



# IAP-ICC – COLLEGE OF PEDIATRIC CRITICAL CARE

## Curriculum for Indian Fellowship in Pediatric Critical Care (Two-year training)

### Curriculum and schedule for two-year pediatric critical care fellowship:

The fellowship schedule is designed to expose the fellow to the full range of critically ill patients as well as take up clinical research.

#### In first year:

Hands on time needs to be spent in the Pediatric Intensive Care Unit, learning management of critically ill patients, initiation and management of mechanical ventilation, inotropic support, learning of procedures (central line, arterial line, intubation, chest tube placement and peritoneal dialysis) parenteral sedation and transport. Additional time (preferably 3 weeks or more each) in the first year is spent on rotations in Anesthesia, the emergency room and pediatric cardiac intensive care (even if rotation is arranged by the program director at a different center).

With approximately 20 days for vacation, five additional work days may be used annually for attendance at a scientific meeting. In addition to the rotations listed above, fellows are also expected to attend PALS training in order to become PALS certified. Fellows are expected to participate in didactic teaching conferences as often as possible as well as journal club as per the fellowship program academic schedule.

Fellows must take up a clinical research project and actively work towards presentation of at least one first author abstract/poster presentation in a scientific meeting as well as write one article under the supervision of the program director or faculty member.

#### In second year:

PICU posting inclusive but not limited to plan and administer comprehensive PICU management with multiorgan support, conduct rounds with residents and first year fellows, counsel the families. Additional learning procedures include but not limited to use of bedside ultrasound for assessment of critically ill patient, high frequency ventilation, intracranial pressure monitoring, intra abdominal pressure monitoring, advanced hemodynamic monitoring, and pediatric bronchoscopy. Continuation of research project as taken up in the beginning of fellowship, analysis of data and departmental presentation is required. Preparation of thesis and submission at the time of two year fellowship exit exam is required.

Twenty working days are provided for vacation. Up to five work days may be used annually for attendance at a scientific meeting.

All fellows are expected to participate in didactic teaching conferences as often as possible as well as presentation in journal club. Additional time may be allowed for acquiring special skill related to practice of pediatric critical care as well as for attending workshops at the discretion of the program director.

#### Syllabus:

Following syllabus includes the outline and components of minimum expected theoretical and practical knowledge within the scope of the 2year fellowship in pediatric intensive care. Percentage weight age has been included (but no limited ) to emphasize various common day to day issues of practical significance for fellowship candidates as well as the accredited fellowship program teachers to concentrate on , as a guide to prepare for the exit exam as well as for the fellow to prepare for taking the exam.

<b>Core syllabus Outline for two years fellowship</b>	<b>%Weightage</b>
I.Cardiovascular. ....	14.0.....
II.Respiration .....	14.0 .....
III.Neurology and Neuromuscular.....	11.0 .....
IV.Infectious Disease, Immunology, and Inflammation .....	11.0 .....
V.Renal and Electrolytes .....	6.0 .....
VI.Metabolism and Endocrinology .....	3.0 .....
VII.Hematology/Oncology .....	4.0 .....
VIII.Gastroenterology and Nutrition.....	4.0 .....
IX.Poisonings, Toxins, and Overdoses .....	4.0 .....
X.Trauma and Burns.....	5.0 .....
XI.Pharmacology .....	5.0.....
XII.Perioperative Care and Procedural Sedation .....	4.0 .....
XIII.Research methodology and biostatistics.....	6.0.....
XIV.Special critical care issues, legal, malpractice and end of life.....	3.0.....
XV.Principles of Monitoring and Technical Procedures.....	6.0 .....

## I. Cardiovascular

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

### **1. Anatomy**

Know the anatomy of the heart

Know the anatomy of the circulation of the myocardium

Understand the determinants of blood flow across the ductus arteriosus before and after birth

Anatomically differentiate right and left ventricles

Know the general contributions of the developmental embryology of the heart to congenital heart disease

Know the recognizable genetic developmental abnormalities of the heart

### **2. Myocardial mechanics**

#### **a. Sarcomere function**

(1). Excitation-contraction coupling

Understand calcium flux in excitation-contraction coupling

Identify the types of receptors on the myocyte and their functions

Understand the role of actin, myosin, troponin, tropomyosin, calcium, and sarcoplasmic reticulum in contraction

(2). Length-tension relationship

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

#### **b. Integrated muscle function**

(1). Pressure-volume relationship

Interpret pressure-volume relationships

(2). Ventricular function curve

Interpret ventricular function curves

Understand the effects of afterload, contractility, and preload on the ventricular function curve

(3). Venous return curve

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

(4). Determinants of function

(a). Inter-relationship

Recognize the inter-relationship between the determinants of cardiac function

(b). Preload

Understand how preload alters ventricular stroke volume

Recognize the conditions that alter ventricular preload

(c). Afterload

Understand how afterload alters ventricular stroke volume

Understand the concept of afterload and factors that affect afterload (Laplace equation)

Understand the concept of wall stress and its effect on stroke volume

(d). Contractility

Understand how contractility alters ventricular stroke volume

Understand how to quantitate contractility (slope of pressure-volume curves)

(e). Heart rate

Understand how heart rate alters cardiac output

(5). Neural control

Understand neural effects on myocardial function

Understand the effects of heart denervation on cardiac function

Understand the role of carotid and aortic baroreceptors in cardiocirculatory regulation

(6). Cardiac response to hormonal and pharmacologic influences

(a). Beta-adrenergic agonists and antagonists

Understand beta-adrenergic effects on myocardial function

(b). Alpha-adrenergic agonists and antagonists

Understand alpha-adrenergic effects on myocardial function

(c). Calcium

Understand effects of calcium on myocardial function

(d). Cardiac glycosides

Understand the effects of cardiac glycosides on myocardial function

(e). Bipyridines (amrinone, etc)

Understand the effects of phosphodiesterase III inhibitors (eg, amrinone, milrinone) on myocardial function

(f). Natriuretic peptides

Understand the effects of natriuretic peptides on myocardial function

(g). Nitrates

Understand the effects of nitrates on myocardial function

(7). Developmental changes

Know the changes in myocardial function that occur with postnatal development

Know the changes in adrenergic myocardial receptors that occur with postnatal development

Understand the chronology of presentation of congenital heart disease

### **c. Mechanical dysfunction**

#### (1). Systolic dysfunction

Understand how to evaluate systolic dysfunction

Identify the clinical disorders associated with systolic dysfunction

Understand the mechanisms of systolic dysfunction

#### (2). Diastolic dysfunction

Understand how to evaluate diastolic dysfunction

Identify the factors that influence diastolic ventricular function

Know the clinical disorders associated with diastolic dysfunction

## **B. Electrophysiology**

### **1. Impulse formation**

#### a. Normal mechanism

Understand the normal mechanism for impulse formation

Understand the roles of sodium current, calcium current, and potassium current in normal impulse formation

#### b. Neural influences

Understand how neural function influences impulse formation

#### c. Humoral influences

Know the humoral influences on impulse formation

#### d. Effects on drugs

Differentiate the effects of various classes of drugs on impulse formation

#### e. Effects on electrolyte abnormalities

Recognize the effects of electrolyte abnormalities on impulse formation

### **2. Impulse conduction**

#### a. Normal mechanism

Understand the normal pathways of impulse conduction

Understand the mechanism of impulse conduction

Recognize the differences in depolarization pattern between pacemaker cell and other cardiac cells

#### b. Neural influences

Understand how neural factors influence impulse conduction

#### c. Humoral influences

Know which humoral factors influence impulse conduction

d. Effects of drugs

Differentiate the effects of various classes of drugs on impulse conduction

e. Effects of electrolyte abnormalities

Understand the effects of electrolyte abnormalities on impulse conduction

f. Developmental changes

Understand how atrioventricular conduction pathways mature after birth

**3. Rhythm disturbances**

a. Disorders of impulse formation

Know how to differentiate disorders of impulse formation

Understand the pathogenesis of disorders of impulse formation

Know the treatment of disorders of impulse formation

b. Disorders of impulse conduction

Know how to differentiate disorders of impulse conduction

Understand the pathogenesis of disorders of impulse conduction

Know the treatment of disorders of impulse conduction

c. Specific disorders of impulse formation, conduction

(1). Supraventricular reentrant tachycardia

Understand the pathogenesis of supraventricular reentrant tachycardia

Know the treatment of supraventricular reentrant tachycardia

(2). Junctional ectopic tachycardia

Understand the pathogenesis of junctional ectopic tachycardia

Plan the management of a patient with junctional ectopic tachycardia

(3). Ventricular tachycardia

Understand the pathogenesis of ventricular tachycardia

Plan the management of a patient with ventricular tachycardia

(4). Heart block

Understand the pathogenesis of heart block

Plan the management of a patient with heart block

**C. Myocardial metabolism and blood flow**

**1. Normal myocardial metabolism**

a. Aerobic myocardial metabolism

Understand myocardial energy metabolism

Understand the use of energy substrates by the myocardium

b. Determinants of myocardial oxygen consumption

Identify the factors that determine the relationship between myocardial metabolic rate and blood flow

Understand the effects of PCO<sub>2</sub> and PO<sub>2</sub> on myocardial blood flow regulation

Understand autoregulation of myocardial blood flow

Understand the mechanical factors that influence myocardial blood flow

Recognize settings in which myocardial oxygen demand exceeds potential supply

Recognize the conditions and drugs that increase coronary blood flow

Recognize the relationship between oxygen demand and preload, afterload, and contractility

Know which drugs increase myocardial oxygen demand

Understand the relationship between oxygen supply and demand, both functionally and anatomically (eg, subendocardium, myocardial muscle mass, blood flow)

Understand the neural regulation of myocardial blood flow

c. Hormonal influences on myocardial metabolism

Recognize hormonal effects on myocardial metabolism

**2. Effects of abnormal metabolism on myocardium**

a. Hypoxia/ischemia

Understand the effects of hypoxia/ischemia on myocardium

b. Acid-base imbalance

Understand how pH alters myocardial function

Understand how pH alters myocardial responses to drugs

c. Other primary metabolic disturbances

Recognize the effects of metabolic disturbances and inborn errors of metabolism on myocardium

**3. Regional circulations**

a. Blood flow and perfusion

(1). General

Understand the structure of the microcirculatory vascular beds

Understand the relationship between intravascular volume and pressure and organ blood flow

(2). Autoregulation

Recognize normal and disrupted autoregulation

Understand the concept of blood flow autoregulation

Understand the contribution of autoregulation to cardiac output

(3). Neural influences

Understand how neural input influences tissue blood flow

(4). Humoral influences

Know which humoral factors influence tissue blood flow

(5). Responses to hypoxia

Understand the effects of hypoxemia on systemic vascular resistance

(6). Responses to acid-base imbalance

Understand how acidosis affects tissue perfusion

Understand how alkalosis affects tissue perfusion

(7). Local regulation of vascular tone

Understand how prostanoids, platelet-activating factor, and other inflammatory mediators affect tissue perfusion

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

(2). Myocardium

(3). Liver

(4). Kidney

(5). Gut

(6). Skeletal muscle

Recognize the factors affecting blood flow to skeletal muscle

(7). Lung

c. Control of blood pressure

d. Systemic oxygen supply and demand

Understand the determinants of oxygen content and delivery

Understand the factors that increase systemic oxygen consumption

Understand tissue and systemic responses to acute and chronic oxygen deprivation

Know how to estimate the adequacy of oxygen delivery

Understand the concept of delivery-dependent oxygen consumption

e. Mechanisms of transcapillary fluid flux

Understand the factors affecting transcapillary fluid flux (Starling equation)

Understand the factors that lead to the development of systemic edema

## **D. Interactions with other systems**

### **1. Cardiopulmonary interactions**

Recognize the major forms of interaction between heart and lungs

Understand the effect of inspiration on right ventricular preload

Recognize the effects of increased lung volumes on left ventricular preload

Understand the effects of lung volume and breathing on right ventricular afterload

Understand the effects of lung volume and breathing on left ventricular afterload

Understand features of large or small airway obstruction that may contribute to development of pulmonary edema

### **2. Effects of systemic venous congestion**

Know the signs, pathogenesis, and effects of systemic venous congestion

### **3. Effects of pulmonary venous congestion**

Know the signs, pathogenesis, and effects of pulmonary venous congestion

### **4. Cardioendocrine relations**

Understand the endocrine response to impaired circulation

Understand the role of the cardiovascular system in water-sodium homeostasis

## **E. Assessment of structure, function, and dysfunction**

### **1. Physical examination**

Differentiate cardiovascular diseases by physical examination

### **2. Radiographic evaluation**

Differentiate cardiovascular diseases by radiographic evaluation

Know the type of information that can be collected by cardiac catheterization

### **3. Electrocardiography**

Recognize Wolff-Parkinson-White syndrome by ECG

Interpret ventricular hypertrophy on ECG

Interpret cardiac rhythm disturbances by ECG

Appreciate the age dependence of ventricular forces seen on ECG

Recognize artifacts on ECG tracings

Recognize myocardial infarction by ECG

Recognize ST changes on ECG

Recognize T changes on ECG

Recognize ventricular dysrhythmias on ECG

Recognize supraventricular dysrhythmias on ECG

Recognize conduction disturbances on ECG

Recognize abnormalities in cardiac axes on ECG

#### **4. Echocardiography and Doppler flowmetry**

Know the indications and limitations of echocardiography, including Doppler flowmetry, for evaluating cardiovascular disease

Recognize abnormalities of cardiac function on echocardiography

Recognize depressed myocardial function based on echocardiographic findings

Understand the limitations of diagnosis of pulmonary hypertension by echocardiography

Point of Care lung ultrasound

#### **5. Measurement of vascular pressures, resistances**

Interpret vascular pressures

Understand invasive techniques for measurement of vascular pressure

Know the potential complications of invasive vascular pressure monitoring

#### **6. Quantitation of cardiac output and blood flow**

##### **a. Invasive techniques**

Understand invasive methods for the evaluation of cardiac output and blood flow

##### **(1). Thermodilution**

Understand thermodilution measurement of blood flow

##### **(2). Fick technique**

Understand the Fick principle for calculation of blood flow

##### **b. Noninvasive techniques**

Understand noninvasive techniques for the evaluation of cardiac output and blood flow

##### **(1). Echocardiography**

##### **(2). Doppler flowmetry**

#### **7. Quantitation and detection of shunts**

##### **a. Thermodilution**

Know qualitative effects of left-to-right and right-to-left shunts on thermodilution cardiac output determination

##### **b. Fick technique**

Know how to quantify shunt flow using the Fick principle

Understand how to calculate systemic blood flow in the presence of a left-to-right shunt

##### **c. Contrast echocardiography**

Know how shunts are visualized by contrast echocardiography

d. Doppler flowmetry

Know how shunts are visualized by color Doppler flowmetry

## **8. Biomarkers**

Understand the use of brain natriuretic peptide as a diagnostic test for cardiac dysfunction

Understand the use of troponin, creatine kinase, and free myoglobin as markers of myocardial cell injury

## **F. Cardiac disease**

### **1. Cardiac malformations**

a. General

Identify other congenital anomalies or diseases associated with congenital heart malformations

Recognize asplenia syndrome

b. Acyanotic obstruction of left heart

Understand the pathophysiology of left heart obstruction

Know the signs and findings of left heart obstruction

Know the initial medical therapy for critical left heart obstruction

Know the effects of systemic hypertension on obstructive lesions on the left side of the heart

Know and recognize specific disorders causing left heart obstruction

c. Acyanotic obstruction of right heart

Understand the pathophysiology of right heart obstruction

Recognize the signs and findings of right heart obstruction

Know the initial medical therapy for critical right heart obstruction

Know and recognize specific disorders causing right heart obstruction

d. Left-to-right shunt lesions

Understand the pathophysiology of left-to-right shunt lesions

Recognize the signs and findings of left-to-right shunt lesions

Know the medical therapy for management of large left- to-right shunt lesions

Understand the use and toxicity of drugs that can be employed to manipulate the ductus arteriosus (prostaglandin E1, indomethacin)

Know and recognize specific disorders causing left-to-right shunt lesions

e. Right-to-left shunt lesions

Understand the pathophysiology of right-to-left shunt lesions

Know the signs and findings of right-to-left shunt lesions

Know the medical therapy for management of critical hypoxemia with right-to-left shunt lesions

Know and recognize specific disorders causing right-to-left shunt lesions

f. Admixture lesions

Understand the pathophysiology, signs, and findings of transposition of the great arteries

Understand the pathophysiology, signs, and findings of total anomalous pulmonary venous connection

g. Valvar regurgitation

Understand the pathophysiology of valvar regurgitation

Know the signs of valvar regurgitation

Know the medical therapy for management of an unstable patient with valvar regurgitation

h. Single ventricles

Understand the pathophysiology, signs, and findings of tricuspid atresia

Plan the medical management (including preoperative care) for a patient with hypoplastic left heart syndrome

Plan the preoperative preparation of a patient with truncus arteriosus

Understand the preoperative support and surgical options required for a patient with pulmonary atresia

Understand the pathophysiology of hypoplastic left heart syndrome

Understand the pathophysiology of pulmonary atresia

**2. Vascular malformations**

**3. Shock (also see section iv)**

**a. General**

Know the complications and sequelae of circulatory shock

Recognize the signs of perfusion failure, including altered mental status

Differentiate between the various types of shock

**b. Hypovolemic shock**

Recognize the signs of hypovolemic shock

Know how to investigate causes of hypovolemic shock

Understand the treatment of hypovolemic shock

Understand the pathophysiology of hypovolemic shock

**c. Obstructive shock**

Recognize the signs of obstructive shock

Know how to investigate causes of obstructive shock

Understand the treatment of obstructive shock

Understand the pathophysiology of obstructive shock

#### **d. Cardiogenic shock**

Recognize the signs of cardiogenic shock

Know how to investigate causes of cardiogenic shock

Understand the treatment of cardiogenic shock

Understand the pathophysiology of cardiogenic shock

#### **e. Distributive shock**

Recognize the signs of distributive shock

Know how to investigate causes of distributive shock

Understand the treatment of distributive shock

Understand the pathophysiology of distributive shock

#### **f. Septic shock**

Recognize the signs of septic shock

Know how to investigate the causes of septic shock

Understand the treatment of septic shock

Understand the pathophysiology of septic shock

#### **4. Congestive heart failure**

Understand the pathogenesis of congestive heart failure

Understand the pathophysiology of congestive heart failure

Know the differential diagnosis of congestive heart failure

Plan medical therapy for a patient with congestive heart failure

Understand the effect of mechanical ventilatory strategies in congestive heart failure

#### **5. Systemic hypertension**

#### **6. Tamponade**

Recognize pericardial tamponade and understand its pathogenesis

Understand the pathophysiology of tamponade

Know the differential diagnosis of tamponade

Plan medical therapy for a patient with tamponade

#### **7. Cardiopulmonary arrest**

Recognize and understand events leading to cardiac arrest

Understand the principles of resuscitation for cardiac arrest

#### **8. Myocardial infection**

Understand the pathogenesis of myocarditis

Know how to diagnose myocardial infection

Plan medical therapy for a patient with myocardial infection

### **9. Pericardial infection**

Understand the pathogenesis of pericardial infection

Understand the pathophysiology of pericardial infection

Know how to investigate the etiology of pericardial infection

Plan medical therapy for a patient with pericardial infection

### **10. Endocardial infection**

Understand the pathogenesis of endocardial infection

Understand the pathophysiology and natural history of endocardial infection

Know how to investigate the etiology of endocardial infection

Know the prophylaxis and medical therapy for endocardial infection

Recognize endocardial infection as a cause of persistent bacteremia

Recognize the complications of endocardial infection

### **11. Traumatic cardiac injury**

Understand the pathogenesis of cardiac injury in trauma

Understand the pathophysiology of cardiac injury in trauma

Know how to diagnose traumatic cardiac injury

Know the therapy (including indications for surgery) of cardiac injury in trauma

### **12. Cardiac hypoxia, asphyxia (limited DO<sub>2</sub>)**

Recognize myocardial asphyxia and its manifestations

Understand the pathogenesis of cardiac hypoxia and asphyxia (limited DO<sub>2</sub>)

Understand the pathophysiology of cardiac hypoxia and asphyxia (limited DO<sub>2</sub>)

Plan medical therapy for a patient with cardiac hypoxia and asphyxia (limited DO<sub>2</sub>)

### **13. Cardiomyopathy**

Understand the pathogenesis of cardiomyopathy

Understand the pathophysiology of cardiomyopathy

Know how to investigate the etiology of cardiomyopathy

Plan medical therapy for a patient with cardiomyopathy

### **14. Myocardial infarction**

Recognize the causes of myocardial ischemia and infarction in children

Understand the pathogenesis of myocardial ischemia and infarction

Know the appropriate therapy for patients with myocardial ischemia and infarction

## **15. The heart in systemic disease**

### **a. Muscular dystrophies**

Recognize the muscular dystrophies associated with impaired myocardial function

Recognize the effect of restrictive lung disease on myocardial function in children with muscular dystrophies

### **b. Marfan syndrome and homocystinuria**

Recognize the structural cardiac abnormalities associated with Marfan syndrome

Recognize the structural cardiac abnormalities associated with homocystinuria

### **c. Mitochondrial and glycogen storage diseases**

Understand the spectrum of mitochondrial disease and its impact on cardiovascular function

Understand how myocardial function is altered in glycogen storage diseases

### **d. Carnitine deficiency and long-chain fatty acid disorders**

Understand the role of long-chain fatty acids in heart disease

Recognize the indications for carnitine administration in heart disease

## **G. Heart, lung, and heart/lung transplantation**

### **Indications and contraindications**

Know the indications and contraindications for heart, lung, and heart/lung transplantation

## **H. Cardiac surgery**

### **1. Indications and contraindications**

Know the indications and contraindications for cardiac surgery

Recognize and interpret important data in the preoperative evaluation of a patient scheduled for cardiac surgery

### **2. Surgical**

Know the anatomic relationship of the ductus arteriosus to adjacent structures such as the recurrent laryngeal nerve

Know the common techniques and indications for the repair/palliation of congenital cardiac diseases

### **3. Postoperative care**

Recognize the setting of mesenteric arteritis after repair of coarctation of the aorta

Diagnose mesenteric arteritis on the basis of clinical and laboratory findings in a child with hypertension after repair of coarctation of the aorta

Recognize that control of postcoarctectomy hypertension prevents mesenteric arteritis

Understand the complications and risks of cardiac surgery including bypass, cardioplegia, cross-clamp, hypothermia, and circulatory arrest

Understand and plan the management of common complications following closure of ventricular septal defects

Understand and plan the management of common complications following systemic to pulmonary shunts

Understand and plan the management of common complications following the Fontan procedure

Understand and plan the management of common complications following cardiac valve replacement

Understand and plan the management of common complications following first-stage surgery for single ventricles

Understand common and plan the management of complications following atrioventricular canal repair

Understand and plan the management of common complications following repair of tetralogy of Fallot

Understand and plan the management of common complications following the arterial switch procedure

Understand the use of cardiac pacemakers after cardiac surgery

Understand the indications for preload versus inotropy versus afterload reduction following cardiac surgery

Recognize and plan the management of postpericardiotomy syndrome

Recognize and plan the management of diaphragmatic paralysis following cardiac surgery

Recognize and plan the management of chylothorax following cardiac surgery

Recognize and plan the management of protein-losing enteropathy following cardiac surgery

Understand and plan the management of common complications following the bidirectional Glenn procedure

Understand the etiology and therapy of renal impairment following cardiac surgery

Understand alterations in hepatic function following cardiac surgery

Recognize and diagnose myocardial ischemia following cardiac surgery

Understand ventilator management following cardiac and cardio-pulmonary bypass surgery

Understand the pathogenesis of restrictive lung disease following cardiac surgery

Understand and plan the management of the syndrome of low cardiac output following complex congenital heart disease surgery

## **II. Respiration**

### **A. Development and Functional Anatomy**

#### **1. Development of the respiratory system**

Understand how prenatal alterations in lung development lead to specific diseases or conditions in infancy

Understand the main processes involved in fetal maturation of the lungs and the transition to air breathing

Understand the anatomic and functional changes experienced by the airways, pulmonary vessels, and lungs during postnatal development

Understand the anatomic and functional changes experienced by the chest wall during postnatal development

#### **2. Functional anatomy of the conducting airways**

Understand the pathophysiology and manifestations of laryngeal nerve palsies

Understand the ultrastructure and function of the bronchial cilia

Know the anatomic and functional differences between bronchi and bronchioles

Know the cranial nerves responsible for sensory and motor innervation of the upper and lower airways

Know the anatomic differences between the airways of infants and adolescents

#### **3. Functional anatomy of the acinus**

Know the structure of the alveolar-capillary unit and pulmonary interstitium

Identify the structural and ultrastructural characteristics and function of type I pneumocytes, type II pneumocytes, and alveolar macrophages

Know the anatomy of the acinus

#### **4. Functional anatomy of the pulmonary vessels**

Know the anatomy and relationships of the pulmonary and bronchial circulations

Understand the anatomic changes involved in the normal and abnormal postnatal remodeling of the pulmonary vessels

Understand the processes involved in the adaptation of the fetal pulmonary vessels to extrauterine life

## **B. Physiology**

### **1. Mechanics of breathing**

Understand how spontaneous and positive-pressure breathing influence the caliber of the extrathoracic and intrathoracic airways

Understand the components of the work of breathing

Know the factors that determine the depth and frequency of breathing

Understand the relationships between airway opening pressure, alveolar pressure, and pleural pressure during breathing

Understand the concept and determinants of transpulmonary pressure, lung and chest wall compliance, airway and lung tissue resistance to air flow.

Know the muscles of breathing and their function in health and disease

Understand the basic factors that determine energy supply utilization by the respiratory muscles in health and disease

Understand how changes in lung and chest wall compliance airway resistance affect the volume-pressure relationships of the lungs and chest wall

Understand how changes in airway resistance affect the volume-pressure relationships of the lungs

Understand the mechanisms that determine the volume of the lungs in health and disease

Understand the factors that influence the rate of emptying of the lungs during expiration

Understand the concept of time constant as it applies to both lung inflation and deflation

Understand the concept of gas flow limitation and its applicability to pulmonary function testing

Interpret physiologic and pathologic variations in flow-volume relationships during tidal breathing and maximal forced expiration

### **2. Surface tension and pulmonary surfactant**

Know the indications for and the use of surfactant replacement therapy

Understand the concept of surface tension and its implications for alveolar stability

Know the principal components of pulmonary surfactant

Understand the biologic functions of the surfactant apoproteins

Understand how surfactant influences the volume dependence of surface tension in the pulmonary air spaces

### **3. Pulmonary circulation**

Know the effects of pH, PCO<sub>2</sub>, and PO<sub>2</sub> on pulmonary vascular tone

Know the effects of gravity on the distribution of blood flow in the lungs

Understand the concept and calculation of pulmonary vascular resistance

Understand the effects of blood viscosity and vascular caliber on pulmonary vascular resistance

Know the contributions of pulmonary arteries, capillaries, and veins to pulmonary vascular resistance

Understand the influence of lung volume and alveolar pressure on the resistance of alveolar wall capillaries

Understand the influence of lung volume and airway pressure on the resistance of extra-alveolar arteries and veins

#### **4. Fluid filtration in the lungs**

Understand the basic forces that determine net water flux across pulmonary capillary walls in health and disease

Know the anatomy and function of the pulmonary lymphatics

Understand how lung volume and surface tension influence fluid filtration in pulmonary vessels

Understand how changes in pulmonary arterial and venous caliber influence fluid filtration in pulmonary vessels

Know the mechanisms of fluid removal from the alveoli and pulmonary interstitium

Understand how changes in systemic venous pressure influence fluid balance in the lungs and pleural space

Understand the mechanisms of fluid filtration and removal from the pleural space

#### **5. Pulmonary gas exchange**

Understand the mechanisms that match ventilation and perfusion in the normal lung

Understand the factors that govern the equilibration of alveolar gas and pulmonary capillary blood

Know the mechanisms involved in oxygen uptake by the blood

Know the mechanisms by which carbon dioxide is transported in the blood and the relationship between carbon dioxide content and PCO<sub>2</sub>

Know the concept and calculation of the respiratory quotient

Understand the factors that determine the relationship between oxygen content and PO<sub>2</sub>

Understand the concept and calculation of pulmonary shunt and venous admixture

Understand the concept and calculation of dead space in the lungs

Know how PO<sub>2</sub> influences carbon dioxide transport and how PCO<sub>2</sub> influences oxygen transport by the blood

Know the factors that determine alveolar PO<sub>2</sub>

Know the concept and calculation of oxygen uptake by the lungs

Know the concept and calculation of whole body carbon dioxide production

Understand the concept and calculation of blood oxygen content

Understand the mechanisms involved in the release of carbon dioxide by the venous blood in the lungs

Understand the concept and estimation of ventilation-perfusion mismatch ★ and the factors that disturb it

Know how abnormalities in ventilation, diffusion, perfusion and ventilation-perfusion ratios affect gas exchange in the lungs

Know the effects of decreased consciousness and posture on pulmonary gas exchange

Understand the mechanisms that increase the alveolar-arterial PO<sub>2</sub> difference

### **6. Cardiopulmonary interactions**

Understand the effects of breathing (spontaneous or mechanical) on arterial blood pressure and heart rate and on the transmural pressure of the intrathoracic vessels and heart chambers

Understand the differential effects of spontaneous and positive airway pressure breathing on pulmonary and systemic arterial blood flow.

### **7. Control of breathing**

Know the hierarchical organization of breathing control in the central nervous system

Understand the chemoreceptor mechanisms that maintain arterial PO<sub>2</sub> and PCO<sub>2</sub> constant

Know how lung and chest wall mechanoreceptors influence tidal volume and breathing rate

Know the neuroanatomic structures involved in the coordination of upper airway tone and ventilation

Know the factors that influence the tone of the upper airway muscles

### **8. Immunological responses of the lungs and airways**

Understand the mechanical defenses of the respiratory system against invasion by microorganisms

Understand the role of immunoglobulins in pulmonary host defense

Understand the role of macrophages in immune defense of the lung

Demonstrate understanding of the mechanisms involved in lung hypersensitivity reactions

### **9. The role of the lung in acid-base balance regulation**

Understand the role of ventilation in the acid buffering system

Know the pathophysiology and treatment of respiratory acidosis

Understand the mechanisms of adaptation to chronic hypercapnia

Know the principal causes, pathophysiology, and treatment of respiratory alkalosis

### **C. Pharmacology and developmental pharmacology**

#### **1. Upper airway**

Know the pharmacologic therapy for the treatment or prevention of laryngeal and subglottic edema

Know the effects of sedatives on pharyngeal tone

#### **2. Lung**

Understand the pharmacology of the airway smooth muscle

Know the effects of diuretics on lung water

#### **3. Pulmonary circulation**

Understand the effects of vasoactive drugs and nitric oxide on pulmonary circulation

#### **4. Control of respiration**

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

Understand the pathophysiology and presentation of upper airway malformations in neonates

Plan treatment for upper airway malformation in a neonate

#### **b. Vascular compression of airways**

Recognize vascular compression of airways

Understand the embryology and pathophysiology of the various syndromes of vascular compression of the airways

Plan treatment for vascular compression of airways

#### **c. Acquired narrowing of the airway**

Know the factors that predispose to subglottic stenosis

Recognize acquired narrowing of the airway

Understand the pathophysiology of acquired narrowing of the airway

Plan treatment for a patient with acquired narrowing of the airway

#### **d. Paralysis of the vocal cords**

Know the most frequent causes of vocal cord paralysis

Recognize and diagnose paralysis of the vocal cords

Plan treatment for a patient with paralysis of the vocal cords

**e. Infection**

(1). Croup

Know how to diagnose croup

Understand the pathophysiology of croup

Plan treatment for a patient with croup

(2). Epiglottitis

Know the acute evaluation and management of epiglottitis

Understand the pathophysiology of epiglottitis

(3). Tracheitis

Understand the acute treatment of bacterial tracheitis

Understand the pathophysiology of tracheitis

Know how to diagnose and evaluate tracheitis

(4). Peritonsillar/retropharyngeal abscess

Know how to diagnose retropharyngeal or peritonsillar abscess

Know the life-threatening complications of peritonsillar or retropharyngeal abscess

Identify the organisms commonly associated with retropharyngeal or peritonsillar abscess

**f. Tracheomalacia**

Recognize the clinical features of tracheomalacia

Understand the pathophysiologic effects of tracheomalacia

Plan treatment for a patient with tracheomalacia and respiratory distress

**g. Obstructive sleep apnea**

Know how to diagnose and evaluate obstructive sleep apnea

Plan perioperative management for a patient with obstructive sleep apnea

**2. Lung**

**a. Disorders of the bronchi**

**(1). Malformations of the bronchial system**

Understand the pathophysiology of malformations of the bronchial system

Plan treatment for malformations of the bronchi

Know how to diagnose and evaluate malformations of the bronchi

**(2). Disorders of the bronchial system**

**(a). Bronchiolitis**

Recognize the clinical features of bronchiolitis

Know the organisms that commonly cause bronchiolitis

Plan treatment for a patient with bronchiolitis

**(b). Bronchial hyperreactivity/asthma**

Understand the pathogenesis of the mechanical and gas exchange abnormalities associated with asthma

Know how to diagnose disorders characterized by bronchial hyperreactivity

Understand the pathophysiology of disorders characterized by bronchial hyperreactivity

Know the treatment of disorders characterized by bronchial hyperreactivity

Understand the use of various drug therapies for the treatment of asthma

Know which drugs are contraindicated (relative and absolute) in a patient with asthma

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**

Understand the factors that lead to the development of pulmonary edema

**(b). Acute respiratory distress syndrome**

Know the epidemiologic risk factors for acute respiratory distress syndrome

Understand the pathogenesis of lung dysfunction in acute respiratory distress syndrome

Know how to diagnose acute respiratory distress syndrome

Understand the pathophysiology of acute respiratory distress syndrome

Know the principles of management in acute respiratory distress syndrome

Plan mechanical ventilation in acute respiratory distress syndrome

**(c). Cardiogenic or hydrostatic pulmonary edema**

Understand the pathogenesis of pulmonary edema in congestive cardiac failure

Know how to diagnose hemodynamic pulmonary edema

Understand the pathophysiology of hydrostatic pulmonary edema

Plan treatment for a patient with hydrostatic pulmonary edema

**(2). Neonatal respiratory distress syndromes**

**(a). Hyaline membrane disease**

Know the principles of mechanical ventilation for the treatment of hyaline membrane disease

Know how to diagnose hyaline membrane disease

Understand the pathophysiology of hyaline membrane disease

Plan treatment for a patient with hyaline membrane disease

**(b). Meconium aspiration**

Understand the pathophysiology, presentation, and management of meconium aspiration

**(c). Neonatal pneumonia**

Know how to diagnose neonatal pneumonia

Understand the pathophysiology of neonatal pneumonia

Plan treatment for a patient with neonatal pneumonia

Know the pathogens that can cause neonatal pneumonia

**(3). Ventilation-perfusion mismatching**

Know the treatment of ventilation-perfusion mismatching

Differentiate among the causes of hypoxia

Differentiate among the causes of hypercapnia

**(4). Pneumonitis**

(a). Infectious pneumonitis

Understand the pathophysiology and pathogenesis of infectious pneumonitis

(b). Chemical pneumonitis

Know how to diagnose chemical pneumonitis

Understand the pathophysiology of chemical pneumonitis

Plan treatment for a patient with chemical pneumonitis

Know which agents cause chemical pneumonitis

Plan treatment for a patient with aspiration pneumonitis

**c. Global respiratory disorders**

**(1). Bronchopulmonary dysplasia**

Recognize and diagnose bronchopulmonary dysplasia

Understand the pathogenesis and pathophysiology of bronchopulmonary dysplasia

Know the treatment of acute pulmonary decompensation in a patient with bronchopulmonary dysplasia

**(2). Oxygen toxicity**

Understand the mechanisms involved in oxygen- and oxygen radical-mediated lung injury

Understand the role of antioxidant enzymes

Know mechanisms for detoxifying intracellular oxygen radicals

**(3). Pulmonary hemorrhage**

Know how to diagnose pulmonary hemorrhage

Understand the pathophysiology of pulmonary hemorrhage

Plan treatment for a patient with pulmonary hemorrhage

Know the diseases associated with pulmonary hemorrhage

### **3. Mechanical abnormalities of pulmonary function**

#### **a. Thoracic cage dystrophy or dysfunction**

Understand the pathophysiology of thoracic cage dystrophy or dysfunction

Plan treatment for a patient with thoracic cage dystrophy or dysfunction

Know how to evaluate the severity of thoracic cage dystrophy or dysfunction

Understand the pathogenesis of respiratory failure in patients with thoracic cage dystrophy

#### **b. Diaphragmatic dysfunction**

Know how to diagnose diaphragmatic dysfunction

Understand the pathophysiology of diaphragmatic dysfunction

Plan treatment for a patient with diaphragmatic dysfunction

Recognize diaphragmatic dysfunction in the differential diagnosis of respiratory failure

Know the causes of phrenic nerve injury (birth trauma, surgical trauma)

Plan the management of a patient with diaphragmatic paralysis

### **4. Pulmonary circulation**

#### **a. Malformations of pulmonary circulation**

Know how to diagnose malformations of pulmonary circulation

Understand the pathophysiology of malformations of pulmonary circulation

Know the treatment of malformations of pulmonary circulation

#### **b. Pulmonary embolism**

Know how to diagnose pulmonary embolism

Understand the pathophysiology of pulmonary embolism

Recognize recurrent pulmonary embolism in the differential diagnosis of pulmonary hypertension

Understand the pathophysiology of the blood gas abnormalities associated with pulmonary embolism

Plan treatment for a patient with acute pulmonary embolism

Identify the risk factors for pulmonary embolism

#### **c. Pulmonary hypertension**

Know how to diagnose persistent pulmonary hypertension of the newborn

Understand the pathophysiology of persistent pulmonary hypertension of the newborn

Plan treatment for a patient with persistent pulmonary hypertension of the newborn

Recognize primary pulmonary hypertension

Evaluate the severity of primary pulmonary hypertension

Plan treatment for a patient with primary pulmonary hypertension

## **5. Disorders of blood oxygen and carbon dioxide transport**

Know how to diagnose disorders of blood oxygen and carbon dioxide transport

Understand the pathophysiology of disorders of blood oxygen and carbon dioxide transport

Know the treatment of disorders of blood oxygen and carbon dioxide transport

Know the physiologic effects of anemia

Understand the toxic and pharmacologic causes of abnormal oxygen transport

## **6. Disorders of control of respiration**

Recognize disorders of the control of respiration in the differential diagnosis of hypercapnia

Know how to diagnose disorders of control of respiration

Understand the pathophysiology of disorders of control of respiration

Know the treatment of disorders of control of respiration

## **7. Disorders of pleura and lymphatics**

Differentiate among the causes of pleural effusion

Know the pathogenesis of chylous effusion

Plan treatment for a patient with chylous effusion

## **8. Lung disorders in immune dysfunction**

Know the differential diagnosis of pneumonitis in a patient with immune deficiency

Evaluate a patient with acute respiratory failure and immune deficiency

Plan treatment for a patient with an opportunistic lung infection

## **9. Lung injury in thoracic trauma**

Know the physical findings of pulmonary contusion

Know how to diagnose lung injury in thoracic trauma

Understand the pathophysiology of lung injury in thoracic trauma

Know the treatment of lung injury in thoracic trauma

## **E. Respiratory diagnostic modalities**

### **1. Physical examination**

Know the physical findings of respiratory failure in the spontaneously breathing child

Differentiate between the various causes of respiratory distress by physical examination

## **2. Imaging studies**

Use imaging studies to differentiate among the various causes of respiratory distress in infants and children

Assess airway obstruction by radiography

Recognize the radiographic findings characteristic of atelectasis, pulmonary infiltrates, pneumothoraces, and pleural effusions

## **3. Blood gas examination and end-tidal gas analysis**

Recognize the limitations inherent in using end-tidal gas as a sample of alveolar air in the abnormal lung

Distinguish acute from chronic hypercapnia using arterial and end-tidal gas analysis

Distinguish hypoventilation from ventilation-perfusion mismatch using arterial and end-tidal gas analysis

Determine the pathogenesis of hypoxemia by blood gas analysis

## **4. Bronchoscopy and bronchoalveolar lavage**

Know the indications for bronchoscopy

Know the acute complications associated with bronchoscopy

Know the indications for bronchoalveolar lavage

Know the acute complications associated with bronchoalveolar lavage

Know the constituents of normal bronchoalveolar lavage fluid

## **5. Pulmonary function testing for extubation**

Assess readiness for extubation in a patient recovering from acute lung disease, with weakness due to neuromuscular disease, recovering from anesthesia, with long-standing lung disease.

Know how to use tests of mechanics of breathing such as negative inspiratory force or forced vital capacity to predict extubation

## **6. Indirect calorimetry**

Understand the principles of indirect calorimetry

Know the limitations of indirect calorimetry

## **F. Therapy**

### **1. Manipulation of metabolic demand**

Understand the relation of nutrient intake to respiratory quotient and carbon dioxide production

Understand the relation of work of breathing to oxygen demand in respiratory failure

### **2. Principles of respiratory stabilization and support**

Understand the principles involved in selecting initial ventilator settings for the patient with respiratory failure

Understand the physiologic effects of positive-pressure breathing

Understand the potential use of different maneuvers of chest physiotherapy and positioning

### **3. Principles of postoperative respiratory care**

Understand the principles of mechanical ventilation as a means to stabilize the patient after major or prolonged surgery

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 conventional mechanical ventilation**

Understand the principles and applications of the various modes of volume-controlled mechanical ventilation

Know the advantages and limitations of the various modes of pressure-controlled mechanical ventilation

Recognize that problems with temperature control of humidifiers may lead to hypothermia or hyperthermia

Understand the effects of decreased pulmonary compliance on mechanical ventilation

Know the effects of patterns of gas flow during mechanical ventilation oxygenation

Understand the devices used for humidification of respiratory gases

Understand the principles and applications of the various modes of pressure-controlled mechanical ventilation

Know the advantages and limitations of the various modes of volume-controlled mechanical ventilation

Understand the effects of high airways resistance on mechanical ventilation

Understand the problems of mechanical ventilation presented by asymmetrical lung disease

Understand the appropriate application of CPAP/PEEP

Understand the deleterious effects of CPAP/PEEP

Understand the effects of the ventilator circuit on gas exchange

#### **b. High-frequency ventilation/oscillation**

Understand the principles underlying the use of high-frequency jet and high-frequency oscillatory ventilation

Know the advantages and limitations of high-frequency/oscillatory ventilation

Identify the clinical situations where high-frequency/oscillatory ventilation is useful

Adjust parameters of high-frequency/oscillatory mechanical ventilation to maintain normal gas exchange

Understand the ways of shifting from conventional ventilation to HFOV and back.

### **c. Noninvasive ventilation (NIV)**

#### **(1). Negative-pressure mechanical ventilation**

Know the principles underlying the use of negative-pressure mechanical ventilation

Know the advantages and disadvantages of negative-pressure mechanical ventilation

Know the appropriate settings for the use of negative-pressure mechanical ventilation

#### **(2). Positive-pressure mechanical ventilation NIV**

Know the principles underlying the use of positive-pressure in NIV

Know the advantages and disadvantages of positive-pressure in NIV

Know the clinical settings for the use of positive-pressure in NIV

Understand the use of various types of patient-ventilator interface patients of different age groups.

### **d. Application of exogenous gases and other adjuncts**

Understand the indications for and applications and complications of helium-oxygen therapy

Understand the indications for and mechanisms of the delivery of nitric oxide via a ventilator

Understand the indications for and mechanisms of the delivery of surfactant in the mechanically ventilated patient

Understand the indications for and application and complications of hyperbaric oxygen therapy

Understand how to administer aerosol therapy in the mechanically ventilated patient

### **5. Weaning from mechanical ventilation**

Understand the principles of weaning patients from mechanical ventilation

### **6. Complications of mechanical ventilation**

Know the complications resulting from mechanical ventilation

Know the factors associated with mechanical ventilation that contribute to lung injury

Understand the concepts of tension, stress, and strain in mechanical ventilation

Recognize, diagnose, and plan treatment for a tension pneumothorax

### **7. Tracheostomy**

Recognize the indications of tracheostomy.

Know how to manage accidental decannulation of a tracheostomy

Know the immediate and long-term postoperative complications of tracheostomy

## **G. Gas therapy and physics**

### **1. Delivery**

Understand the limitations of the various manual ventilation devices (eg, bag-mask)

Understand that patients rarely receive more than 40% oxygen effectively by simple masks

Understand the principles of the use of a nonrebreathing mask

### **2. Physics**

Know the effect of altitude on partial pressure of gases in the alveolus

Know how to use the alveolar gas equation

Understand the importance of gas density/viscosity in airway resistance

## **III. Neurology and Neuromuscular:**

### **1. Basic anatomy of the CNS and peripheral Nervous system**

Applied anatomy: Localization of lesions in the brain

Including the Major central nervous system neurotransmitters

Understand the function of the major central nervous system neurotransmitters

### **2. Pathophysiology of neuronal injury**

### **3. Know the relative volume of the principal intracranial compartments as applicable to raised ICT**

### **4. Imaging:** A Functional knowledge of CT and MRI of the central nervous system

### **5. Sympathetic nervous system**

Understand the functions of the sympathetic nervous system and its role in health and disease.

Including the important transmitters of the sympathetic nervous system that impact on health and in disease states.

### **6. Parasympathetic nervous system**

Functional anatomy and applied physiology.

Know the consequences of parasympathetic blockade

Know the consequences of excess parasympathetic activity

### **7. Blood-brain barrier**

Understand the physiologic basis of the blood-brain barrier

Identify the causes of blood-brain barrier disruption

### **8. Neuromuscular junction**

Know the structure of the neuromuscular junction

Understand the electrical and biochemical mechanism of muscular contraction

Understand competitive and noncompetitive inhibition of the neuromuscular junction

**9. Metabolic requirements:** basic aspects of metabolic and oxygen requirements and its use of fuels in health and disease

**10. Cerebral blood flow, autoregulation, and modulation/regulation by various factors in normal and disease states.** With special reference to the treatment of patients with raised ICT

### **11. Cerebrospinal fluid**

Know the basic physiology of cerebrospinal fluid production, absorption, and circulation

### **12. Neurologic evaluation**

#### **1. Assessment of mental status**

Know the components of the Glasgow Coma Scale

Understand the use of the Glasgow Coma Scale

Know the pediatric modifications to the Glasgow Coma Scale

#### **2. Ocular abnormalities**

##### **a. Pupillary responses**

Know that pupillary innervation is by the third cranial nerve as well as by adrenergic and cholinergic nerves

Recognize and differentiate among the causes of unilateral dilated pupil

Recognize and differentiate among the causes of unilateral constricted pupil

Understand the ciliospinal reflex

**b. Extraocular movement**

Understand the response of the vestibular apparatus to cold water in the comatose and awake patient

Know the cranial nerves that control eye movements and the interpretation of signs

**c. Retinal exam**

Recognize the fundoscopic appearance of papilledema

Recognize the fundoscopic appearance of retinal hemorrhages

Recognize the fundoscopic appearance of systemic fungemia

**13. Neuromuscular function:** Examination of the peripheral nervous system including under sedation and neuromuscular blockade

**14. Electroencephalography**

Recognize the following EEG patterns: spike and wave, burst- suppression, slow wave activity, isoelectric EEG, ECG artifact, in herpes encephalitis

Know the significance of the following EEG patterns: spike and wave, burst-suppression, slow wave activity, isoelectric EEG, ECG artifact

**15. Recognize the clinical situations in which electromyography and Evoked potentials might be useful in patients with neuromuscular conditions.**

Usefulness and limitations of SSEPs/ EPs

**16. Cerebrospinal fluid:** Indications and contraindications for examination.

Interpretation of the various components of the fluid.

Special tests for specific circumstances

**17. Cerebral blood flow:** methods of measuring CBF at the bedside and their interpretation

**18. Central nervous system aspects of metabolic disorders**

**a. Electrolyte disturbances:** Detailed knowledge of fluids & electrolytes and the treatment of derangements

**b. Inborn errors of metabolism**

: Recognize the role of IEMs including mitochondrial disorders in the pathophysiology of acute conditions presenting to the ICU: only as a broad group

**c. Hepatic encephalopathy**

Understand the pathophysiology and complete management of acute and chronic of hepatic encephalopathy. Basic aspects of indications and preparation for liver transplant

**19. Neurologic aspects of CNS infection:** recognize and treat a wide variety of infections and a general approach to a patient with a suspected infection

Plan the management of increased intracranial pressure in a patient with a central nervous system infection

**20. Vascular diseases and disorders of cerebral circulation**

**a. Vasculitis**

Recognize cerebral vasculitis as a possible explanation for seizures, stroke, or altered mental status

**b. Various types of lesions causing CNS deficit from hemorrhage. Including in the spinal cord**

**c. Stroke**

Understand the causes and pathophysiology of embolic and thrombotic stroke in children

and their management

Basic knowledge of antithrombotic therapy

## **21. Hypoxic-ischemic encephalopathy**

Understand the pathophysiology and possible developmental aspects of hypoxic-ischemic encephalopathy with complications and management

**22. Central nervous system and neoplasm:** Recognition and emergency management

**23. Spinal cord tumors, acute demyelinating conditions, causes & management**

**24. Central nervous system involvement in miscellaneous illnesses:** e.g. Transplant, chemotherapy, HLH

**25. Head and spinal cord trauma:**

Detailed knowledge of the pathophysiology, causes, derangements, management of an injured patient in all aspects.

Special emphasis on the understanding and management of raised ICT and cerebral edema and herniation syndromes

**26. Seizure disorders**

**a. Classification**

**b. Neonatal seizures**

Know the causes of neonatal seizures and the evaluation and treatment

**c. Status epilepticus:** Detailed knowledge of causes, management, preventive aspects, neuroprotection and various protocols

**27. Neuromuscular disorders:** A knowledge of the various Neuromuscular disorders that present to the ICU and their individual management

## IV. Infectious Disease, Immunology, and Inflammation

### A. Structure, function, and development of the main components of the immune system

#### 1. Host defenses

##### a. General

Distinguish among the specific immune functions performed by the components of the innate immune system and the acquired immune system including but not exclusive to role of toll-like receptors, transcription factor NF- $\kappa$ B, acute phase reactants,

Know the importance of endothelial/epithelial barriers as defense against infection

Understand the pathogenesis of fever

Understand the production & biochemistry of inducible nitric oxide

Understand disseminated intravascular coagulation as a component of the innate immune response

##### b. Phagocytic system

Understand the function of the phagocytic system

Understand the mechanisms by which endothelium and phagocytic cells interact

Understand the functions of macrophages, neutrophils, eosinophils, and basophils

##### c. Understand the role of the reticuloendothelial system

##### d. Lymphocytic system

Know the immune function of the B-cell system

Know the immune function of the T-cell system

Know the immune function of the immunoglobulins

##### e. Platelets

Know the role of activated platelets

f. Humoral immune/inflammatory system

Understand the basics of the complement system

Understand the role of cytokines in inflammation

Understand the role of oxyradicals in inflammation

Know the signs of inflammation

2. Immune dysfunction

a. General

Recognize manifestations of dysfunction of the several components of the normal immune system

Know how to evaluate a patient for specific immune deficiencies

b. Iatrogenic

c. Nutritional

d. Infectious immune depression: risks for immune suppression secondary to an infectious disease

e. Integument

Know the pathogens that typically infect defective or injured integument

Know the life-threatening complications of skin infection

f. Endothelial barriers

Recognize endothelial barrier failure as a possible cause of sepsis

Recognize gastrointestinal endothelial injury/translocation as a cause of sepsis/inflammation

g. B-cell system/immunoglobulins

Recognition, disorders and management

h. T-cell system: Recognition, disorders and management

i. Phagocytic system: Recognition, disorders and management

Understand the pathogenesis of chronic granulomatous disease

j. Complement system

Recognize the manifestations of deficient complement activity

k. Reticuloendothelial system

Recognize the manifestations of dysfunction of the reticuloendothelial system in an acutely ill patient

Identify the pathogens to which a child with defective or deficient reticuloendothelial function is susceptible

Know the disorders that cause defective or deficient reticuloendothelial function

### **I. Acquired immunodeficiency syndrome (AIDS)**

(1). Pathophysiology

(2). Clinical course

(3). Diagnosis

Recognize the common clinical presentations of HIV type 1 infection

Understand the interpretation of laboratory tests used in the diagnosis of HIV type 1 infection

(4). Life-threatening complications

Identify the bacterial viral and opportunistic pathogens to which a child with AIDS is particularly susceptible

(5). Treatment

Plan appropriate management and complications of treatment for critically ill patients with AIDS

(6). Risk factors

Plan appropriate procedures and techniques to minimize exposure of hospital staff to the risk of acquiring HIV infection from patients

Know which factors increase the risk of acquired HIV infection

**B. Specific disorders**

**1. Central nervous system infections**

a. General

Differentiate the types of meningeal infection by clinical and laboratory features

Differentiate among the manifestations of meningitis, encephalitis, and encephalopathy

Know the major causes of central nervous system bacterial infections and the predominant patient age-groups with which they are associated

Understand the penetrance of antimicrobial drugs into the cerebrospinal fluid compartment

b. Meningitis: recognition, management, complications, prevention, the prognosis and long-term sequelae of bacterial, viral, meningitis

c. Encephalitis

Understand the pathogenesis and pathophysiology, clinical manifestations of encephalitis

Know the clinical course of encephalitis

life- threatening complications of encephalitis

Plan appropriate medical treatment for a patient with encephalitis

d. Brain abscess

e. Fungal infection

**2. Parenchymal pulmonary infections**

a. Bacterial pneumonia; empyema, viral pneumonia, lung abscess

Differentiate between pneumonia and bacterial colonization in an intubated patient or a patient with a tracheostomy

prevention of HAP

Know the subgroups of patients at high risk for the life-threatening complications of respiratory syncytial virus, pneumococcal disease,

Know the isolation procedures for air-borne infections in the intensive care unit

c. Fungal and opportunistic organisms

Understand the pathogenesis and pathophysiology of fungal and opportunistic pneumonias

clinical manifestations; course of fungal and opportunistic pneumonias; appropriate therapy; risk factors

### **3. Sepsis**

#### **a. Multiple organ system failure**

Understand the relation of sepsis and perfusion failure to the development of multiple organ system failure

Know the pathogenesis and pathophysiology of myocardial dysfunction in a child with multiple organ system failure

Understand the treatment of the failing heart in a child with multiple organ system failure

Understand the use of clinical scoring systems in predicting outcome of groups of patients with multiple organ system failure

b. Bacterial (eg, meningococemia, group B streptococcus, gram negative)

Treatment and support required

c. Viral (herpes, etc)

Understand the pathogenesis and pathophysiology of disseminated viral infection with shock

Know the specific pharmacologic treatments of disseminated viral infections

Recognize the clinical manifestations of viral hemorrhagic fevers

#### **4. Systemic inflammatory response syndrome (SIRS)**

Recognize the relationship of multiple organ system failure with activation of the systemic inflammatory response syndrome

Understand the concept of the systemic inflammatory response syndrome

Understand the role of innate immunity in the development of the systemic inflammatory response syndrome

#### **5. Infection-associated syndromes**

a. Toxic shock syndrome

b. Kawasaki syndrome

c. Rheumatic fever

d. Hemorrhagic shock encephalopathy

e. Rocky Mountain spotted fever- rickettsial diseases

g. Parasitic infections

Clinical features and manifestations and management of severe parasitic infections, including malaria, amoebiasis, and toxoplasmosis

#### **6. Other infections encountered in the PICU**

a. Orbital cellulitis

b. Urosepsis, pyelonephritis

c. Peritonitis, abdominal abscess

d. Necrotizing fasciitis

e. Viral-associated hemophagocytic syndrome

g. Methicillin-resistant staphylococcus aureus infection

Recognize the risk factors colonization and invasive infection

Plan the evaluation and treatment of a patient with possible MRSA infection

prevention of spread in the hospital & ICU

d. Immunosuppressive effects of drug therapy

Recognize the infectious complications of immunosuppressive therapy

e. Infectious agents

(1). Cytomegalovirus

Recognize the life-threatening manifestations of cytomegalovirus infection in the immunodeficient patient

Plan appropriate therapy for the life-threatening manifestations of cytomegalovirus infection

(2). Herpes virus

Recognize the life-threatening manifestations of herpes virus infection in the neonate

Plan appropriate therapy for the life-threatening manifestations of herpes virus infection

(3). Varicella

Recognize varicella as an important opportunistic pathogen in the immunosuppressed patient

Know the available therapy for varicella infection in the immunocompromised patient

Protection of contacts of the varicella patient may be protected by administration of zoster immune globulin

Recognize the life-threatening manifestations of varicella infection

Plan appropriate therapy for the life-threatening manifestations of varicella infection

(4). Pneumocystis jiroveci (carinii)

(5). Epstein-Barr virus

(6). Aspergillus

## **7. Infectious complications of invasive monitoring**

a. Foley catheter

b. Endotracheal tube complications and infections

c. ventilator-associated pneumonia as a potential complication of intubation; diagnose management and prevention

d. Vascular catheter and CRBSI (catheter related blood stream infection): recognition, management and prevention

## **C. Isolation techniques**

1. Universal precautions

2. Specific isolation precautions

Know the means of transmission for common pathogens

3. Reverse isolation: Indications, methods

## **D. Collagen vascular disease**

### **1. Systemic lupus erythematosus**

Recognize the manifestations of life-threatening complications of systemic lupus erythematosus

Plan treatment for the life-threatening manifestations of systemic lupus erythematosus

### **2. Juvenile rheumatoid arthritis**

Recognize the manifestations and life-threatening complications of juvenile rheumatoid arthritis

### **3. Dermatomyositis**

Recognize the manifestations and life-threatening complications of dermatomyositis

#### 4. Vasculitis

Understand the pathogenesis and pathophysiology of the different types of vasculitis

Know how to investigate the etiology of the different types of vasculitis

Know the medical therapy for the different types of vasculitis

#### **E. Anaphylaxis: pathophysiology, natural history, Recognize the manifestations appropriate therapy**

#### F. Antimicrobials

##### 1. Sensitivities

Know the clinical significance of the laboratory determination of infectious agent susceptibility to antimicrobial/antifungal drugs

Understand the use of serum concentration determinations in planning antimicrobial treatment regimens

Plan appropriate therapy for infection with beta-lactamase producing, coagulase-negative staphylococci

Know the characteristics and spectrum of activity of aminoglycoside antibiotics

Know the characteristics and spectrum of activity of commonly used cephalosporins

Know the characteristics and spectrum of activity of semisynthetic penicillins

Know the characteristics and spectrum of activity of the macrolide antibiotics

Know the characteristics, spectrum of activity, and appropriate use of vancomycin

Know the characteristics and spectrum of activity of carbapenems and monobactams

Know the characteristics and spectrum of activity of the different classes of commonly used antifungal agents

Understand the principles behind the choice of antimicrobials

Understand the principles behind combining antimicrobials

Understand the concept of emerging resistance to antibiotics

Know the characteristics and spectrum of activity of the different classes of commonly used antiviral agents

Know the characteristics and spectrum of activity of the different classes of commonly used antiparasitic agents

Know the basic pharmacokinetics, mode of action, mode of emerging resistance, adverse effects

## **V. Renal and Electrolytes**

### **A. Structure and function**

#### **1. Anatomy**

Know the anatomy of the circulation of the kidneys

Know the structure and function of the renal tubule

Know the structure and function of the glomerulus (proximal and distal)

#### **2. Physiologic principles**

Know how to estimate excretion and clearance of endogenous waste products

Understand the concept of renal clearance

Understand the developmental changes in glomerular filtration rate during the first year after birth

Know the clinical factors that modulate glomerular filtration rate

Know the mechanisms of glomerular injury

Know the mechanisms of tubular injury

#### **3. Renal circulation**

Understand the effects of autonomic influences on renal circulation

Understand the physiology of renal blood flow

Know the effects of dopaminergic drugs on renal vascular resistance

Understand neural influences on renal blood flow

Understand local humoral influences on renal blood flow

#### **4. Hormone effects**

Know the effects of alpha-adrenergic drugs on renal vascular resistance

Know the effects of dopamine on renal function  
Know the effects of circulating hormones on renal function  
Know the effect of atrial natriuretic hormone on renal function  
Know which conditions are associated with release of atrial natriuretic hormone  
Know the effects of vasopressin on renal function  
Know the effects of parathyroid hormone on the kidney

## **5. Assessment**

Interpret the results of urinalysis (chemistry, microscopic)  
Know appropriate radiologic evaluation of renal function  
Understand how the calculation of creatinine clearance is used in the assessment of renal function  
Calculate serum osmolarity  
Calculate fractional excretion of sodium

## **B. Fluid and electrolyte balance**

### **1. General**

Understand the effects of diarrhea on fluid balance  
Understand the mechanisms of and know the sites for electrolyte transport  
Understand the effects of diuretics on fluid and electrolyte balance  
Interpret serum electrolyte concentrations and identify sources of error

### **2. Electrolyte disorders**

#### **a. Hyperkalemia**

Understand the pathogenesis of hyperkalemia in renal failure  
Recognize hyperkalemia as a manifestation of adrenal insufficiency  
Understand the effects of hyperkalemia on the heart  
Recognize the manifestations of hyperkalemia  
Plan appropriate management for a patient with life-threatening hyperkalemia  
Understand the association of acidosis and hyperkalemia

#### **b. Hypokalemia**

Recognize the clinical and laboratory manifestations of severe hypokalemia  
Understand the relation of hypokalemia to alkalosis  
Recognize the implications of hypokalemia in the patient treated with digoxin  
Plan appropriate therapy for the life-threatening complications of hypokalemia

Know the normal requirement for potassium and the principles of potassium replacement therapy

Know causes of hypokalemia without potassium deficit

Know causes of hypokalemia with associated potassium deficit

### **c. Hypercalcemia**

Understand the various causes of hypercalcemia

Know the effects of hypercalcemia

Plan appropriate therapy for a patient with severe hypercalcemia

### **d. Hypocalcemia**

Understand the physiologic effects of hypocalcemia

Recognize the clinical and electrocardiographic manifestations of hypocalcaemia

Understand the relation of ionized calcium to total calcium and the significance of ionized hypocalcaemia

Understand the interaction of calcium and phosphate, and the relation of hypocalcaemia to hyperphosphatemia

Plan appropriate therapy for complications of hypocalcaemia

Distinguish among the causes of hypocalcaemia

### **e. Hypernatremia**

Recognize diabetes insipidus as a cause of hypernatremia

Recognize salt poisoning as a cause of hypernatremia

Recognize water loss as an iatrogenic cause of hypernatremia as in therapy with mannitol, sorbitol, lactulose, etc

Recognize the occurrence of hypernatremia in diarrheal dehydration

Recognize the clinical manifestations of hypernatremia

Know that hypernatremic dehydration may cause subdural bleeding

Recognize the life-threatening complications of hypernatremia

Plan appropriate treatment of hypernatremia

Understand the complications of rapid correction of hypernatremia

### **f. Hyponatremia**

Distinguish hyponatremia caused by water intoxication from inappropriate secretion of antidiuretic hormone

Recognize the manifestations of life-threatening hyponatremia

Recognize the iatrogenic causes of hyponatremia

Understand the complications of rapid correction of hyponatremia

Know causes of hyponatremia with decreased total body sodium

Know causes of hyponatremia with normal total body sodium

Know causes of hyponatremia with increased total body sodium

Plan treatment for a patient with hyponatremia

### **g. Disorders of magnesium homeostasis**

Recognize the manifestations of hypomagnesemia

Know the causes of hypomagnesaemia

Know the causes of hypermagnesemia

Recognize the manifestations of hypomagnesaemia

Plan treatment for a patient with hypomagnesaemia

Plan treatment for a patient with hypomagnesaemia

### **h. Disorders of phosphorus homeostasis**

Know the causes of hypophosphatemia

Know the causes of hyperphosphatemia

Recognize the clinical signs of hypophosphatemia

Plan treatment for a patient with hypophosphatemia

Plan treatment for a patient with hyperphosphatemia

Recognize the clinical signs of hyperphosphatemia

## **3. Dehydration**

Understand the pathophysiology of water and electrolyte loss that occur in severe dehydration in infants and children

Recognize the manifestations and life-threatening complications of severe dehydration

Plan management for a child with severe dehydration

Recognize that vascular volume expansion is the first priority in dehydration with shock and know how to accomplish it

Calculate serum osmolality in a patient with hypernatremic dehydration

Know the mechanisms and sites for water absorption

Calculate free water replacement in a patient with hypernatremic dehydration

## **4. Acid-base balance**

### **a. Acid-base**

Know the role of the kidney in acid-base balance

Distinguish disorders of acid-base homeostasis, including primary,

compensatory, and mixed disturbances

Know the management of acid-base disorders

### **b. Acidosis**

Understand the mechanisms of lactic acidosis

Understand the consequences of acidosis and hypoglycemia

Distinguish between causes of metabolic acidosis

Understand the difference between anion- and nonanion-gap metabolic acidosis

### **c. Alkalosis**

Know how to treat metabolic alkalosis

Know the causes of metabolic alkalosis

## **C. Renal failure**

### **1. General**

Know the life-threatening complications of acute renal failure

Understand the principles of treatment of renal failure in the context of circulatory shock

Diagnose acute renal failure using urinary and serum electrolyte concentrations

Recognize the clinical manifestations of hepatorenal syndrome

Plan fluid management for a patient with renal failure

### **2. Disorders of renal circulation**

#### **a. Vascular disease**

Understand the pathophysiologic response to alterations in renal blood flow that occur during renal vascular disease

#### **b. Ischemia**

##### **(1). Prerenal azotemia**

Distinguish the clinical and laboratory manifestations of prerenal azotemia from those of renal parenchymal disease

Understand the pathophysiology of oliguria in a child with prerenal azotemia

##### **(2). Acute tubular necrosis**

Understand the pathophysiology of acute tubular necrosis secondary to shock

Recognize the clinical and laboratory manifestations of acute tubular necrosis

Recognize the patient at risk for acute tubular necrosis

Know the natural history of acute tubular necrosis

Recognize the life-threatening complications of acute tubular necrosis

Plan treatment for a patient with acute tubular necrosis

### **(3). Acute cortical necrosis**

Understand the pathogenesis and pathophysiology of acute cortical necrosis of the kidney  
Know the clinical course of acute cortical necrosis of the kidney

#### **c. Renal vein thrombosis**

Understand the pathogenesis and pathophysiology of renal vein thrombosis  
Recognize the clinical and laboratory manifestations of renal vein thrombosis  
Plan treatment for a patient with renal vein thrombosis

#### **d. Abdominal compartment syndrome**

Understand the pathogenesis of abdominal compartment syndrome in children  
Recognize renal failure caused by abdominal compartment syndrome  
Plan treatment for renal failure caused by abdominal compartment syndrome

### **3. Glomerulonephritis**

Differentiate acute glomerulonephritis from other causes of renal failure on the basis of its clinical and laboratory features

Understand the pathogenesis and pathophysiology of glomerulonephritis

Know the causes of glomerulonephritis

Recognize the manifestations and life-threatening complications of glomerulonephritis

Plan treatment for a patient with glomerulonephritis

### **4. Nephrotic syndrome**

Know the pathogenesis and pathophysiology of nephrotic syndrome

Recognize the clinical manifestations and life-threatening complications of nephrotic syndrome

Plan treatment for the life-threatening complications of nephrotic syndrome

### **5. Hemolytic-uremic syndrome**

Know the pathogenesis and pathophysiology of hemolytic-uremic syndrome

Know the features and clinical course of hemolytic-uremic syndrome

Recognize the manifestations and life-threatening complications of hemolytic-uremic syndrome

Plan treatment for a patient with hemolytic-uremic syndrome

Know the association of hemolytic-uremic syndrome with E. coli :O157

### **6. Toxic**

Recognize the manifestations of drug-induced renal insufficiency

Recognize tumor lysis syndrome

Plan treatment for a patient with pigment nephropathy

Understand the mechanisms of NSAID-induced renal dysfunction

Plan the management of a patient with tumor lysis syndrome

Recognize renal toxicity associated with calcineurine inhibitors

Recognize renal failure from acetaminophen toxicity

## **7. Obstructive**

Recognize the manifestations of renal failure secondary to severe urethral obstruction

Know the causes of urinary tract obstruction

## **D. Renal replacement therapy**

### **1. Hemodialysis**

Recognize the complications of hemodialysis

Know the appropriate clinical application for hemodialysis in a patient with renal failure

Know the (relative) contraindications to hemodialysis

### **2. Peritoneal dialysis**

Recognize the complications of peritoneal dialysis

Recognize the respiratory/gas exchange complications of peritoneal dialysis

Know the appropriate clinical application for peritoneal dialysis in a patient with renal failure

Know the (relative) contraindications to peritoneal dialysis

### **3. Continuous renal replacement therapy**

Recognize the complications of continuous renal replacement therapy

Know the appropriate clinical application for continuous renal replacement therapy in a patient with renal failure

Know the appropriate clinical application for continuous renal replacement therapy in a patient with fluid overload without renal failure

Understand the principles of water and electrolyte balance in a patient undergoing continuous renal replacement therapy

Understand how to set up and maintain renal replacement therapy systems

## **E. Hypertension**

### **1. Pathophysiology**

Understand neural influences on systemic blood pressure

Understand humoral regulation of blood pressure

Understand the developmental changes in systemic blood pressure

Understand the pathophysiology of systemic hypertension

Recognize the effect of acute and chronic hypertension on cerebral autoregulation

Know the acute and chronic renal disorders associated with hypertension

Know which tumors are associated with hypertension

Know the endocrine causes of hypertension

Know which drugs can cause hypertension

## **2. Clinical course**

Know the clinical course of hypertension in the disorders that cause it

## **3. Diagnosis**

Know how to evaluate the etiology and severity of hypertension in infants and children

## **4. Complications**

Recognize the manifestations and life-threatening complications of acute hypertension

Recognize the manifestations and life-threatening complications of acute exacerbation of long-standing hypertension

Recognize hypertensive encephalopathy

## **5. Treatment**

Understand the normal mechanisms for blood pressure control

Plan medical therapy for a patient with systemic hypertension

Plan initial therapy for a patient with acute severe hypertension

Plan the management of hypertension in a child with chronic renal disease

Know the mechanism of action of commonly used antihypertensive drugs

Know contraindications to the use of antihypertensive drugs

Know the adverse effects and toxicities associated with the use of various antihypertensive agents

## **F. Renal transplantation**

Differentiate among the causes of acute renal failure following renal transplantation

Recognize the life-threatening complications that may occur following renal transplantation

## **G. Renal handling of drugs and organic molecules**

Know the renal handling of drugs and organic molecules commonly used in pediatric critical care

Know the renal handling of drugs and organic molecules commonly ingested by children

# **VI. Metabolism and Endocrinology**

## **A. Adrenal**

1. Steroid function

Know the classes of steroids synthesized by the adrenal cortex and their function  
Understand the mechanisms of steroid action in the cardiovascular system  
Understand the mechanisms of steroid action in the immune system  
Understand the mechanisms of steroid action in the endocrine system  
Know the genetic or acquired abnormalities of steroid biosynthesis resulting in critical illness  
Understand the mechanisms of steroid action in the central nervous system

## 2. Adrenal insufficiency

### a. Acquired adrenal insufficiency

#### (1). Pathophysiology

Understand the pathogenesis and pathophysiology of acquired adrenal insufficiency

Know the hypoadrenal disorders associated with increased ACTH concentrations

Know the hypoadrenal disorders associated with decreased ACTH concentrations

#### (2). Clinical course

Recognize acquired adrenal insufficiency as a complication of infection or sepsis syndrome

Know the clinical and laboratory manifestations of acquired adrenal insufficiency

Know how to diagnose acquired adrenal insufficiency

Know the importance of bound versus free cortisol concentrations

#### (3). Treatment

Plan the treatment of a patient with possible acquired adrenal insufficiency

### b. Congenital adrenal insufficiency

#### (1). Pathophysiology

Understand the pathogenesis and pathophysiology of congenital adrenal insufficiency

#### (2). Clinical course

Recognize the manifestations of congenital adrenal insufficiency

Distinguish the clinical presentation of a 2-week-old infant with congenital adrenal insufficiency from one with sepsis

#### (3). Treatment

Plan the acute treatment of an infant with shock due to congenital adrenal insufficiency

## 3. Hyperadrenalism

### a. Cushing disease

Know the manifestations and life-threatening complications of Cushing disease

### b. Corticosteroid toxicity

Know the acute and chronic adverse effects of corticosteroids

#### 4. Pheochromocytoma

Recognize the clinical and laboratory manifestations of pheochromocytomas, and differentiate them from those of the serotonin syndrome

Identify the underlying conditions associated with pheochromocytomas

Plan treatment for a child with pheochromocytoma prior to surgery

### **B. Thyroid**

#### 1. General

Know the role of thyroid hormones in regulating energy metabolism

Know the role of thyroid hormones in modulating catecholamine effects

Know that which drugs may interfere with the normal thyroid hormone axis

#### 2. Thyroid storm

##### a. Pathophysiology

Understand the pathogenesis and pathophysiology of thyroid storm in a child with thyrotoxicosis

##### b. Clinical course

Recognize the manifestations of thyroid storm

##### c. Diagnosis

Distinguish thyroid storm from acute psychosis

##### d. Treatment

Plan the treatment of a child with acute thyroid storm

#### 3. Hypothyroidism

##### a. Pathophysiology

Understand the association between acquired hypothyroidism and the use of specific drugs (eg, amiodarone) or specific conditions (eg, trisomy 21)

##### b. Clinical course

Recognize the manifestations of congenital hypothyroidism

Recognize the manifestations of acquired hypothyroidism

#### 4. Sick euthyroid syndrome

Recognize the laboratory manifestations of sick euthyroid syndrome

Know that thyroid supplementation is not indicated for patients with sick euthyroid syndrome

### **C. Endocrine pancreas**

#### 1. General

Know the alterations in insulin and glucagon secretion caused by critical illness

## 2. Diabetes mellitus

### a. Pathophysiology

Understand the pathophysiology of diabetic ketoacidosis

Understand the factors associated with the development of cerebral edema complicating diabetic ketoacidosis

### b. Life-threatening complications

Recognize a patient with diabetic ketoacidosis with cerebral edema

Recognize diabetes mellitus as a cause of coma

Recognize insulin overdose as a cause of coma

### c. Treatment

Plan the initial management of a child with diabetic ketoacidosis

Plan the management of cerebral edema occurring during diabetic ketoacidosis

## 3. Acute or episodic hyperinsulinism

Recognize the manifestations of acute insulin overdose

Know the cellular effects of insulin and glucagon

## **D. Antidiuretic hormone and the renin-angiotensin-aldosterone axis**

### **1. General**

Understand the physiology of the renin-angiotensin-aldosterone axis

Recognize conditions characterized by increased activity of the renin-angiotensin-aldosterone system

Understand the actions of the renin-angiotensin-aldosterone and antidiuretic hormone systems during dehydration and positive- pressure ventilation

### **2. SIADH**

#### a. Pathophysiology

Recognize SIADH as a cause of hyponatremia

Understand the mechanism of hyponatremia during SIADH

Understand the pathophysiology of sodium and water balance in a patient with SIADH

#### b. Clinical course

Know how to establish the diagnosis of SIADH

Recognize the instability of the antidiuretic hormone function after head injury

Differentiate between SIADH and other causes of increased total body water

#### c. Life-threatening complications

Plan appropriate therapy for the life-threatening complications of hyponatremia due to SIADH

Recognize seizure as a complication of SIADH

d. Treatment

Plan acute treatment for a child with SIADH after head injury

### **3. Cerebral salt wasting**

a. Pathophysiology

Recognize cerebral salt wasting as a cause of hyponatremia

b. Clinical course

Know how to diagnose cerebral salt wasting and distinguish it from SIADH and water intoxication

c. Treatment

Plan the management of a patient with cerebral salt wasting

### **4. Central diabetes insipidus**

a. Pathophysiology

Understand the variable course of diabetes insipidus following brain injury

Know the causes of diabetes insipidus

b. Clinical course

Recognize the clinical and laboratory manifestations of diabetes insipidus and differentiate from nephrogenic diabetes insipidus

c. Life-threatening complications

Know the life-threatening complications of diabetes insipidus

d. Treatment

Plan the acute management of a child with diabetes insipidus

### **E. Endocrine disorders of calcium homeostasis**

1. Parathyroid hormone

a. Deficiency

(1). Pathophysiology

Understand the pathogenesis and pathophysiology of hypoparathyroidism

(2). Clinical course

Know the clinical and laboratory manifestations of hypoparathyroidism

Recognize the association of congenital hypoparathyroidism and T-cell immunodeficiency (DiGeorge syndrome)

(3). Diagnosis

Understand the possibility of hypoparathyroidism in an infant with refractory hypocalcemia

(4). Life-threatening complications

Know the life-threatening complications of hypoparathyroidism

(5). Treatment

Understand the acute management of an infant or child with symptomatic hypocalcaemia due to hypoparathyroidism

b. Excess

(1). Pathophysiology

Understand the pathogenesis and pathophysiology of hyperparathyroidism in the patient with chronic renal failure

Understand the manifestations of hyperparathyroidism and pseudohyperparathyroidism

(2). Treatment

Know the treatment of hyperparathyroidism

**F. Metabolism**

**1. Normal metabolism**

Know the sources of ATP in energy metabolism

a. Aerobic and anaerobic metabolism

Understand the relationship between anaerobic and aerobic metabolism

Understand anaerobic metabolism

Identify which cell types require aerobic metabolism

b. Gluconeogenesis

Understand gluconeogenesis

Identify the substrates for rate-limiting steps in gluconeogenesis

**2. Inborn errors of metabolism**

**a. Carbohydrate**

Understand the pathogenesis and pathophysiology of galactosemia

Recognize the clinical manifestations and life-threatening complications of galactosemia

Recognize glycogen storage disease as a cause of hypoglycemia

**b. Protein/amino acid**

Recognize maple syrup urine disease

Recognize specific amino acid disorders such as homocystinuria and hyperglycinemia

Know the clinical course of a patient with maple syrup urine disease

Know how to diagnose inborn errors of amino acid metabolism

Recognize the importance of withholding dietary protein in the initial management of acidosis due to errors of amino acid metabolism

Plan supportive management for specific amino acid disorders

Understand the life-threatening complications of inborn errors of amino acid metabolism

### **c. Organic acid**

Know several inherited diseases that might produce metabolic acidosis (eg, Leigh disease, methylmalonic academia, pyruvate dehydrogenase complex abnormalities)

Know the clinical and laboratory manifestations and the course of the organic acidurias

Know the life-threatening complications of the organic acidurias

Understand the association of glutaric aciduria type I and D-2-hydroxyglutaric aciduria with subdural hemorrhages

### **d. Urea cycle**

Recognize urea cycle disorders

Understand the roles of dialysis, arginine, and benzoate in the treatment of urea cycle disorders

Recognize defects in the urea cycle as potential causes of hyperammonemia

Understand the emergency management of patients with urea cycle disorders, especially hyperammonemia

### **e. Fatty acid**

Recognize disorders of fatty acid metabolism

Plan the management of a patient with a disorder of fatty acid metabolism

### **f. Mitochondrial**

Recognize the neurologic and muscular manifestations of mitochondrial disorders

Plan the management of a patient with a mitochondrial disorder

## **G. Glucose and critical illness**

### **1. Neonatal hypoglycemia (excluding hyperinsulinism)**

#### **a. Pathophysiology**

Understand the mechanisms of hypoglycemia other than hyperinsulinism in the neonate

#### **b. Clinical course**

Know the clinical manifestations and outcome of neonatal hypoglycemia of various causes other than hyperinsulinism

#### **c. Diagnosis**

Differentiate among the causes of neonatal hypoglycemia (other than hyperinsulinism)

#### **d. Treatment**

Know the treatment of hypoglycemia (other than hyperinsulinism) and its complications in the neonate

## **2. Non-neonatal hypoglycemia**

a. Pathophysiology and diagnosis

Understand the causes and mechanisms of hypoglycemia in infants, children, and adolescents

b. Clinical course and treatment

Know the clinical course and treatment of hypoglycemia in infants, children, and adolescents

## **3. Hyperglycemia**

a. Pathophysiology

Understand the causes of hyperglycemia in critically ill patients without diabetes

Understand the adverse effects on patient outcome associated with hyperglycemia

b. Treatment

Plan the management of hyperglycemia in a critically ill patient

# **VII. Hematology/Oncology**

## **A. Structure, function, and development**

### **1. Hematopoietic system**

Understand the development of the hematopoietic system

Know the biology of different colony-stimulating factors and their uses

### **2. Erythrocyte**

Know the nutritional requirements for erythrocyte precursors

Understand the function of erythropoietin

Know the potential indications for the use of erythropoietin in critically ill patients

Understand the life cycle of erythrocytes

### **3. Neutrophil**

Know the role of the neutrophil in host defense

Know the effects of drugs and stress on neutrophil concentrations

Know the role of the neutrophil in the inflammatory response

Know the kinetics of polymorphonuclear leukocytes in the circulation

### **4. Macrophage**

Know the role of the tissue macrophage

Know the role of the macrophage in antigen presentation

### **5. Platelet**

Know the development of the platelet, and the significance of large and small platelets in the circulation

Know the role of platelets in coagulation

### **6. Lymphocytes**

Know the role of the lymphocyte in host defense

Understand the role of the various lymphocyte classes

### **7. Spleen**

Know the functions of the spleen

Know the clinical and laboratory manifestations of altered/absent splenic function

## **B. Specific disorders**

### **1. Anemia**

#### **a. General**

Distinguish among the various causes of anemia

#### **b. Nutrient deficiency**

Recognize the clinical and laboratory manifestations of anemia caused by chronic bleeding and/or iron deficiency

Recognize anemia caused by nutrient deficiency

#### **c. Hemolytic**

Understand the pathogenesis, pathophysiology, and clinical manifestations of hemolytic disease due to various causes

Plan treatment for a child with severe acute hemolytic anemia and prostration

Differentiate among the causes of hemolytic anemia

#### **d. Aplastic disorders**

Plan medical management for a patient with aplastic anemia

Know the manifestations of aplastic anemia

Understand the pathogenesis and pathophysiology of aplastic anemia

Know the clinical manifestations and clinical course of drug-induced aplastic anemia

Distinguish aplastic from hemolytic anemia on the basis of clinical and laboratory features

#### **e. Hemoglobinopathy**

Know the pathogenesis and pathophysiology of sickle cell crisis

Recognize the clinical and laboratory manifestations of vasoocclusive sickle cell crisis

Recognize the life-threatening complications of sickle cell disease

Plan treatment for a patient with sickle cell crisis

Recognize the clinical and laboratory manifestations of acute chest syndrome

Recognize the clinical and laboratory manifestations and management of acute sequestration crisis

Recognize the clinical and laboratory manifestations of acute aplastic crisis

Recognize the signs and symptoms associated with methemoglobinemia

Plan the treatment for a patient with methemoglobinemia

Recognize the clinical and laboratory manifestations of *S. pneumoniae* bacteremia in a child with sickle cell disease

#### **f. Hemorrhagic disorders**

Know the pathophysiology of hemorrhagic shock

Understand the pathophysiology of ischemia-reperfusion injury

Know that toxic oxygen species are involved in ischemia-reperfusion pathogenesis

Recognize the common factor deficiencies associated with hemorrhagic disorders

Plan initial management of a patient with hemorrhagic shock

Understand the appropriate use of exogenous factor replacement in critically ill patients

g. Causes of anemia in intensive care setting

#### **2. Polycythemia**

Understand the causes of polycythemia

Understand the adverse effects of polycythemia

Plan the management of a patient with polycythemia

#### **3. Thrombocytopenia**

##### **a. General**

Recognize hypersplenism as a cause of thrombocytopenia

Recognize infection as an etiology of thrombocytopenia

Know the causes of thrombocytopenia

Know the complications of thrombocytopenia

Distinguish among the causes of thrombocytopenia (dilutional loss, impaired production, destruction)

##### **b. Immunologic**

Understand the pathogenesis of immune thrombocytopenia

Recognize the clinical and laboratory manifestations of idiopathic thrombocytopenia purpura

Understand the principles of treatment of idiopathic thrombocytopenia purpura

Recognize the bleeding and thrombotic diatheses of the patient with infection/sepsis and purpura

Differentiate infectious from thrombotic thrombocytopenic purpura

Understand how to diagnose and treat heparin-induced thrombocytopenia

Understand that treatment of thrombotic thrombocytopenic purpura is an emergency

#### **c. Disseminated intravascular coagulation**

Understand the pathogenesis and pathophysiology of disseminated intravascular coagulation

Understand the clinical and laboratory manifestations of disseminated intravascular coagulation

Know the clinical disorders associated with disseminated intravascular coagulation

Recognize infarction as a complication of thrombotic intravascular coagulation

Plan appropriate replacement therapy for a patient with disseminated intravascular coagulation

Know the role of drugs like heparin, fibrinolytic and thrombolytic agents in the treatment of disseminated intravascular coagulation

#### **4. Thrombocytosis**

Understand the causes of thrombocytosis

Understand the complications of thrombocytosis

#### **5. Neutropenia**

Understand the pathogenesis and pathophysiology of neutropenia

Understand the infectious risks of neutropenia

Recognize neutropenia as a manifestation of overwhelming infection

Recognize the clinical manifestations of infection in the neutropenic patient

Recognize the life-threatening complications of neutropenia, including sepsis

Select an appropriate antibiotic regimen for a patient with neutropenia and presumed sepsis

Recognize the indications and complications of neutrophil transfusion

Know the indications for using granulocyte colony-stimulating factor

#### **6. Coagulopathies**

Know the coagulation cascade

Know the interpretation and utility of different available tests to diagnose specific factor deficiency.

Recognize intracranial hemorrhage as a risk of clotting factor deficiency

Know the effects of hepatocellular disease on clotting factors

Know the effects of disseminated intravascular coagulation on clotting factors

Know the effects of heparin administration on clotting factors

Understand the pathogenesis and treatment of drug-induced coagulopathies

Interpret the results of coagulation studies

Understand the risks of warfarin therapy and methods to reverse effects of warfarin

Know the indications and contraindications for the use of protamine and other heparin antagonists

Know the indications and contraindications for the use of anti- fibrinolytics, such as aminocaproic acid and tranexamic acid

Know that anticoagulants used outside the body (EDTA, citrate, oxalate) may be administered via blood products or as additives with other therapies

Know the indications for various blood products to enhance coagulation

Know the indications and contraindications of specific factor transfusion

Know the indications and contraindications for the use of specific coagulation factors for the treatment of bleeding disorders

To know the monitoring during anticoagulation therapy

## **7. Thrombosis**

Understand the indications and contraindications for thrombolytic therapy

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, recombinant agents

Understand the mechanism of action of commonly used thrombolytic drugs

Plan the evaluation of a patient with thrombosis

Understand the mechanisms of thrombosis

Plan the management of a patient with an arterial thrombosis (eg, gangrene in a limb or digit, cerebrovascular stroke, myocardial infarction)

Know the indications and contraindications for the use of antiplatelet drugs

Know the indications and contraindications for the use of fibrinolysis inhibitors

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**

Know the expected clinical course of a hematopoietic stem cell transplant

Recognize graft-versus-host disease after hematopoietic stem cell transplantation

Recognize the complications resulting from hematopoietic stem cell transplantation (eg, hepatic venoocclusive disease)

Know pediatric diseases where hematopoietic stem cell transplantation is utilized (malignant and non-malignant)

Recognize the difference in rates of various complications during the phases after hematopoietic stem cell transplantation (pre-engraftment, post-engraftment, > 100 days)

Understand the etiologies of respiratory failure after hematopoietic stem cell transplantation

To know the spectrum of etiological agents responsible for infections in this group of patients

To know the presentation, diagnostic workup and management of graft-vs.host disease host disease

#### **D. Malignancies**

Recognize the life-threatening complications of malignancies, including leukemia at initial presentation

Recognize the complications and life-threatening risks associated with therapies for malignancies, including leukemia

Recognize the potential gastrointestinal complications of malignancy

Recognize the risks of and plan treatment for hyperleukocytosis

Recognize the risk of airway compression from intrathoracic malignancies

Plan therapy for a patient with an anterior mediastinal mass and respiratory distress including airway management

Prevention, recognition, diagnosis and management of tumor lysis syndrome

#### **E. Blood banking and blood component transfusion**

Recognize the clinical and laboratory manifestations of transfusion reaction

Understand the principles of component transfusion

Know what screening is routinely performed on donor blood prior to release from the blood bank

Understand the potential hazards of blood transfusion

Know the specific indications for the use of irradiated erythrocytes

Know the complications of a massive blood transfusion

Know the treatment for coagulopathy resulting from massive blood transfusion

Know what constitutes compatible blood for transfusion

Plan therapy for complications of transfusion

Know the indications for leukocyte transfusion

Know the indications for platelet transfusion

Know which mechanisms reduce the risk of cytomegalovirus infection resulting from blood transfusion

Know the risks and advantages of directed donor transfusion

Plan the management of a patient who received Rh-incompatible blood

Know the alternatives to blood transfusion

Understand the indications for erythrocyte transfusion in various disease states (i.e., cyanotic congenital heart disease, severe respiratory failure, and severe dehydration)

Know the indications for plasma transfusion

Know the indications for plasmapheresis

## **VIII. Gastroenterology and Nutrition**

### **A. Structure, function, and physiologic development**

#### **Chewing and swallowing:**

Recognize the role of intact neural function in airway protection during swallowing

Know the anatomic and functional characteristics of swallowing

#### **Gastrointestinal motility:**

Factors affecting gastric motility and emptying time

#### **Digestion and exocrine function**

##### **a. Salivary:**

Understand the role of salivary enzymes (lysozyme and peroxidase) in defense against bacterial invasion

Understand the role of mouth care in preventing ventilator-associated pneumonia

##### **b. Gastric**

Understand the regulation and role of gastric pH.

##### **c. Hepatic**

Understand the biliary drainage, synthetic functions, storage functions, role of bile salts in digestion and xenobiotic (detoxification) metabolism.

##### **d. Pancreatic**

Know the types and function of pancreatic enzymes

##### **e. Intestinal**

Understand the physiology of the brush border of the small intestine, identify the causes of decreased intestinal surface area

### **B. Gastrointestinal neuroendocrine function**

Understand the mechanism and role of gastrointestinal peptides in gastric acid secretion, in glucose metabolism, in gastrointestinal motility

### **C. Hepatic metabolism**

#### **a. Nutrients**

Recognize the role of hepatic metabolism in the clearance of ammonia during protein catabolism

Recognize gluconeogenesis, glycogenolysis and regulation of carbohydrate metabolism

Recognize the role of hepatic metabolism in bilirubin elimination

#### **b. Pharmacologic agents**

Know the role of hepatic metabolism in drug metabolism/detoxification

Recognize drug-induced alterations in hepatic metabolism as a mechanism of drug-drug interaction

### **D. Gastrointestinal absorption and secretion**

#### **a. Water**

Know the acid/base characteristics of gastrointestinal secretions and the effects of these secretions on systemic acid-base balance, drug absorption

#### **d. Electrolytes and minerals**

Know the role of the gastrointestinal tract in the regulation of serum calcium, phosphorus, and on electrolyte balance

### **E. Gastrointestinal lymphatics**

Know the function and significance of gastrointestinal lymph flow

Recognize the causes and effects of impaired gastrointestinal lymph flow

Know the anatomy of the circulation of the gastrointestinal system

know the principles of enterohepatic circulation

Know the anatomy and physiology of the hepatic/portal circulation

Understand the mechanisms of ascitis formation

Know the effect of adrenergic drugs on gastrointestinal blood flow

Know the effect of gastrointestinal hormones on intestinal vascular tone

Know the effect of dopaminergic drugs on gastrointestinal blood flow

Know the effect of vasopressin on gastrointestinal blood flow

#### **F. Gastrointestinal pharmacology**

Know the pharmacology of pH regulation in the gastrointestinal tract

Know the drugs that decrease gastrointestinal motility and their clinical importance

Know the drugs that increase gastrointestinal motility and their clinical importance

Identify the drugs that increase or decrease lower esophageal sphincter tone

Understand the importance of delivering drugs to the appropriate location in the gastrointestinal tract (e.g., drugs dependent on an acid milieu)

#### **G. Interactions with other organ systems**

##### **With airway and lungs**

###### **a. Reflux and aspiration**

Recognize gastroesophageal reflux and the differential diagnosis.

Aspiration as a possible cause of acute life-threatening event in infancy, and management.

Understand effects of gastric emptying time; pH of gastric secretions; pathophysiologic effects of aspirated gastric contents on airway and lung parenchyma.

Know techniques for decreasing the aspiration of saliva.

###### **b. Chylous effusion**

###### **c. Elevated diaphragms due to abdominal distension**

Understand the effect of elevated diaphragms on respiratory function

###### **d. Nutrition and respiratory musculature**

Know the effect of reduced caloric intake on respiratory muscle function

##### **With mediastinum (eg, esophageal perforation)**

Recognize the causes significance of esophageal perforation

Know pathophysiology of caustic injury, and management

Recognition and management mediastinitis

##### **With peritoneum**

Recognize peritonitis as a cause of sepsis, pathophysiology of abdominal compartment syndrome.

**With reticuloendothelial system**

Understand the interrelationship of gut ischemia and sepsis

Recognize the contributions of the gastrointestinal system to host defense: salivary immunoglobulins, gastric acid, normal gut motility, physical barriers (mucin, etc)

Understand the gastrointestinal factors that increase bacterial translocation

**With acid/base balance**

Know the effects of systemic alterations in acid-base homeostasis on gastrointestinal electrolyte absorption

**With cardiovascular system**

a. Congenital heart disease

Recognize that certain gastrointestinal malformations occur more commonly with certain forms of congenital heart disease.

Recognize the special nutritional issues associated with surgical repair of congenital heart disease.

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)

Understand the hemodynamic significance of intraperitoneal or intestinal fluid accumulation.

**With central nervous system**

Understand the conditions (e.g., TBI, hypoxic encephalopathy, etc) in which a patient should undergo evaluation of suck-swallow mechanisms prior to attempts at oral feeding

Understand the risks associated with chronic nasogastric tube feeding in a patient with impaired airway protective reflexes

**H.Functional assessment of GI, Liver and pancreas**

Gastro Intestinal and liver: (aim is to differentiate between normal and abnormal functional capabilities of GI and liver both clinically and with the help of investigations)

Know how to assess absorption of nutrients, abnormality in metabolism of various nutrients.

Know how to assess integrity of functions of the GIT and liver and pancreas: (clinical and laboratory assessment of liver cell failure); for example -

Gastric and esophageal pH,

Context specific stool examination,

Indications and complications of endoscopy,

Indications of laryngoscopy and bronchoscopy for GI diseases,

Use of plain and contrast radiologic assessment in various GI & liver conditions,

Abdominal ultrasonography,

Indications and limitations of FAST (*focused abdominal sonography for trauma*) versus formal abdominal ultrasonography in children,

Indications and limitations of abdominal CT scan

Indications and limitations of radionuclide scans

## **I. Knowledge of GI, Pancreatic and Liver diseases**

### **Liver Failure**

Etiology (infective, toxic, metabolic, genetic),

Know clinical features, pathophysiology of acute liver cell failure

Pathogenesis of encephalopathy

Etiology, clinical features, pathophysiology of chronic liver cell failure

Management principles, precipitating factors of liver cell failure

Liver support systems

Indications of liver transplant and principles of post operative management of liver transplants

### **Pancreatic Disease**

Etiology, clinical features, diagnosis, pathophysiology, complications (such as sepsis and ARDS) and prognosis of acute and chronic pancreatitis

Management of pancreatitis

### **GI Diseases**

**Etiology, clinical features, pathophysiology, and management of all (but not limited to) the following diseases**

Inflammatory bowel disease, celiac disease, Ulceration, Short-gut syndrome; helicobacter pylori infection, antibiotic induced GI disorders, necrotizing enterocolitis etc.

Role of drugs that alter the gastric pH / secretion, lavage, somatostatins.

### **Caustic and other GI burns**

### **Upper and lower GI bleeding: etiology, pathogenesis, management**

## **J.Nutritional assessment**

### **Nutritional (Calorie, Protein, Micronutrients) requirements of normal children**

Know the nutritional requirements, dietary calculations and the factors that influence the nutritional requirements of normal infants and children

Know various types of carbohydrates, aminoacids, fats and micronutrients (e.g., vitamins and minerals)

### **Nutritional (Calorie, Protein, Micronutrients) requirements of critically children**

Know the nutritional requirements, dietary calculations and the factors that influence the nutritional requirements of critically ill infants and children

Pitfalls of routine clinical and laboratory assessment of nutritional adequacy in critically ill children

Know various types of carbohydrates, aminoacids, fats and micronutrients (e.g., vitamins and minerals) and available special sources for nutritional supplementation

Resting energy expenditure, predicted energy expenditure (methods of calculation)

Pathophysiology of increased energy expenditure

Principles of direct and indirect calorimetry

Use of respiratory quotient in assessment of nutritional adequacy

### **Nutritional requirements of disorders such as.. (but not limited to)**

**1. Burns**

**2. Sepsis**

**3. Malignancy**

**4. Chronic infection**

**5. Congestive cardiac failure**

**6. Respiratory failure**

**7. Starvation / severe PEM (protein energy malnutrition)**

Recognize classification, pathophysiologic consequences of protein malnutrition

Characterize protein metabolism of the stress response

Understand the differences in the metabolic response to simple and stressed starvation

Understand the principles of nutritional support during the stress response

Understand the principles of refeeding in malnutrition syndromes

Know the complications & pathophysiology of refeeding syndromes

### **8. Primary gastrointestinal and liver disorders**

Nutrition in hepatic failure, inflammatory bowel disease, celiac disease, Ulceration, Short-gut syndrome; helicobacter pylori infection, antibiotic induced GI disorders, necrotizing enterocolitis etc.

Role of drugs that alter the gastric pH / secretion, lavage, somatostatins.

Caustic and other GI burns

Upper and lower GI bleeding: etiology, pathogenesis, management

### **9. Renal failure and uremia**

### **10. Central nervous system**

Nutritional needs of a comatose (traumatic, nontraumatic) child.

Ketogenic diet for control of intractable seizures

### **11. Multiple organ system failure: (principles of nutritional support)**

## **K. Enteral, Parenteral Nutrition and immunonutrition:**

### **Enteral Nutrition**

Plan enteral nutrition regimen (disease specific in critically ill children)

Recognize enteral feeding limitations, absolute & relative contraindications in critically ill patients (by oral, gastric and jejunal routes)

Enteral vs. parenteral pros and cons.

Understand the role of specialized formulas and predigested formulas to provide nutrition in malabsorption, liver diseases, renal diseases, inborn errors of metabolism etc. in critically ill children

Jejunal / gastric feeding pros and cons

Continuous vs. intermittent feeding pros and cons

Characteristics of Ideal enteral feed in critically ill children

Role of probiotic in critically ill children  
Complications of enteral feeding  
Calculation of CNR (calorie nitrogen ratio) and interpretation  
Recognize dumping syndrome  
Understand importance of protocols of enteral nutrition

### **Total Parenteral Nutrition (TPN)**

Indications of parenteral nutrition  
Calculate and plan parenteral nutrition regimen  
Explain exact method of TPN  
Know method of monitoring a child on TPN  
Know the side effects and/or complications of parenteral nutrition

Role of immunonutrition / trace elements / in PICU:  
Selenium, copper, zinc, Vit A, C, E, probiotics, Omega 3 fatty acids, glutamine, arginine

## **IX. Poisonings, Toxins, and Overdoses**

### **A. General principles of detoxification**

#### 1. Biochemical antagonism

Know the antidotes for common poisonings

#### 2. Gastric emptying

Know the indications and contraindications to induction of vomiting and gastric emptying after ingestion of a toxin

#### 3. Alimentary binding

Know the indications and contraindications for and principles that underlie the use of charcoal after ingestion of a toxin

#### 4. Facilitation of renal excretion

Understand the mechanisms of facilitation of renal excretion of common toxins

Recognize the role of dialysis in detoxification after ingestion of a toxin

#### 5. Facilitation of plasma or organic binding

Recognize facilitation of plasma protein binding as a means to decrease toxicity of ingested substances

#### 6. Whole bowel irrigation

Know the indications for using whole bowel irrigation to remove toxins

#### 7. Surface decontamination

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

Recognize the clinical and laboratory manifestations of acute salicylate ingestion

##### b. Pathogenesis and toxic effects

Know the pathophysiology of salicylate ingestion and associated metabolic derangements.

##### c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of salicylates

##### d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of suspected salicylate ingestion

##### e. Treatment

Plan appropriate therapy for a child with acute salicylate intoxication

#### **2. Acetaminophen**

##### a. Diagnostic features

Recognize the clinical and laboratory manifestations of acute acetaminophen intoxication and how they change as time progresses

##### b. Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of acetaminophen

##### c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of acetaminophen

##### d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of acetaminophen ingestion

##### e. Treatment

Plan appropriate therapy for a child with acute acetaminophen intoxication including liver transplant indications

### **3. Tricyclic antidepressants, Selective serotonin receptor inhibitors (SSRI) and other psychotropic drugs**

#### a. Diagnostic features

Recognize the clinical and laboratory manifestations of acute ingestion of a tricyclic antidepressant, SSRI, or other psychotropic drug

#### b. Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of tricyclic antidepressants, SSRIs, and other psychotropic drugs

Know the mechanism of action of tricyclic antidepressants, SSRIs, and other psychotropic drugs

#### c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of tricyclic antidepressants, SSRIs, and other psychotropic drugs

#### d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of ingesting a tricyclic antidepressant, SSRI, or other psychotropic drug(s)

#### e. Treatment

Plan appropriate therapy for a child with acute intoxication from ingestion of a tricyclic antidepressant, SSRI, or other psychotropic drug(s)

### **4. Theophylline**

#### a. Diagnostic features

Recognize the clinical and laboratory manifestations of acute theophylline intoxication

#### b. Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of theophylline

#### c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of theophylline

#### d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of theophylline ingestion

#### e. Treatment

Plan appropriate therapy for a child with acute theophylline intoxication

### **5. Anticonvulsants**

#### a. Diagnostic features

Recognize the side effects and toxicities of the common anticonvulsants and the associated clinical and laboratory findings

b. Pathogenesis and toxic effects

Know the pathophysiology and toxic effects of overdose of common anticonvulsants

c. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of suspected overdose of one of the common anticonvulsants

d. Treatment

Plan appropriate therapy for a child with overdose of one of the common anticonvulsants

**6. Narcotics**

a. Diagnostic features

Recognize the clinical and laboratory manifestations of narcotic overdose

b. Pathogenesis and toxic effects

Know the pathophysiology and toxic effects of narcotic overdose

c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of narcotic agents

d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of suspected narcotic overdose

e. Treatment

Plan appropriate therapy for a child with narcotic overdose

**7. Cyanide**

a. Diagnostic features

Recognize cyanide toxicity as a problem in smoke inhalation

Recognize the clinical and laboratory manifestations of cyanide poisoning

b. Pathogenesis and toxic effects

Know the pathophysiology and toxic effects of cyanide

c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of cyanide

d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of suspected cyanide poisoning

e. Treatment

Plan appropriate therapy for a child with cyanide poisoning

**8. Amphetamines and congeners**

a. Diagnostic features

Recognize the clinical and laboratory manifestations of acute amphetamine intoxication

b. Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of amphetamines

c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of amphetamines

d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of amphetamine ingestion

e. Treatment

Plan appropriate therapy for a child with acute amphetamine intoxication

**9. Petroleum distillates (hydrocarbons)**

a. Diagnostic features

Recognize the clinical and laboratory manifestations of ingestion of a petroleum distillate (hydrocarbon)

Understand the routes of entry of petroleum distillates (hydrocarbons)

b. Pathogenesis and toxic effects

Understand the pulmonary toxic effects of petroleum distillates (hydrocarbons)

Understand the neurotoxic effects of petroleum distillates (hydrocarbons)

c. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of petroleum distillate (hydrocarbon) ingestion

d. Treatment

Recognize the respiratory indications for intubation after ingestion or aspiration of a liquid hydrocarbon

Plan appropriate therapy for a child with acute petroleum distillate (hydrocarbon) exposure

**10. Corrosive agents**

a. Acids

(1). Diagnostic features

Recognize the clinical and laboratory manifestations of acid ingestion

(2). Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of acid ingestion

(3). Treatment

Plan appropriate therapy for a child with acute acid ingestion

Recognize the potential airway compromise associated with caustic ingestion

b. Alkali

(1). Diagnostic features

Recognize the clinical and laboratory manifestations of acute alkali ingestion

(2). Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of ingested alkali

(3). Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of alkali ingestion

(4). Treatment

Plan appropriate therapy for a child with acute alkali ingestion

**11. Organophosphate insecticide**

a. Diagnostic features

Recognize the clinical and laboratory manifestations of acute organophosphate poisoning

b. Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of organophosphates

c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of organophosphates

d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of organophosphate poisoning

e. Treatment

Plan appropriate therapy for a child with acute organophosphate poisoning

**12. Carbon monoxide**

a. Diagnostic features

Recognize the clinical and laboratory manifestations of carbon monoxide poisoning

b. Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of carbon monoxide

c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of carbon monoxide

d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of carbon monoxide poisoning

e. Treatment

Plan appropriate therapy for a child with acute carbon monoxide poisoning

Know adjunctive therapy for carbon monoxide poisoning

### **13. Illicit (“street”) drugs**

#### a. Diagnostic features

Recognize the clinical and laboratory manifestations of the use of illicit (“street”) drugs other than cocaine (e.g., LSD, MDMA, jimson weed)

Know the signs of acute cocaine ingestion

Know which illicit (“street”) drugs can cause seizures

#### b. Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of illicit (“street”) drugs other than cocaine

Understand the pathogenesis and toxic effects of cocaine

#### c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of illicit (“street”) drugs other than cocaine

Know the metabolism, excretion, and pharmacokinetics of cocaine

#### d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a suspected overdose of an illicit (“street”) drug

#### e. Assessment of extent and severity of injury

Evaluate the extent and severity of illicit (“street”) drug intoxication

#### f. Treatment

Plan appropriate therapy for a patient with an illicit (“street”) drug overdose

### **14. Envenomation and bites**

#### a. Diagnostic features

Recognize the clinical and laboratory manifestations of snake envenomation

Recognize the diagnostic features of spider bites

Recognize the diagnostic features of scorpion bite

#### b. Pathogenesis and toxic effects

Understand the pathophysiologic and toxic effects of various venoms

#### c. Treatment

Plan appropriate therapy for a child with acute envenomation including specific drugs

Recognize anaphylaxis after envenomation, and plan its treatment

Know the complications associated with antivenin therapy

### **15. Glycols and alcohols**

a. Diagnostic features

Recognize the clinical and laboratory manifestations of glycol or alcohol poisoning

b. Pathogenesis and toxic effects

Understand the pathogenesis and toxic effects of glycol or alcohol poisoning

Understand the pathogenesis and toxic effects of methanol ingestion

c. Normal elimination

Know the normal metabolism, excretion, and pharmacokinetics of glycols and alcohols

d. Diagnostic evaluation

Plan the diagnostic assessment and evaluation of a child suspected of glycol or alcohol poisoning

e. Treatment

Plan appropriate therapy for a child with acute glycol or alcohol poisoning

Plan treatment for a patient with methanol ingestion

## **X. Trauma and Burns**

### **A. Initial evaluation and stabilization**

Evaluate a patient with multiple trauma in the emergency department

Plan control of the airway in a patient with multiple trauma in the emergency department

Identify the situations in which immediate surgical intervention is required

Know the general principles and sequence of the concurrent evaluation, stabilization, and prioritization of injuries

### **B. Specific injuries**

**1. Head injury** (also see section of Neurology under head and spinal cord trauma)

**2. Strangulation**

Understand the pathophysiology of a strangulation or hanging injury

**3. Neck injury**

Know the proper evaluation of neck injuries

Plan the appropriate stabilization of a patient with a suspected neck injury

**4. Dental injury, facial and orbital fractures**

Know the implications of dental injuries and facial or orbital fractures for airway compromise and management

**5. Chest injury**

a. Evaluation

Know the physical findings of traumatic hemothorax

Know the physical findings of a traumatic tear of the major airway

Recognize myocardial contusion as a result of closed chest injury

Know the potential complications of closed chest injury

Recognize flail chest and the associated mechanical respiratory impairment

Recognize the clinical and radiographic findings with large vessel damage from closed chest injury and order appropriate additional diagnostic studies

b. Stabilization

Plan stabilization of a child with a closed chest injury

Plan the stabilization of a patient with a penetrating chest injury

Know the appropriate management of flail chest

Recognize the risk of a “sucking” chest wound in the spontaneously breathing patient

c. Treatment

Plan the treatment of a patient with a penetrating chest injury

**6. Abdominal injury**

a. Blunt trauma

(1). Pathogenesis and pathophysiology

Understand the pathophysiology of compensatory responses to acute traumatic blood loss

(2). Evaluation

(a). Physical examination

Recognize external evidence of internal abdominal injury

Recognize the signs of abdominal compartment syndrome

(b). Laboratory assessment

Know the indications for ultrasonography or CT scan in patients with abdominal trauma

Evaluate the merits of radiologic evaluation of abdominal trauma, as compared to paracentesis

Interpret the results of radiographic evaluation in abdominal trauma

(3). Stabilization

Formulate fluid and blood component management strategy for hemorrhagic shock

(4). Treatment

Plan the management of a child with splenic injury

b. Penetrating injury

(1). Pathogenesis and pathophysiology

(2). Evaluation

Know the indications for laparotomy after penetrating injury of the abdomen

Plan the laboratory evaluation of a penetrating abdominal injury

(3). Stabilization

(4). Treatment

c. Laceration

(1). Pathophysiology

Know that lacerations occur with blunt abdominal trauma

(2). Diagnosis

Know the diagnostic procedures to define a lacerated viscus

(3). Treatment

Know the principles of resuscitation for a patient with intra-abdominal laceration

Recognize the life-threatening complications of intra-abdominal laceration

**7. Extremity injuries**

a. General

Recognize the signs of peripheral vascular insufficiency

b. Fractures

(1). Pathogenesis and pathophysiology

(2). Evaluation

Distinguish between nonintentional and intentional fractures

Recognize compartment syndrome

(3). Stabilization

Recognize the potential for large volume shifts associated with long bone fractures

(4). Treatment

Plan the management of a patient with compartment syndrome

**8. Near-drowning/drowning**

a. Pathogenesis and pathophysiology

Understand the pathogenesis and pathophysiology of pulmonary injury in near-drowning

Recognize the potential for associated head/neck injury in near-drowning episodes

b. Evaluation

Know the importance of water temperature in brain outcome from a near-drowning episode

Know how to evaluate the neurologic status of a child after resuscitation from near-drowning

c. Stabilization/treatment

Know the management priorities following a submersion injury

## **9. Burns**

a. Pathogenesis and pathophysiology

b. Evaluation

Recognize the extent of upper airway injury in burn victims

Distinguish between partial- and full-thickness burns

Estimate the percentage of body surface area burned in infants and children

c. Stabilization

Plan the stabilization of a patient with burns of the nose and mouth

d. Treatment

Know the fluid and electrolyte requirements of burn patients

Plan the treatment of a patient with burns of the nose and mouth

Know the risks of infection in burn patients

## **10. Smoke inhalation**

a. Pathogenesis and pathophysiology

Understand the pathogenesis and pathophysiology of different inhaled combustible toxins

Understand the relationship between carbon monoxide poisoning and smoke inhalation

Understand the different effects of steam and smoke inhalation

b. Evaluation

Evaluate the extent of pulmonary injury in a smoke inhalation victim

c. Stabilization/treatment

Plan treatment for a patient with smoke inhalation

## **11. Lightning/electrocution injuries**

a. Pathogenesis and pathophysiology

Recognize that an electrical injury has effects on the central nervous system and heart that are unrelated to cutaneous burns

Recognize that an electrical injury may be associated with delayed vascular injury

b. Evaluation

Recognize entry and exit wounds from an electrical injury

c. Stabilization

Know the principles of stabilization of a victim of lightning injury

d. Treatment

## **12. Multiple trauma**

a. Pathogenesis and pathophysiology

b. Evaluation

Plan the evaluation of a patient with multiple traumatic injuries

c. Stabilization

Plan the initial stabilization of a child with multiple trauma

Understand the potential sequelae of multiple trauma

d. Treatment

Recognize the risk of exacerbating neurologic injury during treatment of other associated injuries (e.g., setting fractures without adequate analgesia, inadequate blood pressure support, etc)

Plan a strategy for the titration of analgesia and sedation in a patient with multiple trauma

### **13. Environmental heat injury**

Recognize the situations in which heat stroke and prostration are most likely to occur

Know the clinical and laboratory manifestations of heat illness

Plan the treatment of a patient with heat stroke

### **14. Hypothermia**

Recognize that active rewarming beyond the temperature required to avoid ventricular fibrillation should be avoided

Understand the complications of rewarming hypothermic patients

Know the clinical and laboratory manifestations of hypothermia

Plan the management of a patient with hypothermia

## **XI. Pharmacology**

### **A. Pharmacokinetics and pharmacodynamics**

#### **1. Half-life concept**

Apply measurement of half-life to plan therapeutic regimens

#### **2. Kinetic concepts**

Differentiate between first-order and zero-order kinetics of drug metabolism

Understand the effects of drug loading doses

Understand changes in serum drug concentration with drug elimination

Know the effects of drug kinetics on drug serum concentrations as a function of time

### **3. Patterns of absorption and routes of administration**

Know the kinetics of intratracheal drug administration

Understand the relationships between bioavailability and route of drug administration

Know the kinetics of intrathecal drug administration

Understand the patterns of aerosolized/ nebulized drug uptake and distribution

Know the kinetics of intraosseous drug administration

Identify the factors that influence enteral drug absorption including drug-food interactions

Identify the factors that influence cutaneous drug absorption

Identify the factors that influence intramuscular drug absorption

### **4. Patterns of drug distribution**

Understand the volume distribution and role of fat solubility in drug distribution

Understand the effect of protein binding on the volume of drug distribution

Identify the factors that affect protein binding of drugs

Understand the developmental effects on drug distribution

### **5. Pathways of drug metabolism**

Understand the role of phase I reactions in drug metabolism

Understand the role of conjugation (phase II) reactions in drug metabolism

Understand the developmental effects on phase I and II reactions in drug metabolism

### **6. Patterns of drug excretion and elimination**

Understand the role of renal excretion in the elimination of certain drugs and the means to enhance this process

Understand the components and the concepts of drug clearance

Know the common, clinically relevant drug interactions

Know the common, clinically relevant pharmacokinetic alterations with organ dysfunction

Know the common, clinically relevant pharmacokinetic alterations with extracorporeal support

Identify the factors that alter renal drug excretion

Identify the factors that influence hepatic drug excretion

Understand the developmental effects on drug excretion and elimination

### **7. Blood-brain barrier and central nervous system penetration by drugs**

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**

Know the mechanisms of norepinephrine inactivation, including neuronal uptake, and how this process is altered

Know the agents that alter norepinephrine re-uptake (e.g., cocaine, imipramine, amphetamines)

### **2. Pharmacology of adrenergic receptors**

Differentiate between alpha-1, alpha-2, beta-1, and beta-2 type adrenergic drug action

Understand the conditions that change adrenergic receptor density

Understand the conditions that change signal transduction in response to adrenergic receptor stimulators

### **3. Pharmacology of acetylcholine synapses**

Know that physostigmine crosses the blood-brain barrier, whereas neostigmine does not

Know the agents that alter transmission at the cholinergic synapse (e.g., cholinesterases)

### **4. Pharmacology of acetylcholine receptors**

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**

Understand the relationship between absorption, distribution, and elimination of general anesthetics and their effects

Understand the effects of combining anesthetic agents

## **D. Sedatives**

Understand the relationship between absorption, distribution, and elimination of sedatives and their effects

Recognize the adverse effects of sedatives and their metabolites

Understand the factors that enhance phenobarbital elimination

## **E. Analgesics**

Understand the relationship between absorption, distribution, and elimination of analgesics and their effects

Recognize the adverse effects of analgesics

Know the comparative analgesic effects of different agents

Know the durations of actions of analgesic agents

Know the methods for reversing and treating the effects of analgesics

## **F. Vasoactive agents**

Understand the relationship between absorption, distribution, and elimination of vasodilating agents and their effects

Recognize the adverse effects produced by vasodilating agents

Know the therapies for the adverse effects of vasodilators, including the therapy for nitroprusside toxicity

Know the effects of common drugs on systemic vascular resistance

Know the pharmacology of common vasoactive drugs and hormones

### **G. Inotropic agents**

Differentiate among sympathomimetic agents on the basis of their affinities for adrenergic receptor subtypes

Understand the relationship between absorption, distribution, and elimination of inotropic agents and their effects

Understand the mechanism of action of commonly used inotropic drugs

### **H. Inodilators**

Understand the dual location of action of inodilators in improving cardiac output

Understand the implications of milrinone's significantly different serum half-life in contrast to adrenergic-receptor agonists

Understand the differences in mechanism of action between the various inodilators

### **I. Vasopressors**

Understand the different relative effects on vascular tone among adrenergic receptor agonists

Know the risks and benefits of vasopressor use in various types of shock

### **J. Cholinergic antagonists**

Understand the end-organ pharmacologic response to the administration of cholinergic antagonists

Know the mechanism of action of anticholinergic drugs as bronchodilators

### **K. Anticonvulsants**

Understand the normal mechanisms of metabolism, absorption, distribution, and elimination of the common anticonvulsants and the relationship between their pharmacokinetics and their effects

Recognize the effects of anticonvulsants on the metabolism of other drugs

Understand the mechanism of action of specific anticonvulsants

### **L. Beta-2 agonists**

Understand the relationship between absorption, distribution, and elimination of beta-2 agonists and their effects

**M. Calcium channel-blocking drugs**

Distinguish among the calcium channel blockers with respect to their relative antidysrhythmic, negative inotropic, and vasodilating activities

**N. Beta-blocking drugs**

Understand the relationship between absorption, distribution, and elimination of beta blockers and their effects

Recognize the adverse effects of beta blockers and the therapy for these effects

**O. Diuretics**

Distinguish among the various classes of diuretics with respect to their site of action in the renal tubule

Understand the relationship between absorption, distribution, and elimination of diuretics and their effects

Recognize the adverse effects of diuretics and the therapy for these effects

**P. Antidysrhythmics**

Distinguish among the various classes of antidysrhythmic drugs with respect to their effect on impulse action potential in the conduction system of the heart

Understand the relationship between absorption, distribution, and elimination of antidysrhythmic drugs and their effects

Recognize the adverse effects of antidysrhythmic drugs and the therapy for these effects

Know the mechanism of action and toxicity of common antidysrhythmic medications

**Q. Immunosuppressive drugs**

Know the mechanism of action of commonly used immunosuppressive drugs

Recognize the drug interactions between drugs commonly used in the PICU and immunosuppressive drugs

**R. Natriuretic peptides**

Know the mechanism of action of B-type natriuretic peptide (nesiritide)

**S. Anticoagulants**

Know the side effects of various thrombolytic agents

Understand the differences between thrombolytic agents that activate and do not activate plasminogen

Understand the pathophysiology of heparin-induced thrombocytopenia

Know the side effects of various anticoagulant agents

Understand the elimination of anticoagulants

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

Know the side effects of antifibrinolytic agents, including aprotinin

## **XII . Perioperative Care, and Procedural Sedation**

### **A. Preoperative considerations**

#### **1. Assessing operative risk**

##### a. Cardiovascular risk

##### (1). Congenital heart disease

##### (a). Right-to-left shunts

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

##### (b). Left-to-right shunts

Know the consequences of the administration of 100% oxygen to patients with left-to-right shunts due to interventricular communications

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

##### (c ). Obstructive lesions

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

##### (d). Cardiac rhythm

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

##### (2). Hypovolemia

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

##### (3). Myocardial dysfunction

Recognize the effects of anesthetic drugs on myocardial function, heart rate, and systemic vascular resistance

Know that narcotics cause the least depression of myocardial function of all anesthetics

Recognize that a patient with sepsis may have impaired myocardial function and hence an exaggerated risk of cardiac depression during anesthesia

## b. Pulmonary risk

Understand the anesthetic/muscle relaxant implications in patients with respiratory failure of neuromuscular origin

Understand the anesthetic/muscle relaxant implications in patients with respiratory failure of central origin secondary to lack of respiratory drive

Understand the anesthetic/muscle relaxant implications in patients with respiratory failure due to abnormal alveolar gas exchange

Understand the anesthetic/muscle relaxant implications in patients with respiratory failure secondary to parenchymal lung or small airways disease

Understand the anesthetic/muscle relaxant implications in patients with respiratory failure secondary to pulmonary vascular disease

Recognize respiratory failure as a factor that increases the risk of hypoxemia during anesthesia

Understand the respiratory effects of anesthesia on minute ventilation, lung volumes, airway resistance, and lung compliance

## c. Neurologic risk

Understand that anesthetic-induced coma cannot be differentiated from coma resulting from neurologic and other causes

## **2. Full stomach**

Plan preoperative airway management for a patient with a “full stomach”

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**

Understand the hemodynamic effects of inhaled anesthetics

Know the differences in onset and offset of inhaled anesthetics

Understand the respiratory effects of inhaled anesthetics

### **2. Muscle relaxants**

#### a. General

#### **(1). Pharmacokinetics**

Know the mechanism of action of commonly used muscle relaxants

Know the metabolism of commonly used muscle relaxants

Differentiate between depolarizing and nondepolarizing drugs

#### **(2). Drug-relaxant interactions: prolongation/potential of effect**

Judge which muscle relaxants are appropriate for use in patients with renal and/or hepatic failure

Recognize that aminoglycosides prolong neuromuscular blockade

Know the effect of hypocalcemia/ hypomagnesemia on neuromuscular blockade

Know which drugs prolong or potentiate the effects of muscle relaxants

Understand how the effects of muscle relaxants can be prolonged or potentiated

### **(3). Evaluation of residual effect**

Understand the relationship between absorption, distribution, and elimination of agents producing neuromuscular blockade and their effects

Know how to evaluate residual neuromuscular blockade with the use of a twitch monitor

Recognize that a patient may have no residual muscle blockade but can become paralyzed again if hypokalemic, hypomagnesaemia, cold, or poorly perfused

Know the commonly used agents reversing neuromuscular blockade and their side effects

Know how to assess residual neuromuscular blockade by history and physical examination

Understand the rationale for combining atropine with a cholinesterase inhibitor

### **(4). Absence of sedative/analgesic action**

Recognize that muscle relaxants have no sedative, analgesic, or anxiolytic properties

Know that pupillary response is usually spared during the use of neuromuscular blocking agents (i.e., muscle relaxants)

### **(5). Relative sensitivity of different muscles**

Know the relative sensitivity of different muscle groups to muscle relaxants

b. Specific

#### **(1). Succinylcholine**

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

Recognize sinus bradycardia/sinus arrest as potential complications of succinylcholine paralysis

Recognize myoglobinuria as a potential complication of succinylcholine administration

Know that succinylcholine can increase intracranial pressure

Recognize the conditions in which the use of succinylcholine has increased risks

Know the causes of prolonged effect of succinylcholine

#### **(2). Pancuronium**

Recognize that pancuronium may cause vagolytic tachycardia

Recognize renal excretion as the major path for the elimination of pancuronium

### **(3). Vecuronium**

Know that vecuronium has only minor hemodynamic effects

Recognize that liver failure prolongs the paralytic effect of vecuronium

### **(4). Cisatracurium**

Know that the hemodynamic effects of cisatracurium are minimal

Know that cisatracurium is eliminated by Hoffman degradation

Know that cisatracurium clearance is not dependent on liver or renal function

### **(5). Rocuronium**

Know that the speed of onset and duration of action of rocuronium is dose-dependent

## **3. Short-acting barbiturates**

### **a. Beneficial effects**

Know the pharmacologic actions, including beneficial effects, of short-acting barbiturates

Know that short-acting barbiturates can decrease intracranial pressure

Know that the duration of action of short-acting barbiturates is related to lipid solubility and redistribution

### **b. Risks**

Recognize that apnea may result from the use of barbiturates

Recognize that myocardial depression may result from the use of barbiturates

Know that short-acting barbiturates are contraindicated in patients with shock

## **4. Ketamine**

Recognize the sympathetic stimulation produced by ketamine, as well as the consequences of this stimulation

Understand that ketamine maintains airway reflexes

Know that ketamine is a cause of hallucinations

Understand that ketamine-induced hallucinations can be prevented/treated with benzodiazepines

## **5. Narcotics**

Understand the mechanism of action of narcotic analgesics

Know the duration of action of commonly used narcotic analgesics

Understand and differentiate the concepts of tolerance, dependence, and addiction associated with narcotic analgesia

Understand methods of weaning patients from narcotic analgesia in the ICU

Understand the potential benefits of patient-controlled analgesia

Understand the use of specific narcotic antagonists

### **6. Propofol**

Understand the use of propofol and the associated risks

Recognize the association between propofol infusion and acidosis, hypotension, and death in children

### **7. Etomidate**

Understand the indications for, use of, and side effects of etomidate

Understand the high potential for adrenal suppression from a single dose of etomidate and the consequences in certain patients (e.g., with septic shock)

### **8. Local anesthetics (amides versus esters)**

#### **a. Signs of toxicity**

Understand that local anesthetics can produce seizures, and know at what doses seizures are likely to occur

Recognize that many local anesthetics are mixed with epinephrine and that catecholamines can produce systemic alterations

Recognize the complications associated with the accidental intravenous injection of local anesthetics

Know that profound myocardial depression can result from the use of local anesthetics

Recognize the early symptoms of local anesthetic toxicity

Understand the risk of intravascular injection of bupivacaine local anesthetic and its use as an epidural anesthetic

#### **b. Treatment of toxicity**

Plan the treatment of a patient with seizures secondary to local anesthesia

### **9. Major tranquilizers**

#### **a. Sedatives**

Know the duration of action and complications of diazepam

Know the duration of action and complications of midazolam

Know the duration of action and complications of lorazepam

Know the specific reversal agents for the various benzodiazepines, the appropriate use of such agents, and complications associated with their use

#### **b. Butyrophenones**

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

Recognize the significance of family history as a risk factor for fatal complications during anesthesia

Know that abnormal neuromuscular function is important in predicting malignant hyperthermia

Recognize the risk factors for malignant hyperthermia

Know the chronology of the onset of malignant hyperthermia

#### 2. Clinical signs

Differentiate postoperative fever (low-grade) from malignant hyperthermia

Recognize malignant hyperthermia in the patient not exposed to anesthetic drugs

Know that clinical signs of acidosis, cyanosis, and increased CO<sub>2</sub> production may antedate defined muscle spasm in malignant hyperthermia

Recognize the clinical and laboratory manifestations of malignant hyperthermia (fever, acidosis, dysrhythmias, cyanosis, increased CO<sub>2</sub> production, masseter spasm, muscle rigidity, disseminated intravascular coagulation, coma)

#### 3. Associated laboratory findings

Recognize the laboratory manifestations of malignant hyperthermia (hyperkalemia, increased serum creatine kinase activity, hypercalcemia)

#### 4. Treatment

Know how to treat malignant hyperthermia with dantrolene

Know the roles of environmental cooling, core cooling, bicarbonate, and antidysrhythmic therapies in malignant hyperthermia

#### 5. Triggering agents

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

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

Differentiate neuroleptic malignant syndrome from sepsis and other causes of fever

## 2. Associated laboratory findings

Recognize neuroleptic malignant syndrome by its clinical and laboratory manifestations

## 3. Triggering agents

Recognize that malignant hyperthermia can be triggered by the use of neuroleptic drugs

## 4. Treatment

Know how to treat neuroleptic malignant syndrome with dantrolene

### **E. Postoperative concerns**

#### 1. Evaluation of failure to awaken

##### a. Residual anesthetic effects

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

Recognize hypothermia as a cause of failure to awaken after anesthesia

##### c. Hypoxic/ischemic encephalopathy

Differentiate residual anesthetic effect from hypoxic insult, residual muscle paralysis, and central nervous system insult

##### d. Spinal cord injury

Recognize the possibility of intraoperative spinal cord injury in patients with unstable cervical spines

##### e. Hypoglycemia

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

Understand that central nervous system depression from anesthesia may produce decreased respiratory drive even when a patient is conscious

##### b. Airway obstruction

Recognize airway trauma, edema, and injury of the recurrent laryngeal nerve as causes of postoperative respiratory insufficiency

##### c. Residual neuromuscular blockade

Recognize residual neuromuscular blockade and resultant weakness as a cause of respiratory insufficiency after an operation

##### d. "Bellows" dysfunction

Differentiate “splinting” after chest or abdominal surgery from true lung disease

Recognize abdominal distension as a cause of respiratory insufficiency after an operation

Recognize phrenic nerve injury as a cause of respiratory insufficiency after an operation

Recognize pneumothorax as a cause of respiratory insufficiency after an operation

Know the relative effects of various operations on different body regions and their effects on “splinting” and postoperative atelectasis

e. Parenchymal disease

Differentiate upper airway obstruction following extubation from primary lung dysfunction

3. Fluid management

a. Evaluating intraoperative fluid administration

Recognize that deficit, maintenance, insensible, and ongoing fluid losses must be considered during intraoperative fluid replacement

Recognize hypovolemia secondary to inadequate intraoperative fluid administration

Recognize hypervolemia secondary to intraoperative fluid administration

b. SIADH secondary to surgery (ADH secretion, etc)

Recognize the conditions associated with increased postoperative ADH secretion

4. Shivering

Know the metabolic, respiratory, and central nervous system effects of shivering

5. Agitation

Understand the causes of persistent postoperative sinus tachycardia (including hypoxemia, hypoventilation, pain, bladder distention, residual drug effect, hypoxia, anxiety)

Understand the causes and treatment of postoperative emergence delirium

## **F. Management of pain and sedation in the intensive care unit**

1. General

Understand the pathophysiology of pain

Recognize that good pain control improves postoperative outcomes

Plan pain management for patients with various conditions and in various circumstances, including burn debridement and chest tube insertion/removal

2. Pain assessment

Understand the concept of pain scales and objective pain assessment

Assess pain in the intubated patient

3. Regional anesthesia/analgesia for management of postoperative pain

a. Caudal/epidural analgesia

Know the indications for caudal/epidural postoperative pain control

Know the complications of caudal/epidural postoperative pain control

b. Peripheral nerve blocks

Know the indications for postoperative nerve blocks

Know the complications associated with the use of nerve blocks for postoperative pain control

4. Procedural sedation

Understand the definitions and clinical characteristics of the levels of procedural sedation ranging from mild to moderate to deep sedation

Know the national guidelines governing procedural sedation

Plan sedation for a patient with a compromised airway

5. Long-term sedation

6. Withdrawal syndromes

Recognize withdrawal syndromes associated with narcotics, barbiturates, and benzodiazepines and know how to manage them

## **XIII. Research methodology and biostatistics**

### **A. Biostatistics**

#### **1. Types of variables**

Distinguish types of variables (e.g., continuous, categorical, ordinal, nominal)

#### **2. Distribution of data**

Understand how distribution of data affects the choice of statistical test

Differentiate normal from skewed distribution of data

Understand the appropriate use of the mean, median, mode, standard deviation and standard error

#### **3. Hypothesis testing**

Distinguish the null hypothesis from an alternative hypothesis

#### **4. Statistical tests**

Understand the appropriate use of various statistical tests

Interpret a p-value

Interpret a confidence interval

Identify type I and type II errors

### **5. Measurement of association**

Differentiate relative risk reduction from absolute risk reduction

Calculate and interpret relative risk, odds ratio

Interpret a hazard ratio

Understand the uses and limitations of a correlation coefficient

### **6. Regression**

Identify when to apply regression analysis (e.g., linear, logistic) and know how to interpret results

Identify when to apply survival analysis (e.g., Kaplan-Meier) and know how to interpret results

### **7. Diagnostic tests**

Recognize the importance of an independent “gold standard” in evaluating a diagnostic test

Calculate and interpret sensitivity and specificity, positive and negative predictive values

Understand how disease prevalence affects the positive and negative predictive value of a test

Calculate and interpret likelihood ratios

Interpret a receiver operator characteristic curve

Interpret and apply a clinical prediction rule

### **8. Systematic reviews and meta-analysis**

Understand the purpose of a systematic review

Understand the advantages of adding a meta-analysis to a systematic review

Identify the limitations of systematic reviews and meta-analyses

## **B. Principles of Epidemiology and Clinical Research Design**

### **1. Study types**

Distinguish between Phase I, II, III, and IV clinical trials

Recognize a retrospective study

Recognize, understand strengths/limitations of: a case series, cross-sectional studies, case-control studies, longitudinal studies, cohort studies, randomized-controlled studies, before-after studies, crossover studies, open-label studies, post-hoc analysis, subgroup analysis

## **2. Bias and confounding**

Understand how bias and confounding affect the validity of results

Identify common strategies in study design to avoid or reduce bias and confounding

## **3. Causation**

Understand the difference between association and causation

## **4. Incidence and prevalence**

Distinguish disease incidence from disease prevalence

## **5. Screening**

Understand factors that affect the rationale for screening for a condition or disease (e.g., prevalence, test accuracy, risk-benefit, disease burden, presence of a presymptomatic state)

## **6. Decision analysis**

Understand the strengths and limitations of decision analyses

Interpret a decision analysis

## **7. Cost-benefit, cost-effectiveness, and outcomes**

Differentiate cost-benefit from cost-effectiveness analysis

Understand how quality-adjusted life years are used in cost analyses

Understand the multiple perspectives (e.g., of an individual, payer, society) that influence interpretation of cost-benefit and cost-effectiveness analyses

## **8. Sensitivity analysis**

Understand the strengths and limitations of sensitivity analysis and interpret the results

## **9. Measurement**

Understand the types of validity that relate to measurement (e.g., face, construct, criterion, predictive, content)

Distinguish validity from reliability

Distinguish internal from external validity

Distinguish accuracy from precision

Understand and interpret measurements of interobserver reliability (e.g., kappa)

Understand and interpret Cronbach's alpha

## **C. Applying Research to Clinical Practice**

### **1. Assessment of study design, performance & analysis (internal validity)**

Recognize when appropriate control groups have been selected for case-control and cohort studies

Recognize the use and limitations of surrogate endpoints

Understand the use of intent-to-treat analysis

Understand how sample size affects the power of a study

Understand how sample size may limit the ability to detect adverse events

Understand how to calculate an adequate sample size for a controlled trial (e.g., clinically meaningful difference, variability in measurement, choice of alpha and beta)

### **2. Assessment of generalizability (external validity)**

Identify factors that contribute to or jeopardize generalizability

Understand how non-representative samples can bias results

Assess how the data source (e.g., diaries, billing data, and discharge diagnostic code) may affect study results

### **3. Application of information for patient care**

Estimate the post-test probability of a disease, given the pretest probability of the disease and the likelihood ratio for the test

Calculate absolute risk reduction

Calculate and interpret the number-needed-to-treat

Distinguish statistical significance from clinical importance

### **4. Using the medical literature**

Given the need for specific clinical information, identify a clear, structured, searchable clinical question

Identify the study design most likely to yield valid information about the accuracy of a diagnostic test, benefits and/or harms of an intervention or prognosis of a condition

## **XIV. Special Critical Care Issues**

### **A. Legal considerations**

#### **1. Malpractice**

a. Definition

Know the definition of malpractice

Recognize the components of malpractice in clinical practice

b. Defense

Appreciate the importance of appropriate ongoing patient-physician communication, especially as it relates to malpractice issues/ ★ consumer forum complaints

Understand the role of hospital risk-management organizations in assisting and protecting the physician named in a malpractice claim / ★ consumer forum claim

c. Documentation

Understand how chart documentation affects the defensibility of malpractice claims

Understand the types of information reported to, stored, and released by the national physician data bank

d. Physician as expert witness

Understand the limits of acceptable conduct of an expert witness in a malpractice action

**2. Informed consent for clinical care**

a. General

Know the principles of informed and implied consent

Understand the process of obtaining informed consent

Know the elements of informed consent

Understand the limitations of written informed consent

b. Minors

Know the rights of minors

Know the components of informed consent for a child

Understand the importance of consent and assent as they apply to minors

Recognize the settings in which parents are not appropriate surrogate decision makers for their child

c. Proxy decision makers

Understand the concept of proxy decision makers

**3. Interactions with the legal system**

Understand the limitations of the legal system in patient- physician interactions

Understand patient confidentiality

Understand the jurisdiction of the medical examiner/coroner

**4. Child abuse**

a. Recognition and documentation

Recognize the important physical signs and symptoms diagnostic of child abuse

Evaluate a suspected victim of child abuse

Recognize the laboratory findings associated with child abuse

Recognize the factors that predispose a child to abuse

Understand the importance of written and photographic documentation of child abuse

Formulate a differential diagnosis for suspected child abuse

Recognize the laboratory findings and common radiographic manifestations of child abuse

Recognize the possibility of sexual abuse in ★ possible cause / injury children

Diagnose a patient who is the victim of Munchausen syndrome by proxy

b. Reporting responsibility

Differentiate patient confidentiality from medicolegal requirements to report injuries in suspected child abuse

Know the laws regarding the reporting of suspected child abuse/neglect

Understand the role of the child protection team

c. Protection of family/staff

Recognize the importance of a nonaccusatory physician/nurse role in the circumstances of child abuse

Understand the possibility of a battered spouse or other child abuse in an abused child's family

Understand the support needs of a family with a child suspected of being abused

Know that members of the medical staff are protected from litigation resulting from the reporting of suspected child abuse

d. Testifying in court

Recognize the importance of early cooperation with the legal system in cases of child abuse

Recognize the importance of consultation and review with an appropriate attorney prior to a child abuse trial

**5. Patient care vs. legal system**

a. Religious beliefs

Plan an approach to a situation involving refusal of permission for care on the basis of religious beliefs

Know the settings in which obtaining a court order is appropriate

b. Patient autonomy

Understand the principles of patient autonomy and their paramount role in issues of informed consent

Understand the progression of development in a child's understanding of issues related to critical illness and death

Know how to incorporate a pediatric patient's wishes into decision making

c. Parent autonomy

Understand the principles of parent autonomy

Know the limits of parent autonomy in the medical care of children

d. Rights of the dead

Know the limitations on invasion of the deceased

## **B. Ethical issues**

### **1. Definition of an ethical question**

Differentiate between questions of medicine and questions of ethics

### **2. Termination of care**

a. Know in detail the current laws regarding termination of care.

b. Withholding of care

Recognize similarities/differences in withholding/withdrawing care from an ethical and social standpoint

Understand the ethical issues involved in the provision of futile, harmful, or burdensome treatment

Understand when it is appropriate to discontinue resuscitation in the critical care setting

Know when a decision not to resuscitate is appropriate

Know that a do-not-resuscitate order does not in itself limit other treatment

c. Euthanasia

Understand the difference between euthanasia and allowing a patient to die

### **3. Full disclosure**

a. To patient

Know at what age a patient should be included in discussions of ethical decisions regarding his/her care

b. To family member(s)

Know what information may be withheld from family members

Understand parental responses to information regarding their critically ill child

Understand the value of full disclosure to family members

#### **4. Patient/family/physician rights**

Know when to transfer care

Understand the concept of patient abandonment

#### **C. Economic issues**

##### **1. Expense of ICU care**

Know the differences between costs and charges regarding the expense of ICU care

Identify strategies for reducing the cost of ICU care

##### **2. Relationship of ICU cost to hospital cost**

Understand major components of the high cost of ICU care compared to care on other hospital units

##### **3. Reimbursement schemes**

Understand the sources of payment for hospital-based pediatric medical care

Know the difference between capitation and fee-for-service

Understand the concept of cost-shifting within hospitals

##### **4. Billing and compliance**

Understand that admitting a patient to the ICU does not necessarily justify billing that patient for critical care services

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**

Know the traditional definition of death

###### **b. Brain**

Know the conditions that prevent or interfere with the diagnosis of brain death

Know findings in brain death

Understand the factors involved in establishing brain death in neonates

Understand the usefulness and limitations of ancillary neurologic tests (e.g., electroencephalography, brain blood-flow studies, evoked responses) in the setting of brain death

##### **2. Organ donation**

Understand the legal requirement for requesting that organs be donated

Know the relationship between the diagnosis of brain death and organ donation

Understand the federal network of regional donor programs

Recognize the complexities involved in considering anencephalic infants as organ donors

Understand “slippery slope” considerations relative to death and organ donation

Know the contraindications to organ donation

Understand the concept of living-related organ donation

Understand the considerations for and techniques of Donation After Cardiac Death (DCD)

### **3. Tissue donation**

Know that tissue donation is possible after cardiopulmonary death

Know that tissues that may be donated include corneas, skin, bone, heart valves, and great vessels

Know the contraindications to tissue donation

## **XVI. Principles of monitoring and technical procedures**

### **A. Hemodynamic monitoring**

#### **1. Understanding Transducers**

Understand the basic physics involved in the use of transducers

##### **a. Zeroing**

Understand the techniques of zeroing in hemodynamic monitoring

##### **b. Calibration**

Know how to calibrate a vascular pressure monitor

##### **c. Resonance**

Understand the concept of resonance in hemodynamic monitoring

##### **d. Damping**

Understand the concept of damping

##### **e. Catheter whip**

Understand the physiology of catheter whip

#### **2. Arterial blood pressure monitoring**

##### **a. Components of the arterial waveform**

Recognize catheter “fling”

Recognize catheter damping

Know how length and size of tubing alter arterial waveform

Interpret different arterial pressures in different limbs

Recognize catheter “ring”

Know the causes of damping

b. Temporal relation of the arterial waveform to the ECG

Know the timing and physiologic basis of the components of the arterial waveforms

Understand the relationship between arterial waveform components and ECG

Recognize the alterations of waveforms secondary to dysrhythmias

c. Alterations in the waveform

(1). Hemodynamic disorders

Recognize the different arterial waveforms generated by differing pathologic conditions

(2). Drug effects

Recognize the effects of drugs on arterial waveforms

(3). Effects of respiration

Know the effects of respiration on arterial waveforms

### **3. Central venous pressure monitoring**

a. Components of central venous waveform

Know the normal components of the venous waveform

b. Effect of respiratory cycle

(1). Spontaneous respiration

Know the relationship of spontaneous respiration to the central venous pressure waveform

(2). Mechanical respiration

Know the effects of positive-pressure ventilation on the central venous pressure waveform

c. Interpretation in presence of cardiac dysfunction

Understand the effects of altered cardiac physiology on the central venous pressure waveform

d. Temporal relation of the waveform to the ECG

Understand the relationship between venous waveform components and ECG

Recognize the alterations of venous waveforms secondary to dysrhythmias

### **4. ScVO<sub>2</sub> monitoring, noninvasive Cardiac output (pulse contour analysis), and functional echocardiography.**

Know basic principles of ScVO<sub>2</sub> monitoring and practical application of non invasive assessment of cardiac output in ICU for determining oxygen delivery, as well as myocardial function in patients with shock and multiorgan dysfunction.

## **5. Monitoring during mechanical ventilation**

**1. Pulse oximetry and pitfalls:** know the principles, limitations and techniques

**2. Capnography** (sidestream versus mainstream)

(1). Recognition of airway obstruction

Understand the use of capnography in the clinical setting of airway obstruction

(2). Limitations as a predictor of arterial PCO<sub>2</sub>

Understand that the sampling rate of gas withdrawal makes capnography difficult in neonates and small children

Understand that there are physiologic conditions in which capnography will not correlate well with arterial CO<sub>2</sub>, as in obstructions to pulmonary blood flow from air or pulmonary embolus, or an increase in V<sub>d</sub>/V<sub>t</sub>

Know that capnography may contribute to the diagnosis of conditions such as pulmonary embolus

(3). Assessment of endotracheal tube position

Understand the role of capnography in identifying esophageal tube placement

Know that capnography cannot distinguish pharyngeal or main stem bronchial tube placement from tracheal placement

**6. Monitoring of ventilator graphics:**

**Scalar flow pressure and volume waveforms in relation to time graphs,**

**Pressure volume compliance curve, and flow volume loop.**

Be familiar with basics of detecting air leak, overdistension, airway obstruction (upper and lower airway), worsening compliance, and patient ventilator asynchrony.

**7. Intraabdominal pressure monitoring**

Know principles of intra abdominal pressure monitoring in a patient with shock, method of monitoring, normal and abnormal values and practical application.

**8. Intracranial pressure Monitoring**

a. Devices

(1). General

Know the available methods for monitoring intracranial pressure

(2). Epidural devices

Know the technique of epidural monitoring of intracranial pressure

Know the complications associated with epidural monitoring of intracranial pressure

Know the limitations of epidural monitoring of intracranial pressure

(3). Subarachnoid devices

Know the technique of subarachnoid monitoring of intracranial pressure

Know the complications associated with subarachnoid monitoring of intracranial pressure

Know the limitations of subarachnoid monitoring of intracranial pressure

(4). Intraventricular cannulae

Understand that only an intraventricular catheter can be used for fluid removal to reduce intracranial pressure

Know the technique of intraventricular monitoring of intracranial pressure

Know the complications associated with intraventricular monitoring of intracranial pressure

Know the limitations of intraventricular monitoring of intracranial pressure

b. Indications

Recognize the indications for monitoring intracranial pressure

c. Contraindications

Know that bleeding disorders are a relative contraindication for placement of intracranial pressure monitors

Understand the risks associated with monitoring intracranial pressure

d. Interpretation of waveform (e.g., pressure spikes)

Differentiate the waveform produced by a working intracranial pressure monitor from one which is damaged or occluded

Understand the significance of pressure spikes and of plateau waves during intracranial pressure monitoring

Recognize that intracranial pressure may be different in different brain regions

Recognize waveform patterns, including respiratory variation and plateau wave, in intracranial pressure monitoring

e. Concept of cerebral perfusion pressure

Understand how to determine cerebral perfusion pressure

Understand the concept of cerebral perfusion pressure

#### f. Monitoring cerebral blood flow

Understand the principles of radionuclide scans in monitoring cerebral blood flow

#### 7. External (cerebral) ventricular drainage

Understand that external cerebral ventricular drainage may be very difficult or impossible with severe cerebral edema

Know that rapid decompression of increased intracranial pressure can lead to severe hemodynamic alterations

Know that rapid decompression of increased intracranial pressure from ventricles can cause an upward transtentorial shift.

**9. Monitoring of Muscle relaxant effect:** Must be familiar with monitoring of nondepolarizing muscle relaxation such as Train of four nerve stimulator and pharmacological agents to reverse excessive muscle relaxation

**10. Monitoring of level of sedation:** must be familiar with basics of monitoring of level of sedation as well as analgesia.

Pain score, Bispectral index (BIS) and be familiar with pharmacological agents to reverse oversedation or respiratory depression caused by oversedation or overdose of narcotic analgesia

## **B. Technical Procedures**

### **a. Establishing an airway**

#### **1. Intubation**

##### a. Selection of endotracheal tubes

Know how to determine the appropriate size endotracheal tube

Know the reasons to use a cuffed endotracheal tube

##### b. Indications

Recognize the neurologic indications for intubation of a child who has ingested a central nervous system depressant

Understand that intubation may be indicated despite good respiratory function, as in the case of head trauma or increased intracranial pressure

Know that intubation may be indicated prior to the onset of respiratory failure in patients with muscle weakness

Know that hemodynamic instability may necessitate intubation prior to the onset of respiratory failure

Know the conditions in which nasotracheal intubation is safe

Identify the conditions in which nasotracheal intubation is indicated or contraindicated

Understand the advantages and risks associated with nasotracheal intubation

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

Understand the rapidity of intubation that is required in the setting of true upper airway obstruction

(b). Distorted anatomy

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

©. Risks of sedation/muscle relaxants

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

Understand the advantages of using inhalation anesthesia and lidocaine spray in intubating patients with upper airway obstruction

(2). Facial trauma

Recognize the conditions of facial trauma for which oral intubation is preferred over nasal intubation

Know that a nondepolarizing muscle relaxant is required when intubating a patient with a lacerated eye globe to avoid increased intraocular pressure

Recognize the risks and difficulties associated with the intubation of patients with facial lacerations

Recognize the difficulties of using bag-mask ventilation in patients with oropharyngeal bleeding, possible foreign body aspiration, facial burns, or anaphylaxis

(3). Airway burns

Know that facial or airway burns may require early intubation prior to swelling

(4). Difficult anatomy

Recognize micrognathia as a factor complicating intubation

Recognize that macroglossia may be a complicating factor in intubation

Know the importance of testing temporomandibular motion in planning airway management

Know that laryngeal injury may occur following hanging

Know that tracheal tears may occur in trauma patients with pneumomediastinum and/or pneumothorax

(5). Head trauma and/or elevated intracranial pressure

Manage the intubation of a child with head injury

Know how to prevent increased intracranial pressure during intubation

Know that struggling during intubation can dangerously increase intracranial pressure

Understand how to use various drugs (e.g., thiopental sodium, lidocaine, and others) to minimize increased intracranial pressure during intubation

(6). Spinal cord injury

Know how to intubate a patient with a cervical spine injury

(7). Full stomach

Recognize that injury, ileus, or trauma can produce a “full stomach” situation for intubation

Recognize that airway or upper gastrointestinal bleeding may pose a “full stomach” situation for intubation

Know how to apply the rapid-sequence technique for intubation of a child with a full stomach

d. Complications

(1). Physical

Recognize the significance of trismus during intubation

Know the complications associated with endotracheal intubation

Know the factors associated with the development of subglottic stenosis in patients who are intubated

Know the emergency management of laryngeal spasm

(2). Infectious

**b. Cricothyroidotomy**

a. Indications

Know the indications for cricothyroidotomy

b. Technique

Know the technique for cricothyroidotomy

c. Risks

Know the complications of cricothyroidotomy

**c. Tracheostomy**

Know the indications for tracheostomy

Know the complications associated with tracheostomy

**d. Laryngeal mask airway**

a. Indications

Know the indications and contraindications for use of the laryngeal mask airway

b. Technique

Know the technique for insertion of the laryngeal mask airway

c. Risks

Know the complications of the laryngeal mask airway

**e. Vascular access**

**1. Peripheral intravenous catheterization**

Plan the treatment of infiltration with vasoconstricting drugs

**2. Arterial catheterization**

a. Technique

b. Sites to avoid

Know that the brachial artery is to be avoided during arterial catheterization because of a lack of collateral flow

Know that the temporal artery is to be avoided during arterial catheterization because of neurologic complications

Know the appropriate sites for arterial vascular cannulation

c. Risks

(1). Ischemia

Know how to detect arterial ischemia in patients with arterial catheters

(2). Antegrade embolization

Understand the conditions associated with cerebral air embolism in patients with arterial catheters

Recognize distal embolism secondary to arterial catheterization

(3). Retrograde embolization

Understand the risks associated with retrograde embolization in patients with arterial catheters

(4). Accidental intra-arterial injection

Know how to treat accidental intra-arterial injection associated with arterial catheters

**3. Central venous catheterization**

a. Indications

Know the indications for central venous catheterization

b. Sites

Know the various sites for venous catheterization

c. Techniques for placement

Know the techniques for internal jugular catheterization

Know the techniques for subclavian vein catheterization

Determine vascular catheter position by radiography

Know the techniques for femoral catheterization

Know the appropriate location for the catheter tip relative to the vein being catheterized

Know the techniques for ultrasonography-guided insertion of central venous catheters

d. Risks

Understand the risks associated with central venous catheterization (e.g., hemorrhage, perforation of vein or heart, air embolus, thrombus formation, infection, trauma to surrounding

**e. Intraosseous infusion**

a. Indications

Know the indications and contraindications for intraosseous infusion

b. Technique

Know the technique and sites for intraosseous infusion

c. Risks

Know the complications of intraosseous infusion

6. Infectious complications of intravascular catheters

Know how to minimize catheter-related infections

**f. Pleural drainage**

Know how to place a thoracostomy drainage tube using anatomical landmarks such as the height of the liver

Understand that multiple chest tubes may be required on one side

Recognize a chest tube leak

Recognize a bronchopleural fistula

Know the risks associated with thoracostomy tube placement

Understand the principles techniques, and complications of and indications for external pleural drainage

### **g. Abdominal paracentesis**

Know the technique and interpretation of abdominal paracentesis and the use of ultrasonography for abdominal paracentesis

Know the indications for abdominal paracentesis or diagnostic peritoneal lavage

Know the indications for and complications of paracentesis in abdominal compartment syndrome

### **h. Cardiopulmonary resuscitation (CPR)**

#### **1. Airway**

Know the proper technique and positioning of the patient to open the airway during CPR

#### **2. Breathing**

Know the proper breathing technique to apply during CPR for a patient with an obstructed airway

Know the proper sequencing of rescue breaths with chest compressions during CPR of pediatric and adult patients

#### **3. Chest compression**

Understand the indications for and reasons why open chest CPR may be indicated in certain circumstances

Understand the principles of closed chest compression during CPR

#### **4. Drug therapy and access**

Recognize that, during CPR, unusual routes of drug administration may be used

When venous access is limited (e.g., bone marrow, endotracheal administration)

Understand the reasons why alpha-adrenergic agonist drugs are often used in CPR

Know the indications for vasoactive, acid-base, and calcium therapy during CPR

Know the indications and appropriate agents to use for shock- resistant ventricular fibrillation and ventricular tachycardia

#### 5. Defibrillation and cardioversion

Know how to set a machine for defibrillation with the synchronous on/off switch

Recognize the indications for defibrillation during CPR

Know the use of automated external defibrillators (AEDs)

Know the energy required for defibrillation and cardioversion (biphasic and direct current)

#### 6.Outcome

Know the prognosis for outcome of CPR in inpatient vs. outpatient settings

Know when to discontinue CPR

Know the indications for prolonged CPR

#### 7.Complications

Know how to identify the various complications of CPR

### **I. Pericardiocentesis**

Understand the techniques used to guide pericardiocentesis

Know the indications and contraindications for and complications of pericardiocentesis

### **J.Renal replacement therapy CVVH**

Know indications and techniques of various modalities of renal replacement therapy

Peritoneal dialysis, Indications, Catheter placement, various fluids used for dialysis, management of patient on peritoneal dialysis, complications

Hemodialysis

Hemofiltration

### **K.Ultrasound for assessment and procedures in critically ill child**

Know the use of ultrasound modality for quick assessment of a critically ill child

with suspected fluid or blood in abdomen, pleural or pericardial effusion, status of inferior vena cava in patient with shock, cardiac contractility, lung ultrasound to detect atelectasis or pneumothorax .Use of ultrasound guided placement of central line and drainage catheters. FAST examination in trauma patient.

### **I.Flexible fiberoptic Bronchoscopy**

Be familiar with the various indications, the procedure, sedation and monitoring during pediatric flexible fiberoptic bronchoscopy.

### **m. Aortic balloon counterpulsation (ABCP)**

### **Basic knowledge of principles behind use of ABCP**

Understand the principles by which aortic balloon counterpulsation works

Understand the limitations of size in the use of aortic balloon counterpulsation

Evaluate waveforms to see if the aortic balloon counterpulsation machine is working properly

Understand the indications for aortic balloon counterpulsation

### **n.Ventricular assist devices (VAD)**

Know the indications for use of ventricular assist devices

Understand the limitations of size and duration of ventricular assist devices. Know the complications associated with the use of ventricular assist devices and how they are detected

### **6.Introduction to ECMO**

Must be familiar Basic knowledge and principle of ECMO for respiratory indications and cardiac indications

Extracorporeal membrane oxygenation (ECMO)

#### **1.Circuitry**

Understand venoarterial ECMO circuitry

Understand venovenous ECMO circuitry

#### **2.Indications and contraindications**

Know the respiratory indications and contraindications for the use of ECMO

Understand the reasons for ruling out total anomalous pulmonary venous connection prior to ECMO

Know the cardiac indications and contraindications for the use of ECMO

Understand the use of ECMO in CPR (eCPR)

Understand the use of centrifugal versus roller pumps in ECMO

#### **3.Technique**

Realize that the carotid artery may be ligated during ECMO in neonates

#### **4.Physiology**

Understand the physiology of blood flow and gas exchange during venovenous and venoarterial ECMO

#### **5.Outcome**

Understand the current thinking about long-term neurologic follow-up in patients who have undergone ECMO

#### 6. Complications

Recognize the complications of the use of ECMO, particularly hemolysis, bleeding, and infection