
 - b. Recognize volvulus as a complication of malrotation
 - c. Recognize severe enterocolitis as a life-threatening complication of Hirschsprung disease
 - 3. Treatment
 - a. Plan the early management of a neonate or infant with bowel obstruction
 - b. Acquired
 - 1. Pathophysiology
 - a. Know the causes of bowel obstruction in the older child and adolescent
 - 2. Diagnosis
 - a. Recognize the signs and symptoms of bowel obstruction in the older child
 - b. Recognize and differentiate between causes of bowel obstruction
 - 3. Treatment
 - a. Plan the initial management of a patient with bowel obstruction
- 8. Pancreatitis
 - a. Pathophysiology
 - 1. Know the effect of released pancreatic enzymes on adjacent tissues
 - 2. Understand the pathogenesis and pathophysiology of pancreatitis
 - 3. Recognize the life-threatening complications of pancreatitis
 - 4. Understand the association of acute respiratory distress syndrome and pancreatitis

- b. Diagnosis
 - 1. Know the scenarios in which pancreatitis occurs
 - 2. Identify the laboratory abnormalities commonly associated with pancreatitis
 - 3. Know the radiologic methods of diagnosing pancreatitis
 - 4. Recognize the clinical manifestations of pancreatitis
- c. Treatment
 - 1. Know the principles of treatment of pancreatitis
 - 2. Understand and recognize the long-term complications of pancreatitis (ie, pseudocyst formation)
- 9. Disorders of the liver and biliary tree
 - a. Hepatobiliary disorders
 - 1. Pathophysiology
 - a. Understand the pathophysiology of hepatic encephalopathy
 - b. Recognize the cardiopulmonary interactions with the liver in the setting of hepatic failure
 - c. Recognize the association between hepatic failure and renal failure
 - d. Know the common causes of fulminant hepatic failure
 - e. Know the common causes of chronic hepatic failure
 - f. Understand the risk factors for hepatobiliary disorders
 - g. Recognize hypoglycemia as a complication of hepatic failure
 - h. Recognize coagulopathy as a complication of hepatic failure
 - 2. Diagnosis
 - a. Recognize the clinical and laboratory manifestations of hepatic failure
 - b. Differentiate between the causes of hepatic failure
 - c. Recognize the physical findings of acute and chronic hepatic dysfunction
 - d. Recognize the laboratory findings associated with hepatic dysfunction
 - e. Recognize the hepatic manifestations of metabolic disorders (Wilson disease, tyrosinemia, alpha-1-antitrypsin, etc)
 - 3. Clinical course
 - a. Know the clinical course of fulminant hepatic failure
 - b. Know the clinical course of chronic liver failure
 - c. Understand the clinical course after liver transplantation
 - 4. Life-threatening complications
 - a. Evaluate the extent and severity of coagulopathy in a patient with hepatic failure
 - b. Know the clinical manifestations of hepatic encephalopathy
 - 5. Treatment
 - a. Know the principles of treatment of fulminant hepatic failure
 - b. Know the principles of treatment of chronic hepatic failure
 - c. Know the principles of management of encephalopathy in hepatic failure
 - d. Plan the treatment of a patient with toxin-associated liver failure
 - e. Plan the treatment of a patient with ischemia-induced hepatic insufficiency
 - f. Plan supportive therapy for the coagulopathy associated with hepatic failure (including the use of activated Factor VII)
 - g. Plan treatment for patients with ascites complicating liver failure
 - 6. Liver transplantation

- a. Recognize the indications for liver transplantation
 - b. Understand the role of liver support devices
 - c. Recognize the common noninfectious complications of liver transplantation
 - d. Recognize the common infectious complications of liver transplantation
 - b. Hyperbilirubinemia
 - 1. Obstructive jaundice
 - a. Know the clinical and laboratory differences between cholestatic and noncholestatic jaundice in neonates
 - b. Plan the management of a patient with cholestasis
 - 2. Disorders of bilirubin metabolism
 - a. Understand the causes of unconjugated hyperbilirubinemia
 - b. Understand the causes of conjugated hyperbilirubinemia
 - c. Understand the treatment of unconjugated hyperbilirubinemia
 - d. Understand the treatment of conjugated hyperbilirubinemia
10. Cystic fibrosis
- a. Pathophysiology
 - 1. Understand the gastrointestinal manifestations of cystic fibrosis
 - b. Diagnosis
 - 1. Recognize the presentation of cystic fibrosis with meconium ileus
 - 2. Recognize cirrhosis and hepatic failure as complications of cystic fibrosis
 - 3. Recognize islet cell failure (diabetes) as a complication of cystic fibrosis
 - c. Treatment
 - 1. Understand the enzymatic and caloric needs of a patient with cystic fibrosis
11. Other malabsorption syndromes
- a. Pathophysiology
 - 1. Understand the causes of acquired malabsorption in critically ill patients (eg, rotavirus infection, chronic malnutrition)
 - b. Diagnosis
 - 1. Recognize the causes of diarrhea in patients in the ICU (infectious, antibiotic-related, etc)
 - 2. Recognize the risk of celiac crisis in patients with gluten-sensitive enteropathy
12. Necrotizing enterocolitis
- a. Pathogenesis
 - 1. Understand the risk factors for necrotizing enterocolitis in a full-term neonate (eg, ischemia, polycythemia, hypercoagulable state, cyanotic congenital heart disease)
 - b. Diagnosis
 - 1. Recognize the clinical and laboratory features of necrotizing enterocolitis
 - c. Therapy
 - 1. Plan the treatment of an infant with necrotizing enterocolitis
 - 2. Understand the indications for surgical intervention in an infant with necrotizing enterocolitis
13. Nutrient excess
- a. Know the critical care syndromes of nutrient excess
14. Nutrient deficiency
- a. Know the critical care syndromes of nutrient deficiencies

E. Nutritional implications of disorders

1. Burns
 - a. Understand the caloric requirements of patients with extensive burns
2. Sepsis
 - a. Know the nutritional implications of sepsis
3. Malignancy
 - a. Know the nutritional implications of treated and untreated malignancy
4. Chronic infection
 - a. Recognize the increased nutritional needs of patients with chronic infections
5. Congestive cardiac failure
 - a. Identify the nutritional requirements of patients with congestive heart failure
6. Respiratory failure
 - a. Know the contribution of respiratory muscles to total caloric consumption
7. Starvation
 - a. Recognize the pathophysiologic consequences of protein malnutrition
 - b. Diagnose the various categories of malnutrition
 - c. Know the functional consequences of malnutrition
 - d. Characterize protein metabolism of the stress response
 - e. Understand aspects of stress metabolism
 - f. Understand the differences in the metabolic response to simple and stressed starvation
 - g. Characterize carbohydrate metabolism of the stress response
 - h. Understand the principles of nutritional support during the stress response
 - i. Understand the principles of refeeding in malnutrition syndromes
 - j. Know the complications of refeeding in malnutrition syndromes
8. Primary gastrointestinal disorders
 - a. Understand the nutritional issues associated with inflammatory bowel disease
 - b. Understand the nutritional issues associated with hepatic failure
 - c. Recognize the nutritional issues associated with short gut syndrome
9. Renal failure and uremia
 - a. Recognize the nutritional issues associated with renal failure
10. Central nervous system
 - a. Understand the nutritional needs of a patient with traumatic brain injury
 - b. Recognize the critical care diagnostic and management issues in a patient on a ketogenic diet for control of intractable seizures
11. Multiple organ system failure
 - a. Understand the principles of nutritional support for patients with multiple organ system failure

9. **Poisonings, Toxins, and Overdoses**

A. General principles of detoxification

1. Biochemical antagonism
 - a. Know the antidotes for common poisonings
2. Gastric emptying
 - a. Know the indications and contraindications to induction of vomiting and gastric emptying after ingestion of a toxin
3. Alimentary binding

- a. Know the indications and contraindications for and principles that underlie the use of charcoal after ingestion of a toxin
- 4. Facilitation of renal excretion
 - a. Understand the mechanisms of facilitation of renal excretion of common toxins
 - b. Recognize the role of dialysis in detoxification after ingestion of a toxin
- 5. Facilitation of plasma or organic binding
 - a. Recognize facilitation of plasma protein binding as a means to decrease toxicity of ingested substances
- 6. Whole bowel irrigation
 - a. Know the indications for using whole bowel irrigation to remove toxins
- 7. Surface decontamination
 - a. Know the indications for and means to initiate surface decontamination in suspected cases of pesticide exposure, bioterrorism, chemical attack, or radiation dispersal
- B. Specific agents
 - 1. Salicylate
 - a. Diagnostic features
 - 1. Recognize the clinical and laboratory manifestations of acute salicylate ingestion
 - b. Pathogenesis and toxic effects
 - 1. Know the pathophysiology of salicylate ingestion
 - c. Normal elimination
 - 1. Know the normal metabolism, excretion, and pharmacokinetics of salicylates
 - d. Diagnostic evaluation
 - 1. Plan the diagnostic assessment and evaluation of suspected salicylate ingestion
 - e. Treatment
 - 1. Plan appropriate therapy for a child with acute salicylate intoxication
 - 2. Acetaminophen
 - a. Diagnostic features
 - 1. Recognize the clinical and laboratory manifestations of acute acetaminophen intoxication and how they change as time progresses
 - b. Pathogenesis and toxic effects
 - 1. Understand the pathogenesis and toxic effects of acetaminophen
 - c. Normal elimination
 - 1. Know the normal metabolism, excretion, and pharmacokinetics of acetaminophen
 - d. Diagnostic evaluation
 - 1. Plan the diagnostic assessment and evaluation of a child suspected of acetaminophen ingestion
 - e. Treatment
 - 1. Plan appropriate therapy for a child with acute acetaminophen intoxication
 - 3. Tricyclic antidepressants, selective serotonin reuptake inhibitors (SSRIs), and other psychotropic drugs
 - a. Diagnostic features
 - 1. Recognize the clinical and laboratory manifestations of acute ingestion of a tricyclic antidepressant, SSRI, or other psychotropic drug

2. Recognize manifestations of neuroleptic malignant syndrome
 - b. Pathogenesis and toxic effects
 1. Understand the pathogenesis and toxic effects of tricyclic antidepressants, SSRIs, and other psychotropic drugs
 2. Understand the relative difference in toxicities between SSRIs and tricyclic antidepressants
 3. Know the mechanism of action of tricyclic antidepressants, SSRIs, and other psychotropic drugs
 - c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of tricyclic antidepressants, SSRIs, and other psychotropic drugs
 - d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of a child suspected of ingesting a tricyclic antidepressant, SSRI, or other psychotropic drug(s)
 - e. Treatment
 1. Plan appropriate therapy for a child with acute intoxication from ingestion of a tricyclic antidepressant, SSRI, or other psychotropic drug(s)
4. Digoxin
 - a. Diagnostic features
 1. Recognize the clinical and laboratory manifestations of acute digoxin intoxication
 - b. Pathogenesis and toxic effects
 1. Understand the pathogenesis and toxic effects of digoxin
 - c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of digoxin
 - d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of a child suspected of digoxin ingestion
 2. Understand the effect of digoxin antibody treatment on serum digoxin concentration
 - e. Treatment
 1. Plan appropriate therapy for a child with acute digoxin intoxication
 5. Clonidine
 - a. Diagnostic features
 1. Recognize the clinical and laboratory manifestations of clonidine intoxication
 - b. Pathogenesis and toxic effects
 1. Know the pathophysiology and toxic effects of clonidine intoxication
 - c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of clonidine
 - d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of suspected clonidine intoxication
 - e. Treatment
 1. Plan appropriate therapy for a child with clonidine intoxication
 6. Anticonvulsants (see also XI.K)
 - a. Diagnostic features

1. Recognize the side effects and toxicities of the common anticonvulsants and the associated clinical and laboratory findings
 - b. Pathogenesis and toxic effects
 1. Know the pathophysiology and toxic effects of overdose of common anticonvulsants
 - c. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of suspected overdose of one of the common anticonvulsants
 - d. Treatment
 1. Plan appropriate therapy for a child with overdose of one of the common anticonvulsants
7. Antihistamines (and antihistamine-decongestants)
 - a. Diagnostic features
 1. Recognize the clinical and laboratory manifestations of antihistamine overdose
 - b. Pathogenesis and toxic effects
 1. Know the pathophysiology and toxic effects of antihistamine overdose
 - c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of antihistamines
 - d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of suspected antihistamine overdose
 - e. Treatment
 1. Plan appropriate therapy for a child with antihistamine overdose
8. Narcotics
 - a. Diagnostic features
 1. Recognize the clinical and laboratory manifestations of narcotic overdose
 - b. Pathogenesis and toxic effects
 1. Know the pathophysiology and toxic effects of narcotic overdose
 - c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of narcotic agents
 - d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of suspected narcotic overdose
 - e. Treatment
 1. Plan appropriate therapy for a child with narcotic overdose
9. Cyanide
 - a. Diagnostic features
 1. Recognize cyanide toxicity as a complication of smoke inhalation
 2. Recognize the clinical and laboratory manifestations of cyanide poisoning
 - b. Pathogenesis and toxic effects
 1. Know the pathophysiology and toxic effects of cyanide
 - c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of cyanide
 - d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of suspected cyanide poisoning

- e. Treatment
 - 1. Plan appropriate therapy for a child with cyanide poisoning
- 10. Amphetamines
 - a. Diagnostic features
 - 1. Recognize the clinical and laboratory manifestations of acute amphetamine intoxication
 - b. Pathogenesis and toxic effects
 - 1. Understand the pathogenesis and toxic effects of amphetamines
 - c. Normal elimination
 - 1. Know the normal metabolism, excretion, and pharmacokinetics of amphetamines
 - d. Diagnostic evaluation
 - 1. Plan the diagnostic assessment and evaluation of a child suspected of amphetamine ingestion
 - e. Treatment
 - 1. Plan appropriate therapy for a child with acute amphetamine intoxication
- 11. Plant toxins
 - a. Diagnostic features
 - 1. Recognize the clinical and laboratory manifestations of acute ingestion of poisonous mushrooms
 - b. Pathogenesis and toxic effects
 - 1. Recognize potential plant toxin ingestion, and plan appropriate evaluation
- 12. Petroleum distillates (hydrocarbons)
 - a. Diagnostic features
 - 1. Recognize the clinical and laboratory manifestations of ingestion of a petroleum distillate (hydrocarbon)
 - 2. Understand the routes of entry of petroleum distillates (hydrocarbons) and the risk for toxicity based on the physical properties (high volatility and low viscosity)
 - b. Pathogenesis and toxic effects
 - 1. Understand the pulmonary toxic effects of petroleum distillates (hydrocarbons)
 - 2. Understand the neurotoxic effects of petroleum distillates (hydrocarbons)
 - c. Diagnostic evaluation
 - 1. Plan the diagnostic assessment and evaluation of a child suspected of petroleum distillate (hydrocarbon) ingestion
 - d. Treatment
 - 1. Recognize the respiratory indications for intubation after ingestion or aspiration of a liquid hydrocarbon
 - 2. Plan appropriate therapy for a child with acute petroleum distillate (hydrocarbon) exposure
- 13. Corrosive agents
 - a. Acids
 - 1. Diagnostic features
 - a. Recognize the clinical and laboratory manifestations of acid ingestion
 - 2. Diagnostic evaluation

- a. Plan the diagnostic assessment and evaluation of a child suspected of acid ingestion
 - 3. Treatment
 - a. Plan appropriate therapy for a child with acute acid ingestion
 - b. Recognize the potential airway compromise associated with caustic ingestion
 - b. Alkali
 - 1. Diagnostic features
 - a. Recognize the clinical and laboratory manifestations of acute alkali ingestion
 - 2. Pathogenesis and toxic effects
 - a. Understand the pathogenesis and toxic effects of ingested alkali
 - 3. Diagnostic evaluation
 - a. Plan the diagnostic assessment and evaluation of a child suspected of alkali ingestion
 - 4. Treatment
 - a. Plan appropriate therapy for a child with acute alkali ingestion
- 14. Organophosphate insecticide
 - a. Diagnostic features
 - 1. Recognize the clinical and laboratory manifestations of acute organophosphate poisoning
 - b. Pathogenesis and toxic effects
 - 1. Understand the pathogenesis and toxic effects of organophosphates
 - c. Normal elimination
 - 1. Know the normal metabolism, excretion, and pharmacokinetics of organophosphates
 - d. Diagnostic evaluation
 - 1. Plan the diagnostic assessment and evaluation of a child suspected of organophosphate poisoning
 - e. Treatment
 - 1. Plan appropriate therapy for a child with acute organophosphate poisoning
- 15. Heavy metals
 - a. Diagnostic features
 - 1. Recognize the clinical and laboratory manifestations of heavy metal poisoning other than lead (eg, iron, arsenic)
 - b. Pathogenesis and toxic effects
 - 1. Understand the pathogenesis and toxic effects of heavy metal poisoning
 - c. Normal elimination
 - 1. Know the normal metabolism, excretion, and pharmacokinetics of heavy metals
 - d. Diagnostic evaluation
 - 1. Plan the diagnostic assessment and evaluation for a child suspected of heavy metal poisoning
 - e. Treatment
 - 1. Plan appropriate therapy for a child with acute heavy metal poisoning
- 16. Carbon monoxide
 - a. Diagnostic features

1. Recognize the clinical and laboratory manifestations of carbon monoxide poisoning
- b. Pathogenesis and toxic effects
 1. Understand the pathogenesis and toxic effects of carbon monoxide
- c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of carbon monoxide
- d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of a child suspected of carbon monoxide poisoning
 2. Understand the effect of carbon monoxide and methemoglobin-inducing agents on measures of oxygenation
- e. Treatment
 1. Plan appropriate therapy for a child with acute carbon monoxide poisoning
 2. Know adjunctive therapy for carbon monoxide poisoning
17. Illicit ("street") drugs
 - a. Diagnostic features
 1. Recognize the clinical and laboratory manifestations of the use of illicit ("street") drugs other than cocaine (eg, LSD, MDMA, jimson weed)
 2. Know the signs of acute cocaine ingestion
 3. Know which illicit ("street") drugs can cause seizures
 - b. Pathogenesis and toxic effects
 1. Understand the pathogenesis and toxic effects of illicit ("street") drugs other than cocaine
 2. Understand the pathogenesis and toxic effects of cocaine
 - c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of illicit ("street") drugs other than cocaine
 2. Know the metabolism, excretion, and pharmacokinetics of cocaine
 - d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of a suspected overdose of an illicit ("street") drug
 - e. Assessment of extent and severity of injury
 1. Evaluate the extent and severity of an illicit ("street") drug intoxication
 - f. Treatment
 1. Plan appropriate therapy for a patient with an illicit ("street") drug overdose
18. Envenomation and bites
 - a. Diagnostic features
 1. Recognize the clinical and laboratory manifestations of snake envenomation
 2. Recognize the diagnostic features of venomous and nonvenomous spider bites
 - b. Pathogenesis and toxic effects
 1. Understand the pathophysiologic and toxic effects of various venoms
 - c. Treatment
 1. Plan appropriate therapy for a child with acute snake or spider envenomation
 2. Recognize anaphylaxis after envenomation, and plan its treatment
 3. Know the complications associated with antivenin therapy

19. Glycols and alcohols
 - a. Diagnostic features
 1. Recognize the clinical and laboratory manifestations of glycol or alcohol poisoning
 - b. Pathogenesis and toxic effects
 1. Understand the pathogenesis and toxic effects of glycol or alcohol poisoning
 2. Understand the pathogenesis and toxic effects of methanol ingestion
 3. Understand differential effects of ethanol ingestion in infants
 - c. Normal elimination
 1. Know the normal metabolism, excretion, and pharmacokinetics of glycols and alcohols
 - d. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of a child suspected of glycol or alcohol poisoning
 - e. Treatment
 1. Plan appropriate therapy for a child with acute glycol or alcohol poisoning
 2. Plan treatment for a patient with methanol ingestion
20. Biologic, chemical, and nuclear weapons
 - a. Diagnostic features
 1. Recognize the clinical and laboratory manifestations of anthrax, smallpox, plague, vesicants, and nerve agents
 - b. Pathogenesis and toxic effects
 1. Understand the pathogenesis and toxic effects of anthrax, smallpox, plague, vesicants, and nerve agents
 - c. Diagnostic evaluation
 1. Plan the diagnostic assessment and evaluation of suspected exposure to anthrax, smallpox, plague, vesicants, or nerve agents
 - d. Treatment
 1. Plan the management of a patient exposed to anthrax, smallpox, plague, vesicants, or nerve agents

10. Trauma and Burns

- A. Epidemiology
 1. Know the age- and gender-specific risk factors for traumatic injury
 2. Understand the common mechanisms of pediatric trauma and their associated injury patterns
 3. Understand the components of an effective injury prevention program
- B. Trauma systems
 1. Understand the various domains of trauma care: injury prevention, prehospital care, acute care facilities, posthospital care
 2. Understand the use of trauma scores (eg, AIS, ISS, GCS, revised trauma score) and the criteria for patient referral to a trauma hospital
 3. Understand the structure and process of the regionalization of trauma care
- C. Initial evaluation and stabilization
 1. Evaluate a patient with multiple trauma in the emergency department
 2. Plan control of the airway in a patient with multiple trauma in the emergency department

3. Identify the situations in which immediate surgical intervention is required
 4. Know the general principles and sequence of the concurrent evaluation, stabilization, and prioritization of injuries
- D. Specific injuries
1. Head injury (see III.C.7)
 2. Strangulation
 - a. Understand the pathophysiology of a strangulation or hanging injury
 3. Neck and spine injury
 - a. Know the risk factors for neck and spine injury
 - b. Know the proper clinical and radiographic evaluation of potential neck and spine injuries
 - c. Plan the appropriate stabilization of a patient with a suspected neck or spine injury
 4. Dental injury, facial and orbital fractures
 - a. Know the implications of dental injuries and facial or orbital fractures for airway compromise and management
 5. Chest injury (see also I.F.11 and II.D.9)
 - a. Evaluation
 1. Know the risk factors for traumatic chest injury
 2. Know the physical findings of traumatic hemothorax
 3. Know the physical findings of a traumatic tear of the major airway
 4. Recognize myocardial contusion as a result of closed chest injury
 5. Know the potential complications of closed chest injury
 6. Recognize flail chest and the associated mechanical respiratory impairment
 7. Recognize the clinical and radiographic findings with large vessel damage from closed chest injury and order appropriate additional diagnostic studies
 - b. Stabilization
 1. Plan stabilization of a child with a closed chest injury
 2. Plan the stabilization of a patient with a penetrating chest injury
 3. Know the appropriate management of flail chest
 - c. Treatment
 1. Plan the treatment of a patient with a penetrating chest injury
 6. Abdominal injury
 - a. Blunt trauma
 1. Pathogenesis and pathophysiology
 - a. Know the risk factors for blunt abdominal trauma
 - b. Understand the pathophysiology of compensatory responses to acute traumatic blood loss in blunt abdominal trauma
 - c. Understand the pathogenesis and pathophysiology of blunt abdominal trauma
 2. Evaluation
 - a. Physical examination
 1. Recognize external evidence of internal abdominal injury
 2. Recognize the signs and symptoms of abdominal compartment syndrome
 3. Know the risk factors for abdominal compartment syndrome
 4. Know the diagnostic criteria for abdominal compartment syndrome
 5. Plan treatment for a patient with abdominal compartment syndrome

- b. Laboratory assessment
 - 1. Know the indications for ultrasonography or CT scan in patients with blunt abdominal trauma
 - 2. Interpret the results of radiographic evaluation in blunt abdominal trauma
 - 3. Stabilization
 - a. Formulate fluid and blood component management strategy for hemorrhagic shock
 - 4. Treatment
 - a. Know the indications for and benefits and limitations of nonoperative management in a patient with blunt abdominal injury
 - b. Know the indications for and benefits and limitations of radiologic intervention to embolize abdominal organ injury with persistent bleeding or vascular stent to improve perfusion
 - c. Know the indications for operative management in a patient with blunt abdominal injury
 - b. Penetrating injury
 - 1. Pathogenesis and pathophysiology
 - a. Understand the pathogenesis and pathophysiology of penetrating abdominal injury
 - b. Know the early and late complications associated with penetrating abdominal injury
 - 2. Diagnosis
 - a. Know the diagnostic procedures to define a lacerated bowel
 - b. Recognize the signs and symptoms of bowel injury and the risks of delayed diagnosis
 - 3. Treatment
 - a. Know the principles of resuscitation for a patient with intra-abdominal laceration
 - b. Recognize life-threatening complications of intra-abdominal laceration
- 7. Extremity injuries
 - a. Evaluation of blood supply and neurologic function
 - 1. Recognize the signs of peripheral vascular insufficiency
 - 2. Plan the appropriate radiographic evaluation of potential vascular injury
 - 3. Plan the treatment of a patient with vascular insufficiency
 - 4. Recognize the signs of peripheral nerve injury
 - b. Fractures
 - 1. Evaluation
 - a. Plan the appropriate radiologic evaluation of potential fractures
 - b. Distinguish between nonintentional and intentional fractures
 - c. Recognize the signs and symptoms of compartment syndrome
 - d. Know the risk factors for compartment syndrome
 - e. Know the complications associated with compartment syndrome
 - 2. Stabilization
 - a. Recognize the complications associated with long bone fractures
 - b. Understand the time course and management of open and closed fractures

8. Submersion injuries
 - a. Epidemiology
 1. Know the epidemiology of submersion injuries
 2. Know the age- and gender-specific risk factors for submersion injury
 3. Understand the components of effective submersion injury prevention
 - b. Pathogenesis and pathophysiology
 1. Understand the pathogenesis and pathophysiology of pulmonary injury in near-drowning
 2. Recognize the potential for associated head/neck injury in near-drowning episodes
 3. Understand the pathogenesis and pathophysiology of multisystem organ dysfunction following hypoxic-ischemic injury from submersion
 - c. Evaluation
 1. Know the importance of water temperature in brain outcome from a submersion episode
 - d. Stabilization/treatment
 1. Know the management priorities following a submersion injury
 2. Evaluate neurologic function and prognosis after a submersion injury
9. Burns
 - a. Pathogenesis and pathophysiology
 1. Understand the pathogenesis and pathophysiology of various burn injuries
 - b. Evaluation
 1. Recognize the extent of upper airway injury in burn victims
 2. Distinguish between first-, second-, and third-degree burns
 3. Recognize the risk of fluid loss, electrolyte disturbance, and rhabdomyolysis associated with burn injury
 4. Understand the risk of circumferential burns and indications for escharotomy
 - c. Stabilization
 1. Plan the stabilization of a patient with burns of the nose and mouth
 - d. Treatment
 1. Know the fluid and electrolyte requirements of burn patients
 2. Know the risks of infection in burn patients
 3. Understand the benefits of excision and grafting in a patient with burn injury
 4. Understand the risks and benefits associated with the use of skin substitutes in the treatment of burn injury
 5. Understand the risks and benefits of topical burn medications
 6. Understand that burns cause hypermetabolic state
10. Smoke inhalation
 - a. Pathogenesis and pathophysiology
 1. Understand the pathogenesis and pathophysiology of different inhaled combustible toxins
 2. Understand the relationship between carbon monoxide poisoning and smoke inhalation
 3. Understand the different effects of steam and smoke inhalation
 - b. Evaluation
 1. Evaluate the extent of pulmonary injury in a smoke inhalation victim

- c. Stabilization/treatment
 - 1. Plan treatment for a patient with smoke inhalation
- 11. Lightning/electrocution injuries
 - a. Pathogenesis and pathophysiology
 - 1. Understand the pathogenesis and pathophysiology of lightning and electrical injuries
 - 2. Recognize that an electrical injury has effects on the central nervous system and heart that are unrelated to cutaneous burns
 - 3. Recognize that an electrical injury may be associated with delayed vascular injury
 - b. Evaluation
 - 1. Recognize entry and exit wounds from an electrical injury
 - c. Stabilization
 - 1. Know the principles of stabilization of a victim of lightning injury
- 12. Multiple trauma
 - a. Pathogenesis and pathophysiology
 - 1. Understand the pathogenesis and pathophysiology of multiple trauma
 - b. Evaluation
 - 1. Plan the evaluation of a patient with multiple traumatic injuries
 - c. Stabilization
 - 1. Plan the initial stabilization of a child with multiple trauma
 - 2. Understand the potential sequelae of multiple trauma
- 13. Environmental heat injury
 - a. Understand the epidemiology of heat stroke and prostration
 - b. Understand the pathogenesis and pathophysiology of heat injury
 - c. Know the clinical and laboratory manifestations of heat illness
 - d. Plan the treatment of a patient with heat stroke, including various cooling methods
- 14. Hypothermia (see also XIV.A.4)
 - a. Know the epidemiology of hypothermia
 - b. Understand the pathogenesis and pathophysiology of hypothermia
 - c. Know the clinical and laboratory manifestations of hypothermia
 - d. Plan the management of a patient with hypothermia, including rewarming methods
 - e. Understand the complications of rewarming hypothermic patients

11. Pharmacology

- A. Pharmacokinetics and pharmacodynamics
 - 1. Half-life concept
 - a. Apply measurement of half-life to plan therapeutic regimens
 - 2. Kinetic concepts
 - a. Differentiate between first-order and zero-order kinetics of drug metabolism
 - b. Understand the effects of drug loading doses
 - c. Understand changes in serum drug concentration with drug elimination
 - d. Know the effects of drug kinetics on drug serum concentrations as a function of time
 - 3. Patterns of absorption and routes of administration
 - a. Know the kinetics of intratracheal drug administration

- b. Understand the relationships between bioavailability and route of drug administration
 - c. Know the kinetics of intrathecal drug administration
 - d. Understand the patterns of aerosolized/nebulized drug uptake and distribution
 - e. Know the kinetics of intraosseous drug administration
 - f. Identify the factors that influence enteral drug absorption including drug-food interactions
 - g. Identify the factors that influence cutaneous drug absorption
 - h. Identify the factors that influence intramuscular drug absorption
4. Patterns of drug distribution
- a. Understand the volume distribution and role of fat solubility in drug distribution
 - b. Understand the effect of protein binding on the volume of drug distribution
 - c. Identify the factors that affect protein binding of drugs
 - d. Understand the developmental effects on drug distribution
5. Pathways of drug metabolism
- a. Understand the role of phase I reactions in drug metabolism
 - b. Understand the role of conjugation (phase II) reactions in drug metabolism
 - c. Understand the developmental effects on phase I and II reactions in drug metabolism
6. Patterns of drug excretion and elimination
- a. Understand the role of renal excretion in the elimination of certain drugs and the means to enhance this process
 - b. Understand the components and the concepts of drug clearance
 - c. Know the common, clinically relevant drug interactions
 - d. Know the common, clinically relevant pharmacokinetic alterations with organ dysfunction
 - e. Know the common, clinically relevant pharmacokinetic alterations with extracorporeal support
 - f. Identify the factors that alter renal drug excretion
 - g. Identify the factors that influence hepatic drug excretion
 - h. Understand the developmental effects on drug excretion and elimination
7. Blood-brain barrier and central nervous system penetration by drugs
- a. Recognize that the blood-brain barrier is generally more permeable to lipophilic substances than to hydrophilic substances
- B. Autonomic, neuroendocrine, and related drugs
1. Pharmacology of adrenergic neurons
- a. Know the mechanisms of norepinephrine inactivation, including neuronal uptake, and how this process is altered
 - b. Know the agents that alter norepinephrine re-uptake (eg, cocaine, imipramine, amphetamines)
2. Pharmacology of adrenergic receptors
- a. Differentiate between alpha-1, alpha-2, beta-1, and beta-2 type adrenergic drug action
 - b. Understand the conditions that change adrenergic receptor density
 - c. Understand the conditions that change signal transduction in response to adrenergic receptor stimulators

3. Pharmacology of acetylcholine synapses
 - a. Know that physostigmine crosses the blood-brain barrier, whereas neostigmine does not
 - b. Know the agents that alter transmission at the cholinergic synapse (eg, cholinesterases)
4. Pharmacology of acetylcholine receptors
 - a. Differentiate between the actions of nicotinic and muscarinic acetylcholine blockers and sites of action at autonomic ganglia, neuromuscular junction, and visceral organs
- C. Anesthetic agents (see also XII.B and XII.F)
 1. Understand the relationship between absorption, distribution, and elimination of general anesthetics and their effects
 2. Understand the effects of combining anesthetic agents
- D. Sedatives (see also XII.B and XII.F)
 1. Understand the relationship between absorption, distribution, and elimination of sedatives and their effects
 2. Recognize the adverse effects of sedatives and their metabolites
 3. Understand the factors that enhance phenobarbital elimination
- E. Analgesics (see also XII.B and XII.F)
 1. Understand the relationship between absorption, distribution, and elimination of analgesics and their effects
 2. Recognize the adverse effects of analgesics
 3. Know the comparative analgesic effects of different agents
 4. Know the durations of actions of analgesic agents
 5. Know the methods for reversing and treating the effects of analgesics
- F. Vasoactive agents
 1. Understand the relationship between absorption, distribution, and elimination of vasodilating agents and their effects
 2. Recognize the adverse effects produced by vasodilating agents
 3. Know the therapies for the adverse effects of vasodilators
 4. Know the effects of common drugs on systemic vascular resistance
 5. Know the pharmacology of common vasoactive drugs and hormones
- G. Inotropic agents
 1. Differentiate among sympathomimetic agents on the basis of their affinities for adrenergic receptor subtypes
 2. Understand the relationship between absorption, distribution, and elimination of inotropic agents and their effects
 3. Understand the mechanism of action of commonly used inotropic drugs
- H. Inodilators
 1. Understand the mechanism of action of inodilators in improving cardiac output
 2. Understand the implications of milrinone's significantly different serum half-life in contrast to adrenergic-receptor agonists
 3. Understand the differences in mechanism of action between the various inodilators
- I. Vasopressors
 1. Understand the different relative effects on vascular tone among adrenergic receptor agonists

2. Know the risks and benefits of vasopressor use in various types of shock
- J. Cholinergic antagonists
1. Understand the end-organ pharmacologic response to the administration of cholinergic antagonists
 2. Know the mechanism of action of anticholinergic drugs as bronchodilators
- K. Anticonvulsants
1. Understand the normal mechanisms of metabolism, absorption, distribution, and elimination of the common anticonvulsants and the relationship between their pharmacokinetics and their effects
 2. Recognize the effects of anticonvulsants on the metabolism of other drugs
 3. Understand the mechanism of action of specific anticonvulsants
- L. Beta-2 agonists
1. Understand the relationship between absorption, distribution, and elimination of beta-2 agonists and their effects
- M. Calcium channel-blocking drugs
1. Distinguish among the calcium channel blockers with respect to their relative antidysrhythmic, negative inotropic, and vasodilating activities
- N. Beta-blocking drugs
1. Understand the relationship between absorption, distribution, and elimination of beta blockers and their effects
 2. Recognize the adverse effects of beta blockers and the therapy for these effects
- O. Diuretics
1. Distinguish among the various classes of diuretics with respect to their site of action in the renal tubule
 2. Understand the relationship between absorption, distribution, and elimination of diuretics and their effects
 3. Recognize the adverse effects of diuretics and the therapy for these effects
- P. Antidysrhythmics
1. Distinguish among the various classes of antidysrhythmic drugs with respect to their effect on impulse action potential in the conduction system of the heart
 2. Understand the relationship between absorption, distribution, and elimination of antidysrhythmic drugs and their effects
 3. Recognize the adverse effects of antidysrhythmic drugs and the therapy for these effects
 4. Know the mechanism of action and toxicity of common antidysrhythmic medications
- Q. Immunosuppressive drugs
1. Know the mechanism of action of commonly used immunosuppressive drugs
 2. Recognize the drug interactions between drugs commonly used in the PICU and immunosuppressive drugs
- R. Natriuretic peptides
1. Know the mechanism of action of B-type natriuretic peptide (nesiritide)
- S. Anticoagulants
1. Know the side effects of various thrombolytic agents
 2. Understand the differences between thrombolytic agents that activate and do not activate plasminogen
 3. Understand the pathophysiology of heparin-induced thrombocytopenia

4. Know the side effects of various anticoagulant agents
5. Understand the elimination of anticoagulants
6. Know the side effects of various anti-platelet agents, including glycoprotein IIa/IIIb inhibitors, ADP receptor inhibitors, prostaglandin analogs, COX inhibitors, and other drugs affecting platelet function
7. Know the side effects of antifibrinolytic agents

12. **Anesthesiology, Perioperative Care, and Procedural Sedation**

A. Preoperative considerations

1. Assessing operative risk

a. Cardiovascular risk

1. Congenital heart disease

a. Right-to-left shunts

1. Understand the effects of anesthetic-induced alteration of blood pressure on right-to-left shunts

b. Left-to-right shunts

1. Know the consequences of the administration of 100% oxygen to patients with left-to-right shunts due to interventricular communications
2. Understand the effects of anesthetic-induced alteration of blood pressure on left-to-right shunts

c. Obstructive lesions

1. Recognize the risk that hypotension poses to the myocardial status of a patient with critical valvular obstruction

d. Cardiac rhythm

1. Understand how anesthetics alter cardiac rate and rhythm and the associated risks in patients with dysrhythmias

2. Hypovolemia

- a. Understand the importance of volume status in a patient with heart disease

3. Myocardial dysfunction

- a. Recognize the effects of anesthetic drugs on myocardial function, heart rate, and systemic vascular resistance
- b. Know that narcotics cause the least depression of myocardial function of all anesthetics
- c. Recognize that a patient with sepsis may have impaired myocardial function and hence an exaggerated risk of cardiac depression during anesthesia

b. Pulmonary risk

1. Understand the anesthetic/muscle relaxant implications in patients with respiratory failure of neuromuscular origin
2. Understand the anesthetic/muscle relaxant implications in patients with respiratory failure of central origin secondary to lack of respiratory drive
3. Understand the anesthetic/muscle relaxant implications in patients with respiratory failure due to abnormal alveolar gas exchange
4. Understand the anesthetic/muscle relaxant implications in patients with respiratory failure secondary to parenchymal lung or small airways disease
5. Understand the anesthetic/muscle relaxant implications in patients with respiratory failure secondary to pulmonary vascular disease

6. Recognize respiratory failure as a factor that increases the risk of hypoxemia during anesthesia
7. Understand the respiratory effects of anesthesia on minute ventilation, lung volumes, airway resistance, and lung compliance
- c. Neurologic risk
 1. Understand that anesthetic-induced coma cannot be differentiated from coma resulting from neurologic and other causes
2. Full stomach (see also XIII.A.1.c.(7))
 - a. Plan preoperative airway management for a patient with a "full stomach"
 - b. Understand which patients are at risk for a "full stomach" for anesthesia/sedation
- B. Key effects of specific anesthetics and related drugs
 1. Inhalation anesthetics
 - a. Understand the hemodynamic effects of inhaled anesthetics
 - b. Know the differences in onset and offset of inhaled anesthetics
 - c. Understand the respiratory effects of inhaled anesthetics
 2. Muscle relaxants
 - a. General
 1. Pharmacokinetics
 - a. Know the mechanism of action of commonly used muscle relaxants
 - b. Know the metabolism of commonly used muscle relaxants
 - c. Differentiate between depolarizing and nondepolarizing drugs
 2. Drug-relaxant interactions: prolongation/potential of effect
 - a. Judge which muscle relaxants are appropriate for use in patients with renal and/or hepatic failure
 - b. Recognize that aminoglycosides prolong neuromuscular blockade
 - c. Know the effect of hypocalcemia/hypomagnesemia on neuromuscular blockade
 - d. Know which drugs prolong or potentiate the effects of muscle relaxants
 - e. Understand how the effects of muscle relaxants can be prolonged or potentiated
 3. Evaluation of residual effect
 - a. Understand the relationship between absorption, distribution, and elimination of agents producing neuromuscular blockade and their effects
 - b. Know how to evaluate residual neuromuscular blockade with the use of a twitch monitor
 - c. Recognize that a patient may have no residual muscle blockade but can become paralyzed again if hypokalemic, hypomagnesemic, cold, or poorly perfused
 - d. Know the commonly used agents reversing neuromuscular blockade and their side effects
 - e. Know how to assess residual neuromuscular blockade by history and physical examination
 - f. Understand the rationale for combining atropine with a cholinesterase inhibitor
 4. Absence of sedative/analgesic action

- a. Recognize that muscle relaxants have no sedative, analgesic, or anxiolytic properties
 - b. Know that pupillary response is usually spared during the use of neuromuscular blocking agents (ie, muscle relaxants)
- 5. Relative sensitivity of different muscles
 - a. Know the relative sensitivity of different muscle groups to muscle relaxants
- b. Specific
 - 1. Succinylcholine
 - a. Know that succinylcholine causes massive potassium release, dysrhythmias, cardiac arrest, and death in burn patients, in patients with crush injuries and spinal cord injuries, and in patients with renal failure
 - b. Recognize sinus bradycardia/sinus arrest as potential complications of succinylcholine paralysis
 - c. Recognize myoglobinuria as a potential complication of succinylcholine administration
 - d. Know that succinylcholine can increase intracranial pressure
 - e. Recognize the conditions in which the use of succinylcholine has increased risks
 - f. Know the causes of prolonged effect of succinylcholine
 - 2. Pancuronium
 - 3. Vecuronium
 - a. Know that vecuronium has only minor hemodynamic effects
 - b. Recognize that liver failure prolongs the paralytic effect of vecuronium
 - 4. Cisatracurium
 - a. Know that the hemodynamic effects of cisatracurium are minimal
 - b. Know that cisatracurium is eliminated by Hoffman degradation
 - c. Know that cisatracurium clearance is not dependent on liver or renal function
 - 5. Rocuronium
 - a. Know that the speed of onset and duration of action of rocuronium is dose-dependent
- 3. Ketamine
 - a. Recognize the sympathetic stimulation produced by ketamine, as well as the consequences of this stimulation
 - b. Understand that ketamine maintains airway reflexes
 - c. Know that ketamine is a cause of hallucinations
 - d. Understand that ketamine-induced hallucinations can be prevented/treated with benzodiazepines
- 4. Narcotics
 - a. Understand the mechanism of action of narcotic analgesics
 - b. Know the duration of action of commonly used narcotic analgesics
 - c. Understand and differentiate the concepts of tolerance, dependence, and addiction associated with narcotic analgesia
 - d. Understand methods of weaning patients from narcotic analgesia in the ICU
 - e. Understand the potential benefits of patient-controlled analgesia
 - f. Understand the use of specific narcotic antagonists

5. Propofol
 - a. Understand the use of propofol and the associated risks
 - b. Recognize the association between propofol infusion and acidosis, hypotension, and death in children
6. Etomidate
 - a. Understand the indications for, use of, and side effects of etomidate
 - b. Understand the high potential for adrenal suppression from a single dose of etomidate and the consequences in certain patients (eg, with septic shock)
7. Dexmedetomidine
 - a. Understand the mechanism of action of, indications for, and use and side effects of dexmedetomidine
8. Local anesthetics (amides versus esters)
 - a. Signs of toxicity
 1. Understand that local anesthetics can produce seizures, and know at what doses seizures are likely to occur
 2. Recognize that many local anesthetics are mixed with epinephrine and that catecholamines can produce systemic alterations
 3. Recognize the complications associated with the accidental intravenous injection of local anesthetics
 4. Know that profound myocardial depression can result from the use of local anesthetics
 5. Recognize the early symptoms of local anesthetic toxicity
 6. Understand the risk of intravascular injection of bupivacaine local anesthetic and its use as an epidural anesthetic
 - b. Treatment of toxicity
 1. Plan the treatment of a patient with seizures secondary to local anesthesia
 2. Understand the treatment of local anesthetic toxicity with intravenous fat emulsion
9. Major tranquilizers
 - a. Sedatives
 1. Know the duration of action and complications of diazepam
 2. Know the duration of action and complications of midazolam
 3. Know the duration of action and complications of lorazepam
 4. Know the specific reversal agents for the various benzodiazepines, the appropriate use of such agents, and complications associated with their use
 - b. Butyrophenones
 1. Recognize the potential risk of cardiac dysrhythmias and their relation to prolonged QT interval associated with the use of butyrophenones
- C. Malignant hyperthermia
 1. Risk factors
 - a. Recognize the significance of family history as a risk factor for fatal complications during anesthesia
 - b. Know that abnormal neuromuscular function is important in predicting malignant hyperthermia
 - c. Recognize the risk factors for malignant hyperthermia
 - d. Know the chronology of the onset of malignant hyperthermia

2. Clinical signs
 - a. Differentiate postoperative fever (low-grade) from malignant hyperthermia
 - b. Recognize malignant hyperthermia in the patient not exposed to anesthetic drugs
 - c. Know that clinical signs of acidosis, cyanosis, and increased CO₂ production may antedate defined muscle spasm in malignant hyperthermia
 - d. Recognize the clinical and laboratory manifestations of malignant hyperthermia (fever, acidosis, dysrhythmias, cyanosis, increased CO₂ production, masseter spasm, muscle rigidity, disseminated intravascular coagulation, coma)
 3. Associated laboratory findings
 - a. Recognize the laboratory manifestations of malignant hyperthermia (hyperkalemia, increased serum creatine kinase activity, hypercalcemia)
 4. Treatment
 - a. Know how to treat malignant hyperthermia with dantrolene
 - b. Know the roles of environmental cooling, core cooling, bicarbonate, and antidysrhythmic therapies in malignant hyperthermia
 5. Triggering agents
 - a. Know the agents that may trigger malignant hyperthermia (potent inhalation anesthetics such as halothane, isoflurane, enflurane, etomidate, etc; succinylcholine; non-anesthetic stress)
 6. "Safe" agents
 - a. Know the drugs that are generally safe to use in a patient susceptible to malignant hyperthermia (nondepolarizing relaxants, narcotics, nitrous oxide, barbiturates, propofol)
- D. Neuroleptic malignant syndrome
1. Clinical signs
 - a. Differentiate neuroleptic malignant syndrome from sepsis and other causes of fever
 2. Associated laboratory findings
 - a. Recognize neuroleptic malignant syndrome by its clinical and laboratory manifestations
 3. Triggering agents
 - a. Recognize that malignant hyperthermia can be triggered by the use of neuroleptic drugs
 4. Treatment
 - a. Know how to treat neuroleptic malignant syndrome
- E. Postoperative concerns
1. Evaluation of failure to awaken
 - a. Residual anesthetic effects
 1. Recognize residual effects of inhalation anesthetic, narcotic, or muscle relaxant as a cause of postoperative respiratory failure and failure to awaken after surgery
 - b. Hypothermia
 1. Recognize hypothermia as a cause of failure to awaken after anesthesia
 - c. Hypoxic/ischemic encephalopathy
 1. Differentiate residual anesthetic effect from hypoxic insult, residual muscle paralysis, and central nervous system insult
 - d. Spinal cord injury

1. Recognize the possibility of intraoperative spinal cord injury in patients with unstable cervical spines
 - e. Hypoglycemia
 1. Recognize that intraoperative management can lead to hypoglycemia that results in failure to emerge from anesthesia
 2. Evaluation of postoperative respiratory insufficiency
 - a. Central nervous system depression
 1. Understand that central nervous system depression from anesthesia may produce decreased respiratory drive even when a patient is conscious
 - b. Airway obstruction
 1. Recognize airway trauma, edema, and injury of the recurrent laryngeal nerve as causes of postoperative respiratory insufficiency
 - c. Residual neuromuscular blockade
 1. Recognize residual neuromuscular blockade and resultant weakness as a cause of respiratory insufficiency after an operation
 - d. Pulmonary dysfunction
 1. Differentiate "splinting" after chest or abdominal surgery from true lung disease
 2. Recognize abdominal distension as a cause of respiratory insufficiency after an operation
 3. Recognize phrenic nerve injury as a cause of respiratory insufficiency after an operation
 4. Recognize pneumothorax as a cause of respiratory insufficiency after an operation
 5. Know the relative effects of various operations on different body regions and their effects on "splinting" and postoperative atelectasis
 - e. Parenchymal disease
 1. Differentiate upper airway obstruction following extubation from primary lung dysfunction
 3. Fluid management
 - a. Evaluating intraoperative fluid administration
 1. Recognize that deficit, maintenance, insensible, and ongoing fluid losses must be considered during intraoperative fluid replacement
 2. Recognize hypovolemia secondary to inadequate intraoperative fluid administration
 3. Recognize hypervolemia secondary to intraoperative fluid administration
 - b. SIADH secondary to surgery (ADH secretion, etc)
 1. Recognize the conditions associated with increased postoperative ADH secretion
 4. Shivering
 - a. Know the metabolic, respiratory, and central nervous system effects of shivering
 5. Agitation
 - a. Understand the causes of persistent postoperative sinus tachycardia (including hypoxemia, hypoventilation, pain, bladder distention, residual drug effect, hypoxia, anxiety)
 - b. Understand the causes and treatment of postoperative emergence delirium
- F. Management of pain and sedation in the intensive care unit

1. General
 - a. Understand the pathophysiology of pain
 - b. Recognize that antinociception improves postoperative outcomes
 - c. Plan pain management for patients with various conditions and in various circumstances, including burn debridement and chest tube insertion/removal
2. Pain assessment
 - a. Understand the concept of pain scales and objective pain assessment
 - b. Assess pain in the intubated patient
3. Regional anesthesia/analgesia for management of postoperative pain
 - a. Caudal/epidural analgesia
 1. Know the indications for caudal/epidural postoperative pain control
 2. Know the complications of caudal/epidural postoperative pain control
 - b. Peripheral nerve blocks
 1. Know the indications for postoperative nerve blocks
 2. Know the complications associated with the use of nerve blocks for postoperative pain control
4. Procedural sedation
 - a. Understand the definitions and clinical characteristics of the levels of procedural sedation ranging from mild to moderate to deep sedation
 - b. Know the national guidelines governing procedural sedation
 - c. Plan sedation for a patient with a compromised airway
5. Long-term sedation
6. Withdrawal syndromes
 - a. Recognize withdrawal syndromes associated with narcotics, barbiturates, and benzodiazepines and know how to manage them

13. Technical Procedures

A. Establishing an airway

1. Intubation
 - a. Selection of endotracheal tubes
 1. Know how to determine the appropriate size endotracheal tube
 2. Know the reasons to use a cuffed endotracheal tube
 - b. Indications
 1. Recognize the neurologic indications for intubation of a child who has ingested a central nervous system depressant
 2. Understand that intubation may be indicated despite good respiratory function, as in the case of head trauma or increased intracranial pressure
 3. Know that intubation may be indicated prior to the onset of respiratory failure in patients with muscle weakness
 4. Know that hemodynamic instability may necessitate intubation prior to the onset of respiratory failure
 5. Know the conditions in which nasotracheal intubation is safe
 6. Identify the conditions in which nasotracheal intubation is indicated or contraindicated
 7. Understand the advantages and risks associated with nasotracheal intubation
 8. Know that failure of airway protective reflexes may necessitate intubation even when respiratory function is adequate

- c. Special conditions
 - 1. Upper airway obstruction
 - a. Potential for rapid progression
 - 1. Understand the rapidity of intubation that is required in the setting of true upper airway obstruction
 - b. Distorted anatomy
 - 1. Understand that neuromuscular blockade for intubation should be performed with caution in patients with upper airway obstruction, congenital airway abnormalities, or an anterior mediastinal mass
 - c. Risks of sedation/muscle relaxants
 - 1. Understand the risks associated with sedation of patients with upper airway obstruction, congenital airway abnormalities, or an anterior mediastinal mass
 - d. Role of inhalation anesthetics
 - 1. Understand the advantages of using inhalation anesthesia and lidocaine spray in intubating patients with upper airway obstruction
 - 2. Facial trauma
 - a. Recognize the conditions of facial trauma for which oral intubation is preferred over nasal intubation
 - b. Know that a nondepolarizing muscle relaxant is required when intubating a patient with a lacerated eye globe to avoid increased intraocular pressure
 - c. Recognize the risks and difficulties associated with the intubation of patients with facial lacerations
 - d. Recognize the difficulties of using bag-mask ventilation in patients with oropharyngeal bleeding, possible foreign body aspiration, facial burns, or anaphylaxis
 - 3. Airway burns
 - a. Know that facial or airway burns may require early intubation prior to swelling
 - 4. Difficult anatomy
 - a. Recognize micrognathia as a factor complicating intubation
 - b. Recognize that macroglossia may be a complicating factor in intubation
 - c. Know the importance of testing temporomandibular motion in planning airway management
 - d. Know that laryngeal injury may occur following hanging
 - e. Know that tracheal tears may occur in trauma patients with pneumomediastinum and/or pneumothorax
 - 5. Head trauma and/or elevated intracranial pressure
 - a. Manage the intubation of a child with head injury
 - b. Know how to prevent increased intracranial pressure during intubation
 - c. Know that struggling during intubation can dangerously increase intracranial pressure
 - d. Understand how to use various drugs to minimize increased intracranial pressure during intubation
 - 6. Spinal cord injury
 - a. Know how to intubate a patient with a cervical spine injury

7. Full stomach (see also XII.A.3)
 - a. Recognize that injury, ileus, or trauma can produce a "full stomach" situation for intubation
 - b. Recognize that airway or upper gastrointestinal bleeding may pose a "full stomach" situation for intubation
 - c. Know how to apply the rapid-sequence technique for intubation of a child with a full stomach
 - d. Complications
 1. Physical
 - a. Recognize the significance of trismus during intubation
 - b. Know the complications associated with endotracheal intubation
 - c. Know the factors associated with the development of subglottic stenosis in patients who are intubated
 - d. Know the emergency management of laryngeal spasm
 2. Infectious (see IV.B.8.b)
 2. Cricothyroidotomy
 - a. Indications
 1. Know the indications for cricothyroidotomy
 - b. Technique
 1. Know the technique for cricothyroidotomy
 - c. Risks
 1. Know the complications of cricothyroidotomy
 3. Tracheostomy
 - a. Know the indications for tracheostomy
 - b. Know the complications associated with tracheostomy
 4. Laryngeal mask airway
 - a. Indications
 1. Know the indications and contraindications for use of the laryngeal mask airway
 - b. Technique
 1. Know the technique for insertion of the laryngeal mask airway
 - c. Risks
 1. Know the complications of the laryngeal mask airway
- B. Vascular access
1. Peripheral intravenous catheterization
 - a. Plan the treatment of infiltration with vasoconstricting drugs
 2. Arterial catheterization
 - a. Technique
 - b. Sites to avoid
 1. Know that the brachial artery is to be avoided during arterial catheterization because of a lack of collateral flow
 2. Know that the temporal artery is to be avoided during arterial catheterization because of neurologic complications
 3. Know the appropriate sites for arterial vascular cannulation
 - c. Risks
 1. Ischemia

- a. Know how to detect arterial ischemia in patients with arterial catheters
- 2. Antegrade embolization
 - a. Understand the conditions associated with cerebral air embolism in patients with arterial catheters
 - b. Recognize distal embolism secondary to arterial catheterization
- 3. Retrograde embolization
 - a. Understand the risks associated with retrograde embolization in patients with arterial catheters
- 4. Accidental intra-arterial injection
 - a. Know how to treat accidental intra-arterial injection associated with arterial catheters
- 3. Central venous catheterization
 - a. Indications
 - 1. Know the indications for central venous catheterization
 - b. Sites
 - 1. Know the various sites for venous catheterization
 - c. Techniques for placement
 - 1. Know the techniques for internal jugular catheterization
 - 2. Know the techniques for subclavian vein catheterization
 - 3. Determine vascular catheter position by radiography
 - 4. Know the techniques for femoral catheterization
 - 5. Know the appropriate location for the catheter tip relative to the vein being catheterized
 - 6. Know the techniques for ultrasonography-guided insertion of central venous catheters
 - d. Risks
 - 1. Understand the risks associated with central venous catheterization (eg, hemorrhage, perforation of vein or heart, air embolus, thrombus formation, infection, trauma to surrounding structures)
- 4. Intraosseous infusion
 - a. Indications
 - 1. Know the indications and contraindications for intraosseous infusion
 - b. Technique
 - 1. Know the technique and sites for intraosseous infusion
 - c. Risks
 - 1. Know the complications of intraosseous infusion
- 5. Infectious complications of intravascular catheters (see IV.B.8.c)
 - a. Know how to minimize catheter-related infections
- C. Pleural drainage
 - 1. Know how to place a thoracostomy drainage tube using anatomical landmarks such as the height of the liver
 - 2. Understand that multiple chest tubes may be required on one side
 - 3. Recognize a chest tube leak
 - 4. Recognize a bronchopleural fistula
 - 5. Know the risks associated with thoracostomy tube placement

6. Understand the principles techniques, and complications of and indications for external pleural drainage
- D. Pericardiocentesis
 1. Understand the techniques used to guide pericardiocentesis
 2. Know the indications and contraindications for and complications of pericardiocentesis
- E. Abdominal paracentesis
 1. Know the technique and interpretation of abdominal paracentesis and the use of ultrasonography for abdominal paracentesis
 2. Know the indications for abdominal paracentesis or diagnostic peritoneal lavage
 3. Know the indications for and complications of paracentesis in abdominal compartment syndrome
- F. Cardiopulmonary resuscitation (CPR)
 1. Airway
 - a. Know the proper technique and positioning of the patient to open the airway during CPR
 2. Breathing
 - a. Know the proper breathing technique to apply during CPR for a patient with an obstructed airway
 - b. Know the proper sequencing of rescue breaths with chest compressions during CPR of pediatric and adult patients
 3. Chest compression
 - a. Understand the indications for and reasons why open chest CPR may be indicated in certain circumstances
 - b. Understand the principles of closed chest compression during CPR
 4. Drug therapy and access
 - a. Recognize that, during CPR, unusual routes of drug administration may be used when venous access is limited (eg, bone marrow, endotracheal administration)
 - b. Understand the reasons why alpha-adrenergic agonist drugs are often used in CPR
 - c. Know the indications for vasoactive, acid-base, and calcium therapy during CPR
 - d. Know the indications and appropriate agents to use for shock-resistant ventricular fibrillation and ventricular tachycardia
 5. Defibrillation and cardioversion
 - a. Know how to set a machine for defibrillation with the synchronous on/off switch
 - b. Recognize the indications for defibrillation during CPR
 - c. Know the use of automated external defibrillators (AEDs)
 - d. Know the energy required for defibrillation and cardioversion (biphasic and direct current)
 6. Outcome
 - a. Know the prognosis for outcome of CPR in inpatient vs outpatient settings
 - b. Know when to discontinue CPR
 - c. Know the indications for prolonged CPR
 7. Complications
 - a. Know how to identify the various complications of CPR
- G. Extracorporeal membrane oxygenation (ECMO)
 1. Circuitry

- a. Understand venoarterial ECMO circuitry
- b. Understand venovenous ECMO circuitry
- 2. Indications and contraindications
 - a. Know the respiratory indications and contraindications for the use of ECMO
 - b. Understand the reasons for ruling out total anomalous pulmonary venous connection prior to ECMO
 - c. Know the cardiac indications and contraindications for the use of ECMO
 - d. Understand the use of ECMO in CPR (eCPR)
 - e. Understand the use of centrifugal versus roller pumps in ECMO
- 3. Technique
 - a. Realize that the carotid artery may be ligated during ECMO in neonates
- 4. Physiology
 - a. Understand the physiology of blood flow and gas exchange during venovenous and venoarterial ECMO
- 5. Outcome
 - a. Understand the current thinking about long-term neurologic follow-up in patients who have undergone ECMO
- 6. Complications
 - a. Recognize the complications of the use of ECMO, particularly hemolysis, bleeding, and infection
- H. Ventricular assist devices
 - 1. Know the indications for use of ventricular assist devices
 - 2. Understand the limitations of size and duration of ventricular assist devices
 - 3. Know the complications associated with the use of ventricular assist devices and how they are detected
- 14. Principles of Monitoring**
 - A. Noninvasive
 - 1. Pulse and blood pressure
 - a. General
 - 1. Understand the noninvasive techniques for measurement of vascular pressure
 - 2. Recognize artifacts of invasive and noninvasive vascular pressure measurement
 - b. Variations
 - 1. Know that blood pressure measurement varies with the site of acquisition
 - 2. Understand the reasons for differences in measured blood pressure at different sites
 - 3. Know the normal variation of blood pressure with age
 - 2. Respiration
 - a. Rate and rhythm
 - 1. Understand how the measurement of respiratory rate may change with level of consciousness or sleep
 - 2. Understand the mechanics of impedance monitoring
 - 3. Recognize the limitations of impedance monitoring
 - b. Oxygenation
 - 1. Understand the mechanism for determining the oxygen saturation of hemoglobin via pulse oximetry
 - 2. Know the conditions in which pulse oximetry results may be erroneous

3. Know that carboxyhemoglobin concentrations can result in erroneously high oxygen saturation of hemoglobin during pulse oximetry
4. Know the potential errors caused by movement of the patient during pulse oximetry
5. Know the potential effects of peripheral vasoconstriction on pulse oximetry measurements
- c. Capnography (sidestream versus mainstream)
 1. Recognition of airway obstruction
 - a. Understand the use of capnography in the clinical setting of airway obstruction
 2. Limitations as a predictor of arterial PCO₂
 - a. Understand that the sampling rate of gas withdrawal makes capnography difficult in neonates and small children
 - b. Understand that there are physiologic conditions in which capnography will not correlate well with arterial CO₂, as in obstructions to pulmonary blood flow from air or pulmonary embolus, or an increase in V_d/V_t
 - c. Know that capnography may be helpful in consideration of the diagnosis of pulmonary embolus
 3. Assessment of endotracheal tube position
 - a. Understand the role of capnography in identifying esophageal tube placement
 - b. Know that capnography cannot distinguish pharyngeal or main stem bronchial tube placement from tracheal placement
3. Monitoring metabolic function and gas exchange
 - a. Oxygen consumption
 1. Understand how to measure oxygen consumption with regard to how and where measurements are made
 2. Understand the effects of intravenous nutrition on metabolic rate
 - b. Carbon dioxide production
 1. Understand how and where to make measurements needed for calculation of carbon dioxide production
 - c. Haldane transformation
 1. Understand how oxygen levels alter carbon dioxide curves (Haldane effect)
4. Temperature
 - a. Measurement of core temperature
 1. Know the significance of the variation between core and peripheral temperature readings
 - b. Monitoring hypothermia
 1. Know how to monitor a patient with hypothermia
5. Neuromuscular junction monitoring
 - a. Single twitch monitoring
 1. Understand that nondepolarizing neuromuscular blockade cannot be reversed until there is a twitch present on neuromuscular junction monitoring
 2. Know that the height of a single twitch is not altered until 75% of receptors are occupied during neuromuscular junction monitoring

3. Know the relationship between clinical signs of recovery from neuromuscular blockade and ability to maintain independent respiratory function
 4. Understand the risk factors for prolonged neuromuscular weakness following neuromuscular blockade
 - b. Train-of-four stimulation
 1. Interpret the results of train-of-four stimulation
- B. Invasive
1. Arterial catheterization
 - a. Components of the arterial waveform
 1. Recognize catheter "fling"
 2. Recognize catheter damping
 3. Know how length and size of tubing alter arterial waveform
 4. Interpret different arterial pressures in different limbs
 5. Recognize catheter "ring"
 6. Know the causes of damping
 - b. Temporal relation of the arterial waveform to the ECG
 1. Know the timing and physiologic basis of the components of the arterial waveforms
 2. Understand the relationship between arterial waveform components and ECG
 3. Recognize the alterations of waveforms secondary to dysrhythmias
 - c. Alterations in the waveform
 1. Hemodynamic disorders
 - a. Recognize the different arterial waveforms generated by differing pathologic conditions
 2. Drug effects
 - a. Recognize the effects of drugs on arterial waveforms
 3. Effects of respiration
 - a. Know the effects of respiration on arterial waveforms
 2. Central venous catheterization
 - a. Effect of respiratory cycle
 1. Spontaneous respiration
 - a. Know the relationship of spontaneous respiration to the central venous pressure waveform
 2. Mechanical respiration
 - a. Know the effects of positive-pressure ventilation on the central venous pressure waveform
 - b. Components of the venous waveform
 1. Know the normal components of the venous waveform
 2. Interpret pressure tracings and changes related to cardiopulmonary interactions
 - c. Interpretation in presence of cardiac dysfunction
 1. Understand the effects of altered cardiac physiology on the central venous pressure waveform
 2. Recognize waveforms and changes related to catheter position, atrioventricular synchrony, intravascular volume status, and artifact
 - d. Temporal relation of the waveform to the ECG
 1. Understand the relationship between venous waveform components and ECG

2. Recognize the alterations of venous waveforms secondary to dysrhythmias
3. Invasive hemodynamic monitoring
 - a. Zeroing
 1. Understand the techniques of zeroing in hemodynamic monitoring
 - b. Calibration
 1. Know how to calibrate a vascular pressure monitor
 - c. Resonance
 1. Understand the concept of resonance in hemodynamic monitoring
 - d. Damping
 1. Understand the concept of damping
 - e. Catheter whip
 1. Understand the physiology of catheter whip
4. Transducers
 - a. Understand the basic physics involved in the use of transducers
5. Intracranial pressure monitoring
 - a. Devices
 1. General
 - a. Know the available methods for monitoring intracranial pressure
 2. Epidural devices
 - a. Know the technique of epidural monitoring of intracranial pressure
 - b. Know the complications associated with epidural monitoring of intracranial pressure
 - c. Know the limitations of epidural monitoring of intracranial pressure
 3. Subarachnoid devices
 - a. Know the technique of subarachnoid monitoring of intracranial pressure
 - b. Know the complications associated with subarachnoid monitoring of intracranial pressure
 - c. Know the limitations of subarachnoid monitoring of intracranial pressure
 4. Intraventricular cannulae
 - a. Know the technique of intraventricular monitoring of intracranial pressure
 - b. Know the complications associated with intraventricular monitoring of intracranial pressure
 - c. Know the limitations of intraventricular monitoring of intracranial pressure
 - b. Indications
 1. Recognize the indications for monitoring intracranial pressure
 - c. Contraindications
 1. Know that bleeding disorders are a relative contraindication for placement of intracranial pressure monitors
 2. Understand the risks associated with monitoring intracranial pressure
 - d. Interpretation of waveform(eg, pressure spikes)
 1. Differentiate the waveform produced by a working intracranial pressure monitor from one which is damaged or occluded
 2. Understand the significance of pressure spikes and of plateau waves during intracranial pressure monitoring
 3. Recognize that intracranial pressure may be different in different brain regions

4. Recognize waveform patterns, including respiratory variation and plateau wave, in intracranial pressure monitoring
- e. Concept of cerebral perfusion pressure
 1. Understand how to determine cerebral perfusion pressure
 2. Understand the concept of cerebral perfusion pressure
- f. Monitoring cerebral blood flow
 1. Understand the principles of radionuclide scans in monitoring cerebral blood flow
6. External (cerebral) ventricular drainage
 - a. Understand that external cerebral ventricular drainage may be very difficult or impossible with severe cerebral edema
 - b. Know that rapid decompression of increased intracranial pressure can lead to severe hemodynamic alterations
 - c. Know that rapid decompression of increased intracranial pressure from ventricles can cause an upward transtentorial shift
7. New techniques for monitoring brain function and viability
 - a. Know the principles underlying near-infrared spectroscopy (NIRS) for monitoring brain tissue oxygenation
 - b. Know that changes in brain oxygenation may precede any changes in pulse oximetry
 - c. Know the common waveforms on continuous EEG monitoring, and recognize and differentiate between normal and abnormal waveforms (seizures, PLEDs, etc)

15. Special Critical Care Issues

A. Legal considerations

1. Malpractice
 - a. Definition
 1. Know the definition of malpractice
 2. Recognize the components of malpractice in clinical practice
 - b. Defense
 1. Appreciate the importance of appropriate ongoing patient-physician communication, especially as it relates to malpractice issues
 2. Understand the role of hospital risk-management organizations in assisting and protecting the physician named in a malpractice claim
 - c. Documentation
 1. Understand how chart documentation affects the defensibility of malpractice claims
 2. Understand the types of information reported to, stored, and released by the national physician data bank
 - d. Physician as expert witness
 1. Understand the limits of acceptable conduct of an expert witness in a malpractice action
2. Informed consent for clinical care
 - a. General
 1. Know the principles of informed and implied consent
 2. Understand the process of obtaining informed consent
 3. Know the elements of informed consent

4. Understand the limitations of written informed consent
- b. Minors
 1. Know the rights of minors
 2. Know the components of informed consent for a child
 3. Understand the importance of consent and assent as they apply to minors
 4. Recognize the rights of emancipated minors
 5. Recognize the settings in which parents are not appropriate surrogate decision makers for their child(ren)
 6. Know the definition of an emancipated minor
- c. Proxy decision makers
 1. Understand the concept of proxy decision makers
3. Interactions with the legal system
 - a. Understand the limitations of the legal system in patient-physician interactions
 - b. Understand patient confidentiality
 - c. Understand the jurisdiction of the medical examiner/coroner
4. Child abuse
 - a. Recognition and documentation
 1. Recognize the important physical signs and symptoms diagnostic of child abuse
 2. Evaluate a suspected victim of child abuse
 3. Recognize the laboratory findings associated with child abuse
 4. Recognize the factors that predispose a child to abuse
 5. Understand the importance of written and photographic documentation of child abuse
 6. Formulate a differential diagnosis for suspected child abuse
 7. Recognize the laboratory findings and common radiographic manifestations of child abuse
 8. Recognize the possibility of sexual abuse in depressed and/or suicidal children
 9. Diagnose a patient who is the victim of Munchausen syndrome by proxy
 10. Know that child abuse is a common cause of death in infants younger than 1 year of age
 - b. Reporting responsibility
 1. Differentiate patient confidentiality from medicolegal requirements to report injuries in suspected child abuse
 2. Know the laws regarding the reporting of suspected child abuse/neglect
 3. Understand the role of the child protection team
 - c. Protection of family/staff
 1. Recognize the importance of a nonaccusatory physician/nurse role in the circumstances of child abuse
 2. Understand the possibility of a battered spouse or other child abuse in an abused child's family
 3. Understand the support needs of a family with a child suspected of being abused
 4. Know that members of the medical staff are protected from litigation resulting from the reporting of suspected child abuse
 - d. Testifying in court

1. Recognize the importance of early cooperation with the legal system in cases of child abuse
2. Recognize the importance of consultation and review with an appropriate attorney prior to a child abuse trial
5. Suspicion of foul play in the ICU
 - a. Plan an evaluation of a cluster of unusual morbidities or mortalities in the ICU
 - b. Know the legal requirements for reporting evidence of an impaired physician
 - c. Understand the importance of close interaction with hospital legal staff in the investigation of foul play in the ICU
6. Patient care vs legal system
 - a. Religious beliefs
 1. Plan an approach to a situation involving refusal of permission for care on the basis of religious beliefs
 2. Know the procedures for obtaining legal custody
 3. Know the settings in which obtaining a court order is appropriate
 - b. Patient autonomy
 1. Understand the principles of patient autonomy and their paramount role in issues of informed consent
 2. Understand the progression of development in a child's understanding of issues related to critical illness and death
 3. Know how to incorporate a pediatric patient's wishes into decision making
 - c. Parent autonomy
 1. Understand the principles of parent autonomy
 2. Know the limits of parent autonomy in the medical care of children
 - d. Rights of the dead
 1. Know the limitations on invasion of the deceased
- B. Ethical issues
 1. Definition of an ethical question
 - a. Differentiate between questions of medicine and questions of ethics
 2. Termination of care
 - a. Withholding of care
 1. Recognize similarities/differences in withholding/withdrawing care from an ethical and social standpoint
 2. Understand the ethical issues involved in the provision of futile, harmful, or burdensome treatment
 3. Understand when it is appropriate to discontinue resuscitation in the critical care setting
 4. Know when a decision not to resuscitate is appropriate
 5. Know that a do-not-resuscitate order does not in itself limit other treatment
 - b. Euthanasia
 1. Understand the difference between euthanasia and allowing a patient to die
 3. Full disclosure
 - a. To patient
 1. Know at what age a patient should be included in discussions of ethical decisions regarding his/her care
 - b. To family member(s)

1. Know what information may be withheld from family members
2. Understand parental responses to information regarding their critically ill child
3. Understand the value of full disclosure to family members
4. Patient/family/physician rights
 - a. Know when to transfer care
 - b. Understand the concept of patient abandonment
- C. Economic issues
 1. Expense of ICU care
 - a. Know the differences between costs and charges regarding the expense of ICU care
 - b. Identify strategies for reducing the cost of ICU care
 2. Relationship of ICU cost to hospital cost
 - a. Understand major components of the high cost of ICU care compared to care on other hospital units
 3. Reimbursement schemes
 - a. Understand the sources of payment for hospital-based pediatric medical care
 4. Billing and compliance
 - a. Understand documentation issues in billing for critical care time as opposed to other evaluation and management services
- D. Death and dying
 1. Definitions of death
 - a. Cardiorespiratory
 1. Know the traditional definition of death
 2. Know the components of the Uniform Definition of Death Act
 - b. Brain
 1. Know the conditions that prevent or interfere with the diagnosis of brain death
 2. Know findings in brain death
 3. Understand the factors involved in establishing brain death in neonates
 4. Understand the usefulness and limitations of ancillary neurologic tests (eg, electroencephalography, brain blood-flow studies, evoked responses) in the setting of brain death
 2. Organ donation
 - a. Understand the legal requirement for requesting that organs be donated
 - b. Know the relationship between the diagnosis of brain death and organ donation
 - c. Understand the federal network of regional donor programs
 - d. Recognize the complexities involved in considering anencephalic infants as organ donors
 - e. Understand "slippery slope" considerations relative to death and organ donation
 - f. Know the contraindications to organ donation
 - g. Understand the concept of living-related organ donation
 - h. Understand the considerations for and techniques of donation after cardiac death (DCD)
 3. Tissue donation
 - a. Know that tissue donation is possible after cardiopulmonary death
 - b. Know that tissues that may be donated include corneas, skin, bone, heart valves, and great vessels
 - c. Know the contraindications to tissue donation

16. Core Knowledge in Scholarly Activities

A. Principles of use of biostatistics in research

1. Types of variables
 - a. Distinguish types of variables (eg, continuous, categorical, ordinal, nominal)
 - b. Understand how the type of variable (eg, continuous, categorical, nominal) affects the choice of statistical test
2. Distribution of data
 - a. Understand how distribution of data affects the choice of statistical test
 - b. Differentiate normal from skewed distribution of data
 - c. Understand the appropriate use of the mean, median, and mode
 - d. Understand the appropriate use of standard deviation
 - e. Understand the appropriate use of standard error of the mean
3. Hypothesis testing
 - a. Distinguish the null hypothesis from an alternative hypothesis
 - b. Interpret the results of hypothesis testing
4. Statistical tests
 - a. Understand when to use and how to interpret the chi square test
 - b. Understand when to use and how to interpret tests comparing continuous variables between two groups (eg, t test, Mann Whitney U)
 - c. Understand when to use and how to interpret tests comparing continuous variables between three or more groups (eg, ANOVA, Kruskal-Wallis)
 - d. Understand when to use paired tests
 - e. Understand the appropriate use of parametric versus nonparametric tests
 - f. Interpret a p value
 - g. Interpret a p value when multiple comparisons have been made
 - h. Interpret a confidence interval
 - i. Identify a type I error
 - j. Identify a type II error
5. Measurement of association and effect
 - a. Understand how to interpret relative risk and absolute risk
 - b. Understand how to interpret odds ratio
 - c. Understand how to interpret number needed to treat or harm
 - d. Understand how to interpret hazard ratio
 - e. Understand when to use and how to interpret correlation coefficient
6. Regression
 - a. Understand when to use and how to interpret regression analysis (eg, linear, logistic)
 - b. Understand when to use and how to interpret survival analysis (eg, Kaplan Meier)
7. Diagnostic tests
 - a. Recognize the importance of an independent "gold standard" in evaluating a diagnostic test
 - b. Interpret sensitivity and specificity
 - c. Interpret positive and negative predictive values
 - d. Understand how disease prevalence affects the positive and negative predictive value of a test
 - e. Interpret a receiver operating characteristic curve

8. Systematic reviews and meta-analysis
 - a. Understand the purpose of a systematic review
 - b. Understand the advantages of adding a meta-analysis to a systematic review
 - c. Interpret the results of a meta-analysis
- B. Principles of epidemiology and clinical research design
 1. Assessment of study design, performance and analysis (internal validity)
 - a. Recognize and understand the strengths and limitations of a cohort study, case control study, and randomized controlled clinical trial
 - b. Recognize the use and limitations of surrogate endpoints
 - c. Understand the use of intent-to-treat analysis
 - d. Understand how sample size affects the power of a study
 2. Assessment of generalizability (external validity)
 - a. Understand how nonrepresentative samples can bias results
 - b. Assess how the data source (eg, diaries, billing data, discharge diagnostic code) may affect study results
 3. Bias and confounding
 - a. Identify common strategies in study design to avoid or reduce bias
 - b. Identify common strategies in study design to avoid or reduce confounding
 4. Causation
 - a. Understand the difference between association and causation
 5. Incidence and prevalence
 - a. Distinguish disease incidence from disease prevalence
 6. Screening
 - a. Understand factors that affect the rationale for screening for a condition or disease (eg, prevalence, test accuracy, risk benefit, disease burden, presence of a presymptomatic state)
 7. Cost benefit, cost effectiveness, and outcomes
 - a. Interpret cost-effectiveness ratios
 - b. Distinguish costs from charges
 - c. Understand quality-adjusted life years
 8. Measurement
 - a. Understand the types of validity that relate to measurement (eg, face, construct, criterion, predictive, content)
 - b. Distinguish accuracy from precision
 - c. Understand when to use and how to interpret a kappa coefficient
- C. Ethics in research
 1. Professionalism and misconduct in research
 - a. Identify and manage potential conflicts of interest in the funding, design, and/or execution of a research study
 - b. Identify various forms of research misconduct (eg, plagiarism, fabrication, falsification)
 - c. Know how, and to whom, to report concerns of research misconduct
 2. Principles of research with human subjects
 - a. Understand and contrast the functions of an Institutional Review Board and a Data Safety Monitoring Board

- b. Recognize the types of protections in designing research that might be afforded to children and other vulnerable populations
 - c. Understand the federal regulatory definitions regarding which activities are considered research and what constitutes human subjects research
 - d. Understand the federal regulatory definition of minimal risk and apply this to research involving children
 - e. Understand the ethical considerations of study design (eg, placebo, harm of intervention, deception, flawed design)
3. Principles of consent and assent
- a. Understand what constitutes informed consent in research
 - b. Distinguish between consent and assent in research involving children
- D. Quality improvement
1. Design of a Project
- a. Understand various models of quality improvement and recognize that all utilize a data-informed, iterative process using tests of change to achieve a stated aim
 - b. Understand that the aim of any quality improvement project should be specific, measurable, achievable, realistic, and time-limited
 - c. Understand strategies to optimize identification of key drivers and interventions to achieve a specific aim
 - d. Understand tools to facilitate completion of quality improvement work, including key driver diagrams and process maps
 - e. Understand each phase of a Plan-Do-Study-Act (PDSA) cycle
2. Data and Measurement
- a. Differentiate between process, outcome, and balancing measures
 - b. Interpret a run chart and identify shifts, trends, and outliers in data
 - c. Differentiate between a run chart and a control chart
 - d. Differentiate between common cause and special cause variation