CCEMTP Student Study Guide

The information contained in the study guide is a condensed version of concepts that the critical care transport provider needs to know. The presence or absence of information in the study guide is not meant to imply that the information will or will not be on the final examination.

Note: The following modules are not tested on the CCEMTP exam, and are thereby not included in this study guide:

2.5.1 ICP Monitoring (optional module) *2.5 ICP will be on the exam

5.1.1 Fetal Heart Rate Monitoring

5.2.1 Pediatrics- Child Abuse

5.5 Organ Donation and Transplantation

1.1 Concepts and Components:

- Members of the critical care transport team include EMTs, paramedics, nurses, respiratory therapists, perfusionists, and occasionally physicians
- The mission profile will dictate the crew configuration, and the best crew configuration is one that will benefit the patient the most.
    - The most common helicopter configuration is pilot/flight nurse/flight paramedic
    - The most common ground transport configuration is EMT/nurse/paramedic or EMT/nurse/respiratory therapist
- Minimum qualifications for a critical care transport nurse are three years critical-care experience, ACLS, PALS, PEPP, NRP, TNATC, ITLS, ATLS
- Minimum qualifications for a critical care transport paramedic are three years experience in a busy EMS service, ACLS, PALS, PEPP, NRP, ITLS, CCEMTP
- There currently is no standard requirements for continuing medical education (CME) hours in critical care transport
    - The Commission on Accreditation of Medical Transport Services (CAMTS) has recommendations for initial training program requirements
    - The Association of Air Medical Services (AAMS) also has recommendations for air medical crew education that is supported by the National Highway Traffic Safety Administration (NHSTA)
- The decision to use critical care transport is based on a) medical oversight, b) clinical judgment; and, c) logistical considerations
- Be able to recognize a critical care transport candidate based on the guidelines established by the National Association of EMS Physicians, the Air Medical Physician Association, and the Association of Air Medical Services

1.2 Flight Physiology:

- Atmospheric composition remains the same regardless of the altitude
- With an increase in altitude, there is a decrease in atmospheric pressure
- The universal gas law states that gas molecules will move from an area of higher concentration to an area of lower concentration
- The ideal gas law states the amount of a gas is determined by its pressure, volume and temperature
- Boyle's law states that when temperature remains constant, the volume of a gas is inversely proportional to the pressure ("Boyle, balloon, burst"). As a balloon rises and the pressure outside the balloon decreases, the volume will increase.
- Dalton's law states that the total pressure of a gas mixture is the sum of the individual partial pressures of all the gases in the mixture ("Dalton's gang"). As barometric pressure decreases, the molecules in the atmosphere will spread out.
- Henry's law states that the amount of gas in a solution is proportional to the partial pressure of gas in contact with the liquid (think soda in a can).
- Charles' law states that at a constant pressure, the volume of a gas is directly proportional to its temperature ("Charles cold", or "Charles Celsius")

  - An increase in altitude of 1000 feet will result in a decrease of 2°C
- Gay-Lussac's law states that for a gas at a fixed volume, the pressure is proportional to the temperature (as temperature increase, pressure increases - as temperature decreases, pressure decreases)
- Stressors of flight:
  - Hypoxia
  - Barometric changes
  - Thermal variations
  - Decreased humidity
  - Fatigue
  - Noise
  - Vibration
- Know the types of hypoxia
  - Hypoxic hypoxia – inadequate oxygenation secondary to reduced partial pressure of oxygen in inspired air
  - Anemic (hypemic) hypoxia – inadequate tissue oxygenation secondary to reduced oxygen-carrying capacity of blood
  - Stagnant hypoxia – inadequate tissue oxygenation secondary to reduced cardiac output, pooling of blood, reduced blood flow to tissues, or restriction to blood flow
  - Histotoxic hypoxia – inadequate tissue oxygenation secondary to metabolic disorder or poisoning of the cytochrome oxidase enzyme system resulting in cellular inability to utilize oxygen

1.3 Air Medical:

- Some historians state that the first air medical transport occurred in 1870 at the Prussian Siege of Paris using hot air balloons (this event is highly debated, and most likely did not occur)
- Rotor-wing transports are typically used for transports less than 150 nautical miles
- Rotor-wing transports typically occur at altitudes less than 10,000 feet
- Fixed-wing transport are typically used for transport greater than 150 nautical miles
- Fixed-wing transports can occur at altitudes up to 38,000 feet
- Human error poses the single greatest hazard to HEMS operations
- The 51% rule allows any crew member to decline a mission at any time for any reason
- The cardinal sin of any air medical transport is having the patient transported by air when they could have reached an appropriate hospital quicker by ground transport
- 30 miles or 30 minute ground transport time is considered to be the minimum to which air medical transport will be beneficial to the patient
- The landing zone needs to be 100' x 100'
- No personnel should ever operate near the tail rotor of the aircraft
- The acronym "SLOW" is used to establish a landing zone:
  - S = Size of the landing zone should be 100' x 100'
  - L= Landing area
  - O=Obstacles
  - W= Wind

- Sterile cockpit must be maintained during take-off, landing, and when requested by the pilot
- CAMTS is a peer-review organization dedicated to improving patient care and transport safety by providing an accreditation process through the development of standards, education, and services

1.5 Basic Radiograph Interpretation:

- Radiographic density of a material/structure is based on the composition and thickness of a substance
    - Composition: more dense to less dense
    - Lead = white on radiograph
    - Barium Sulfate = white on radiograph
    - Bone = white to light gray on radiograph
    - Muscle = light to dark gray on radiograph
    - Blood = white in acute and gray to black in old on radiograph
    - Liver tissue = shades of gray on radiograph
    - Fat = shades of gray on radiograph
    - Air = black on radiograph
- Cardiac silhouette should be no more than 50% of the transverse diameter of the thoracic cage
- Distal end of ET tube should be 3-7 cm above the carina
- "A – I" approach mnemonic device
    - Airway
    - Bony thorax
    - Cardiac silhouette
    - Diaphragm
    - Effusion
    - Fields (lung)
    - Gastric bubble
    - Hilum
    - Invasive devices and lines

1.6 Basic Lab Data:

- Specificity is the probability that a test will be negative in the absence of a disease
- Sensitivity is the probability that the test will be positive in the presence of a disease
- Uncompensated respiratory acidosis is characterized by the following:
    - Decrease in pH
    - Increased $PaCO_2$
    - No change in HCO_3
- Uncompensated respiratory alkalosis is characterized by the following:
    - Increased pH
    - Decreased $PaCO_2$
    - No change in HCO_3
- Uncompensated metabolic acidosis is characterized by the following:
    - Decreased pH

  - No change in $PaCO_2$
  - Decreased HCO_3
- Uncompensated metabolic alkalosis is characterized by the following:
  - Increased pH
  - No change in $PaCO_2$
  - Increased HCO_3
- ABG normal values
  - pH: 7.35 – 7.45
  - Partial pressure of carbon dioxide ($PaCO_2$): 35 – 45 mmHg
  - Serum bicarbonate (HCO_3-): 22 – 26 mEq/L
  - Base excess: -3 to +3 mmol/l
  - Partial pressure of oxygen (PaO_2): 80 – 100 mmHg
  - Oxygen saturation (SaO_2): 90 – 100%
- The “Golden Rules” of ABG analysis
  - For every 10 mmHg change in CO_2, the pH will change 0.08 in the opposite direction
  - With every change in bicarb of 10mEq, the pH will change 0.15 in the same direction
- Sequence of ABG interpretation
  - Check the pH
  - Check the $PaCO_2$
  - Check the HCO_3
  - Check the PaO_2
  - Assess anion gap (AG)
- ABG seesaw
  - Determines the presence or absence of a respiratory problem
  - When both the pH and $PaCO_2$ are within normal range, the seesaw is balanced
  - If the pH goes down, and the $PaCO_2$ goes up, this is respiratory acidosis
  - If the pH goes up and the $PaCO_2$ goes down, this is respiratory alkalosis
- ABG elevator
  - Determines the presence or absence of a metabolic disorder
  - When both the pH and HCO_3 are within normal ranges, the elevator is in neutral
  - If both the pH and HCO_3 goes up, this is metabolic alkalosis
  - If both the pH and HCO_3 goes down, this is metabolic acidosis
- “Left shift” is seen as an increase in the number of neutrophil bands and is common with acute infections
- Hemoglobin normal average is 15 g/dL (male 14-18/female 12-16)
- Hematocrit normal average is 45% (male 40-54%/female 36-46%)
- “Rule of Three”
  - RBC x 3 = HgB
  - Hb x 3 = Hct
- Prothrombin time (PT)
  - Measures effectiveness of coumadin-type anticoagulant medications
  - Normal value: 11.2 – 13.2 seconds (varies from lab to lab)

- International normalized ratio (INR)
  - Compares PT to standardized control
  - Measures effectiveness of coumadin-type anticoagulant medications
  - Normal values:
    - In persons not on coagulation therapy, the control and PT are equal, resulting in an INR of 1
    - In persons receiving warfarin therapy, INR should be 2-3
- Partial thromboplastin time (PTT)
  - Commonly used to monitor heparin therapy
- Blood urea nitrogen (BUN)
  - BUN evaluates renal function and hydration status
  - Normal value: 7 – 21 mg/dL
- Creatinine (Cr) Male: 0.6 – 1.4 mg/dL Female: 0.6 – 1.1 mg/dL
  - Creatinine is a waste product of protein metabolism found in urine
  - Creatinine aids in the diagnosis of renal dysfunction
- BUN / Creatinine ratio
  - Evaluates renal function
  - Normal values are 10:1 or less
  - Elevation of this ratio indicates renal failure
- Sodium (Na+) normal value: 135 – 145 mEq/L
- Potassium (K+) normal value: 3.5 – 5 mEq/L
- Calcium (Ca++) normal value: 9 – 11 mg/dl
- Creatine phosphokinase (CPK)
  - Normal value: 5 – 35 mcg/ml
  - Rises within 4 – 6 hours of AMI
  - Peaks at 24 hours
  - Returns to normal in 3 – 4 days in patients with normal renal function
- Cardiac-specific troponin I (cTnI) 0.0 - >0.5 ng/ml
  - Troponin elevated within 2 – 6 hours of cardiac injury onset
    - Peaks in 12 – 16 hours

WBC :	4500 – 10000/mL			
RBC:	3.5 – 6 million			
Hemoglobin	Adult	Male: 14 – 18 g/dL	Female: 12 – 16 g/dL	
	Pediatric	11.0 – 16.0 g/dL	Neonate	10.7 – 17.1 g/dL
Hematocrit	Adult	Male: 40% – 54%	Female: 36% – 46%	
	Pediatric	32% – 45%	Neonate	33% – 55%
Platelets	150,000 – 400,000/mm3			
PT:	11.2 – 13.2 seconds			
PTT:	22.1 – 34.1 seconds			
D-dimer:	less than 0.5 - 1 mcg/ml or less than 500-1000 mcg/L			
BNP:	< 100 pg/ml: low likelihood of heart failure			
	100 – 400 pg/ml: indeterminate	> 400 pg/ml: high likelihood of heart failure		

1.7 Peripheral and Central Venous Access Devices:

- The American Heart Association guidelines state that intraosseous access is first line to intravenous access
    - Adult and pediatric IO access are both Class *IIa* interventions
- If cannulating a dialysis shunt for emergency access, make sure that the IV fluids do not run dry
- When injecting fluid or medications into a dialysis shunt, do not use a syringe smaller than 10 ml to prevent catheter damage from excess infusion pressure
- CVACs provide access to the central circulation for long-term venous access, for hemodynamic monitoring, or when peripheral access is limited
- A peripherally inserted central catheter (PICC) is a form of a non-tunneled catheter

- Care requirements for non-tunneled catheters:
    - Keep an occlusive dressing over the exit site
        - The dressing should preferably be translucent
    - Use aseptic techniques for dressing changes
- Tunneled catheters (silicone central venous catheter)
    - Single, double, or triple lumen large bore catheters
    - Constructed of a thick-walled silicone
    - Designed for at-home or long-term use (greater than 3 months)
- SVADs (aka portacaths) are venous access devices that have an injection port, wherein the port includes a self-closing septum for repeated injections
    - Requires a special injection non-coring needle called a Huber needle
- Always flush central access catheters regularly and after every use
- Always wash hands before handling a central access catheter
- Always use aseptic technique whenever accessing a central access catheter
- All central lines should be monitored for signs of infection

1.8B Hemodynamic Monitoring:

- The purpose of hemodynamic monitoring is to evaluate the ability of the cardiovascular system to deliver blood flow and oxygenation to the tissues
- The pulmonary artery catheter is a four lumen catheter
- Before transporting patient always ask for a current wedge
- Requires a 500 cc IV bag of NS with a 300 mmHg pressure bag
    - IV bag must be pressurized to 300 mmHg to overcome the resistance of the flush device in the transducer and to deliver 3ml per hour through the catheter
- Zeroing the transducer tells the monitoring system that the atmospheric pressure is “zero”
- Low hemodynamic monitoring values may be caused by the transducer being above the phlebostatic axis, or by air bubbles or clots in the catheter
- Leveling of the transducer
    - The stopcock that was used to zero the system must be at the phlebostatic axis for all pressure readings

        - If the transducer is lower than the phlebostatic axis, it will cause inaccurately high readings
        - If the transducer is higher than the phlebostatic axis, it will causes inaccurately low readings
    - The transducer must always be level with right atrium
        - IV pole
        - Phlebostatic axis
            - Fourth intercostal space

- Hemodynamic pressures:
    - As the catheter approaches the right atrium, it reflects the CVP and RA pressure
    - The balloon is inflated as it approaches the RA to float the catheter through the chambers of the heart
    - As the balloon advances, the waveform reflects the movement (or turbulence) of the catheter tip
    - The difference between the RV pressure and the PA pressure is reflected in the diastolic pressure
- Central venous pressure (CVP) and right atrial pressure (RAP)
    - CVP
        - Reflects pressure in the great veins
    - RAP
        - Is the pressure in the right atria
        - Measured through the proximal port of the PA catheter
    - CVP and RAP
        - Reflect right ventricular end diastole pressure or preload
        - Normal values 2 – 8 mmHg

- Right ventricular pressure (RVP)
    - Pressure in the right ventricle
    - Seen during insertion of the PA catheter
    - Normal values
        - Systolic 15 – 30 mmHg
        - Diastolic 0 – 8 mmHg
- Pulmonary artery pressure (PAP)
    - Reflects both right and left heart pressures
    - Pressure in the pulmonary artery with the balloon deflated
    - Normal values
        - Systolic 15 – 30 mmHg
        - Diastolic 5 – 15 mmHg
    - Causes of increased PAP:
        - Hypervolemia
        - Pulmonary HTN
        - PPV
        - Cardiac tamponade

        - Left ventricular failure
    - Causes of decreased PAP:
        - Hypovolemia
        - Vasodilation
- Pulmonary artery wedge pressure (PAWP / PCWP / Wedge)
    - Indirectly reflects left atrial pressure and left ventricular end diastolic pressure (LVEDP)
    - Measured with the balloon inflated at the end of expiration
    - Principles of obtaining a wedge pressure:
        - Wedging of the catheter is only done to obtain the wedge pressure
        - The balloon is inflated with 1.5 cc of air and allowed to sail (or wedge) into the distal branch of the pulmonary artery, where it is too narrow for the balloon to pass
        - During the occlusion, the catheter sensing tips “see through” the pulmonary circulation (no valves) into the left atrium giving an indirect reflection of the left atrial pressure (LAP)
        - Inflation of the balloon should not be longer than 15 – 30 seconds
        - Use air only to inflate
        - Never flush the catheter in the wedge position
        - Re-zero and recalibrate the transducer system after each PCWP reading
        - Normal values of 4 – 12 mmHg
- Cardiac output (CO)
    - Amount of blood ejected by the ventricle each minute
    - Evaluates cardiac function
    - Normal range is 4 to 8 L/minute
    - Measured by thermodilution

- Overview of hemodynamic parameters:
    - Mean arterial pressure (MAP): 70 – 100 mmHg
    - Central venous pressure (CVP): 2 – 8 mmHg
    - Pulmonary artery pressure (PAP): 15 – 30 mmHg
    - Pulmonary artery diastolic pressure (PAD): 5 – 15 mmHg
    - Pulmonary artery mean pressure (PCWP/PAWP, Wedge): 4 – 12 mmHg
    - Cardiac output (CO): 4 – 8 L/min
    - Cardiac Index (CI): 2.5-4 L/min
    - Right Ventricular Pressure (RVP): Systolic 15 – 30 mmHg
      Diastolic 0 - 8 mmHg
- If dampened waveform is seen, the catheter might have spontaneously migrated forward
    - Be prepared to encourage the patient to cough, reposition, and if persistent wedge is suspected and unable to be reduces, pull the catheter back until the has resolved in to a PA waveform.
- If a dampened waveform indicating a wedge is seen (when the balloon is <u>not</u> inflated), be prepared to pull catheter back

1.9 Blood Administration:

- Antigens determine blood group and type
- Three major types of antigens
  - A
  - B
  - Rh
- If an individual with Rh- blood were to be exposed to Rh+ blood, antibodies to the antigens could be produced
  - Individuals who are Rh+ can be exposed to Rh+ or Rh- blood without any problems
  - Rh is primarily important in females of childbearing age
- O negative is the universal donor for red blood cells
- AB+ is the universal recipient
- White blood cells (WBCs)
  - WBCs are also known as leukocytes
  - Responsible for protecting the body from invasion by foreign substances such as bacteria, fungi, and viruses
- Platelets and blood clotting
  - Platelets are also known as thrombocytes
  - The blood clotting or coagulation process tested by partial thromboplastin time (PTT) or activated partial thromboplastin time (aPTT)
- Whole blood considerations
  - Use of straight line or Y tubing IV set with micro filter
  - Large bore IV catheter
  - NS is most often used to initiate the infusion of whole blood
  - LR used by some centers
  - Assess for history of transfusion reaction
  - Patient may require pre-medication with antipyretics and antihistamines prior to start of transfusion
  - Allow 30 – 60 minutes for oral medication and 10 minutes for IV medication
  - Blood cannot be returned to blood bank after 30 minutes of warming at room temperature
  - Blood should be warmed when given in large amounts to prevent hypothermia
  - Patients receiving large volume of whole blood should by monitored for hypocalcaemia
    - Citric acid in whole blood binds calcium
- Packed red blood cells (PRBC)
  - Can be administered wide open in critical situations of hypovolemia
- Fresh frozen plasma (FFP) can be infused as fast as patient tolerates
  - Should be given within 6 hours of thawing
  - Patients must be ABO compatible
- Safe administration of blood
  - Insert a large bore IV catheter
    - Do not use an IV catheter smaller than 20 gauge

    - Call physician if patient has a temperature ≥38°C after transfusion
      Never use dextrose solutions
        - May cause hemolysis
    - Transfusion reactions can be acute or delayed
    - Acute reaction occurs during the transfusion or within 24 hours post transfusion
    - Signs of transfusion reaction
        - Severe symptoms
            - Similar to anaphylaxis
            - Fever
            - Hypotension
            - Tachycardia
            - Shock
            - DIC
- Medication should never be added to blood bag or IV tubing
- Complications from transfusions can occur up to 14 days post-transfusion
- Subtle indications of a transfusion reaction include increased heart rate and body temperature

2.1 Respiratory:

- Shifts in the oxyhemoglobin dissociation curve
    - Right shift: more O_2 released from hemoglobin, resulting in greater O_2 delivery to tissues
        - Caused by:
            - Increase in PCO_2
            - Increased temperature
            - Increased 2,3-DPG
            - Decreased pH (acidosis)
    - Left shift: O_2 released by hemoglobin at significantly lower PO_2, resulting in decreased O_2 delivery to tissues
        - Caused by:
            - Decrease in PCO_2
            - Decreased temperature
            - Decreased 2,3-DPG
            - Increased pH (alkalosis)
            - Carbon monoxide poisoning
- Clinical criteria for ARDS:
    - Acute onset
    - Predisposing condition
    - $PaO_2 / FiO_2 < 200$ regardless of PEEP level
    - Bilateral infiltrates on chest radiograph
    - PCWP ≤ 18 mmHg
- ARDS is a clinical diagnosis, with no specific study findings expected except gas exchange abnormalities and radiograph findings

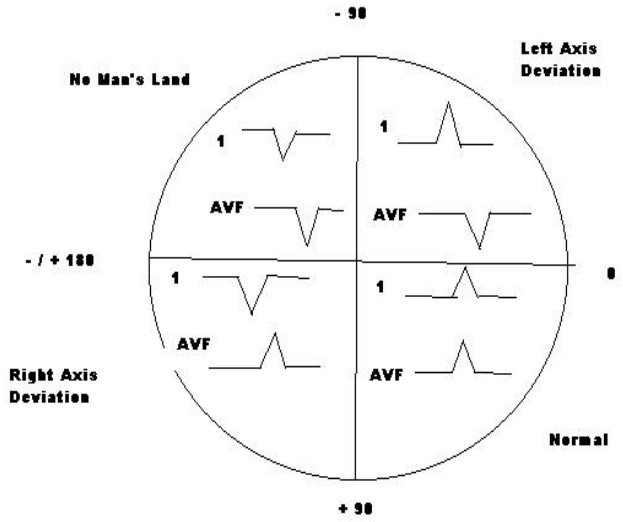
2.2 Cardiology:

- Mean arterial pressure (MAP) = diastolic + 1/3 of the pulse pressure OR (2D)+S/3
- Dyspnea is the most common presenting complaint in elderly patients with acute coronary syndrome
- In pericarditis and myocarditis, ST elevation can be seen in almost all leads
    - In late stages, ST depression can be seen
- Pericarditis pain is positional, and is usually made worse when the patient lies flat, and is relieved when the patient leans forward
- Classic signs and symptoms of a dissecting aortic aneurysm:
    - Flank pain
    - Acute, severe back pain that is non-traumatic
    - Sense of impending death
    - "Ripping" or "tearing" pain in the chest
- Pain of a dissecting aneurysm can be differentiated from that of an MI because a dissection will present with sudden onset of maximal chest pain
- In patients with a suspected dissecting aneurysm, target heart rate is 60 – 80 beats per minute, and target systolic blood pressure is between 100 – 120 mmHg
    - Beta blockers should be given to reduce the blood pressure, thereby reducing the sheer force on the aortic wall
- Hypertensive urgency results in an increase in blood pressure, but no damage to body organs
- Hypertensive emergency occurs when organ damages results from acute hypertension
    - End-stage organ damage is manifested by:
        - Seizures
        - Flash pulmonary edema
        - Acute renal failure
        - Myocardial infarction
        - AMS
- In a hypertensive crisis, the MAP should not be lowered by more than 20% in the first hour of treatment
- Left-sided heart failure is the most common form of CHF
- STEMI usually caused by complete obstruction of the coronary artery, whereas a non-STEMI (NSTEMI) is usually caused by partial obstruction of the coronary artery
- CK-MB shows elevation 4 hours after onset of infarction, and peaks at about 24 hours with a duration of 72 hours
    - Can also be elevated in muscular injuries
- Troponin can be elevated 7-14 days post-infarct
- Troponin increases 20 times in value after an MI and is the preferred biochemical marker for an MI
- Even slight elevations of troponin indicates cardiac injury

2.2.1 12 Lead Interpretation:

- The four primary characteristics of cardiac cells are automaticity, excitability, conductivity, and contractility
- Limb leads look at the heart in a frontal plane, and include leads aVR, aVL, and aVF
- Bipolar leads are also called limb leads and include leads I, II, and III
- All leads that are not bipolar are unipolar
- Chest leads are $V_1 – V_6$
- In normal EKG waveforms, the cardiac axis will be downward and to the left
- ST segment elevation of > 1 mm indicates infarction
- ST segment depression of > 0.5 mm indicates ischemia
- Axis determinations are used for:
    - Diagnosing ventricular tachycardia
    - Diagnosing hemiblocks
    - Identifying patient's whose infarction has become critical leading to significant potential for hemodynamic instability
- When impulses travel towards the electrode, the deflections are always positive; impulses away are negative

- Know axis deviations as described in the clock format:



Axis	Lead I	Lead II	Lead III	Comments
Normal Axis 0 - 90				
Physiologic Left Axis 0 to -40				
Pathological Left Axis -40 to -90				Anterior Hemiblock
Right Axis 90 - 180				Posterior Hemiblock
Extreme Right Axis no man's land				Ventricular in origin

- Leads II, III and aVF look at the right side of the heart which lies sort of on its side in the chest with the right ventricle pointed down (inferior surface of the left ventricle)
- Leads V_2, V_3 and V_4 look at the anterior surface
- Leads V_5, V_6 and aVL look at the lateral surface
- Leads V_1 and V_2 look at the septal surface
- Posterior diagnosis can be made by looking at the anterior leads as a mirror image (an 18 lead can spy on the posterior side)
- Hypokalemia and hypomagnesemia will present with flattened “T” waves
- Hyperkalemia and hypermagnesemia will present with tall, tented “T” waves
- Hypocalcemia will have prolonged QT intervals, and QRS / ST changes that can mimic an MI
- Hypercalcemia will have shortened QT intervals
- To be clinically significant, the height of the ST segment must exceed 1 mm in a limb lead or 2 mm in a precordial lead
- Generalized ST segment elevation, unrelated to the distribution of any coronary artery, implies pericarditis
- ST segment depression is considered significant if the ST segment is at least one box below baseline as measured 2 mm beyond the QRS
- Bundle branch blocks (BBB) present with two distinct QRS complexes overlapped:
    - “Rabbit ear” pattern
    - “RSR” pattern
- Diagnosing left versus right bundle branch blocks
    - The last 0.04 seconds of the deflection on the QRS is used to determine the direction of the block
    - Use V_1 or MCL1
        - If the QRS duration is greater than 0.12 seconds and the last 0.04 seconds of the

second segment of the complex is pointing down, then it is a left bundle branch block
    - Works like the turn signal on a car
  - If the last 0.04 seconds of the QRS is pointing up and is positively deflected, then it is a right bundle branch block
- The characteristics of an inferior wall MI:
  - ST elevation in the inferior leads II, III and aVF
  - Reciprocal ST depression in the anterior leads
- Anterior MI is frequently referred to as the "Widowmaker" because the LAD is the largest of the coronary arteries, and an occlusion of the LAD can result in a massive infarct
- Anterolateral MI will have ST elevation in leads I, aVL, V_2, V_3, V_4, V_5, V_6
- Anteroseptal MI will have ST elevation in leads V_1, V_2, V_3, V_4
- Lateral wall MI will have ST elevation in leads I, aVL, V_5, V_6
- Septal wall MI will have ST elevation in leads V_1 and V_2
- Posterior wall MI will have ST depression leads precordial leads V_1 – V_3, and will be the mirror image of an anteroseptal MI

2.2.2 Mechanical Circulatory Devices:

- Five major stages of the cardiac cycle:
  - Late diastole / ventricular filling
  - Atrial systole
  - Isovolumetric ventricular contraction
  - Ventricular ejection
  - Isovolemic ventricular relaxation
- Myocardial oxygen demand is all about "supply and demand"
- Cardiac output = SV x HR
- Cardiac index = (SV x HR) / BSA

- IABP is a volume displacement device
  - IABP inflation = increased supply
  - IABP deflation = decreased demand
- IABP is placed in the thoracic aorta, 1 – 2 cm below the subclavian artery
- When correctly placed, the balloon will occlude 80 – 90% of the aorta
- Absolute contraindications for the IABP are aortic valve insufficiency, and a dissecting aortic aneurysm
- Tearing or bursting of the balloon may allow blood into the tubing (appears like flakes of rust)
- Check limb pulses 30 minutes after insertion, and then every two hours
- Notify MD if the IABP balloon is immobile for 30 minutes or longer
- If the IABP machine fails, inflate and deflate the balloon with 40 -60 cc's of air or helium every five - 10 minutes (check local protocols!)
- When the IABP balloon is inflated, blood is pushed superiorly into the coronary arteries increasing myocardial perfusion, and inferiorly into the distal organs

- IABP timing:
  - Deflated before the full onset of systole
  - Uses EKG to identify the dicrotic notch (aortic valve closure)
- IABP balloon inflation can be triggered by the "R" wave, arterial waveform, or pacing spike
- During cardiac arrest, the IABP must be placed in pressure mode instead of EKG mode
- IABP balloon is inflated with 35 – 40 cc's of helium
- VADs decrease the workload of the heart while maintaining adequate flow and blood pressure

2.3 Renal and Urology:

- Three main functions of the renal system are excretion, elimination, and regulation
- BUN is a key measurement of renal function, and the most common cause of an elevated BUN is poor kidney function
- Normal pH is 7.35 – 7.45
- Renal lab studies include: BUN, creatinine, urine output, and electrolytes
- Indwelling Foley catheters are a significant risk factor for developing a UTI
- Urethral trauma is a contraindication for the placement of a Foley catheter (typically evidenced by blood at the urinary meatus)
- Foley catheter balloon is typically inflated with 10 cc's of sterile water

2.4 Gastrointestinal:

- Ischemic pain is the most serious type of visceral pain and is usually sudden in onset and extreme in nature
- Patients with suspected upper GI bleeds should have an NG tube placed
- Mallory-Weiss tears occur in the esophagus and are from repeated regurgitation, retching, or forceful coughing
- Acute liver failure (ALF) occurs when there is rapid deterioration of liver function resulting in coagulopathy and alterations in mental status in a previously health individual
- The primary cause of ALF is acetaminophen toxicity
- Acetaminophen overdoses should be treated with N-acetylcysteine (NAC)
- The classical signs and symptoms of esophageal varices are:
  - Hematemesis
    - With or without melena
  - Signs and symptoms of shock
- The classical signs and symptoms of appendicitis are:
  - Anorexia
  - Periumbilical pain
  - Nausea
  - Right lower quadrant pain
  - Vomiting
- The classical signs and symptoms of an abdominal aortic aneurysm are:
  - Most patients will present asymptomatic with a pulsatile abdominal mass just above the umbilicus

- Livedo reticularis (bluish color) of the feet or toes
- AAA rupture:
  - Abdominal pain or rigidity
  - Back pain
  - Buttocks or leg pain
  - Pulsatile abdominal mass
  - Groin pain
  - Syncope
  - Paralysis
  - Flank mass
  - Grey-Turner sign
  - Shock
- The key treatments for AAAs are to control the heart rate, reduce contractility, and be prepared for rupture

2.5 Neurology:

- Hypothalamus is the autonomic control center and influences BP, HR, RR, pupil size, body temperature, and digestive tract motility
- Pons contains the pneumotaxic center (respiratory control center)
- Medulla contains cardiac and respiratory control centers
- CPP = MAP – ICP
- Normal ICP is 5 – 15 mmHg
- GCS should be reassessed every five minutes in the prehospital setting if a head injury is suspected
- Deterioration of two GCS points is significant and must be reported
- Monroe-Kellie Doctrine states normal cranial contents include 80% brain, 10% CSF, and 10% blood volume
- Oxygen saturations in the TBI patient should be maintained at or above 95% and $ETCO_2$ should be maintained around 35 mmHg
- Hyperventilation in the TBI patient is only recommended as a temporizing treatment in the patient who is actively herniating
- Eye and ear protection should be placed on all “tight head” patients during transport
- Avoid use of nasogastric, nasopharyngeal, or nasotracheal tubes in basal skull fractures
- Transient ischemia attack (TIA) is an episode of reversible neurologic impairment that resolves within 24 hours
- Reversible ischemic neurologic deficit (RIND) is a focal neurologic deficit that lasts longer than 24 hours but resolves within one to three days
- IVC monitoring in the gold standard for measuring ICP
- An advantage of the IVC is the CSF can be drained from the catheter, thus reducing ICP
- Subarachnoid bolt and intraparenchymal monitoring do not allow for CSF drainage

2.6 Endocrinology:

- The hypothalamus is considered to be the center for homeostasis; the "control center" for many of the autonomic functions of the peripheral nervous and the endocrine system
- Pituitary gland is often referred to as the "master" gland of the endocrine system because it controls the functions of the other endocrine glands
- Insulin allows glucose to enter into cells (insulin is like a key opening a lock) and stimulates the conversion of glucose into glycogen as a carbohydrate store
- Type I DM is a chronic metabolic disorder caused by an absolute or relative deficiency of insulin
- Hyperglycemia is clinically defined as ≥ 200 mg/dl
- The dextrose "Rule of 50"
  - The ml/kg x D% should always equal 50
    - The dose for infants is 4-6 ml/kg of D10
    - The dose for toddlers is 2 ml/kg of D25
    - The dose for older children is 1 ml/kg of D50
- Type II DM comprises an array of dysfunctions that result from a combination of insulin resistance and inadequate secretion of insulin
- DKA is defined as a blood glucose > 250 mg/dl (although often times it is much higher)
- In HHS, blood glucose > 600 mg/dl
- Thyroid storm is an acute life-threatening hypermetabolic state that occurs when excessive amounts of TH are released in patients with thyrotoxicosis
- Increased temperature is one of the most reliable signs of a thyroid storm

2.7 Hematology Oncology:

- Erythrocytes (RBC) are red blood cells that contain hemoglobin and oxygen
- Leukocytes (WBC) are primarily responsible for immune protection
- Absolute WBC count often not highly specific or sensitive in the diagnosis of diseases
- Differential (percentage of different types of WBCs) can be more helpful in determining presence of active infection
- Platelets are primarily responsible for hemostasis
- Bleeding time
  - Best test of vascular integrity and platelet function
- Platelet count
  - Reported as part of complete blood count (CBC)
- Prothrombin time (PT)
  - Evaluates function of extrinsic pathway of coagulation cascade
  - Normal control values = 11.2 – 13.2 seconds
  - Prolongation of > 2 seconds is significant abnormality
- International normalized ratio (INR)
  - Allows monitoring of anticoagulation effects of Coumadin™
    - Response of PT to a dose of Coumadin™ is dependent on specific thromboplastin used to evaluate PT

        - Use of PT alone to monitor Coumadin™ can lead to under - or overdose of Coumadin™
- Partial thromboplastin time (PTT) used to measure heparin therapy
- Fresh frozen plasma (FFP)
    - Contains all coagulation factors except platelets
    - Indicated for clinically significant depletion of clotting factors
        - Patient on warfarin actively hemorrhaging or requiring emergent surgery
        - Treatment of a patient with an unknown or undiagnosed bleeding disorder with clinically significant active hemorrhage
        - Must be ABO-compatible
        - Minimal risk of transmission of infectious diseases
        - Typical initial dose is 4 units (250 mL/unit) in adults, 15mL/kg in children
- Cryoprecipitate
    - Does not require ABO matching
    - Specifically used for overly aggressive anticoagulation not receiving FFP, massive hemorrhage and DIC
    - Indicated for bleeding due to:
        - von Willebrand Disease (vWD)
        - Hemophilia A
- Packed red blood cells (pRBCs)
    - Indicated for red cell repletion
        - Not indicated primarily for volume repletion
    - Must be ABO-compatible
    - Indicated for red cell repletion
        - Not indicated primarily for volume repletion
- Platelets
    - Indicated for bleeding due to thrombocytopenia or platelet dysfunction
    - ABO matching preferred, but not absolutely required
- Disseminated intravascular coagulation (DIC)
    - DIC is a relatively common acquired coagulopathy and is most often encountered in critical care setting
    - DIC is a life-threatening combination of:
        - Bleeding tendency
        - Fibrin deposition
        - RBC injury and resulting anemia

3.1 Advanced Airway Control:

- Anticipating difficult BVM ventilations: MOANS
  - M: Mask/seal
  - O: Obesity/obstruction
  - A: Age
  - N: No teeth
  - S: Stiff
- Nasogastric tube should be inserted during periods of prolonged BVM ventilation
- The bougie is a tracheal tube introducer
- Needle cricothyrotomy with transtracheal jet ventilation is a temporizing measure only
  - With proper equipment, adequate oxygenation- but not ventilation- can be achieved
- Identification of the difficult cricothyrotomy: SHORT
  - S: Surgery (or other airway disruption)
  - H: Hematoma (including infection / abscess)
  - O: Obesity (includes problems with access)
  - R: Radiation distortion
  - T: Tumor
- All contraindications for a surgical airway are relative (especially in CICV situations)
- Capnograph waveform is considered the gold standard for all intubated patients being transported
- $ETCO_2$ < 10 mmHg after 20 minutes of CPR is generally considered a reliable indicator that resuscitation will be unsuccessful
- RSI is the administration of a potent induction agent followed immediately by a rapidly acting neuromuscular blocking agent to induce unconsciousness and motor paralysis for tracheal intubation
- Administration of RSI medications is preceded by a preoxygenation phase
  - Creates oxygen reservoir in lungs and body tissue
  - Nitrogen washout in lungs
  - Increases PaO_2
  - Allows for period of apnea between cessation of breathing and intubation of the trachea
- Cormack-Lehane laryngeal view
  - Ideal larygoscopic view designated grade 1
  - Worst laryngoscopic view designated grade 4
- Difficult intubation mnemonic “LEMON”
  - L: Look externally
  - E: Evaluate 3-3-2
  - M: Mallampati score
  - O: Obstruction
  - N: Neck mobility
- Methods of RSI preoxygenation:
  - Administration of 100% oxygen via nonrebreather mask for 3 minutes
  - Instructing patient to take 8 vital capacity breaths while receiving 100% oxygen
  - Administration of 100% oxygen via adequate BVM ventilations for 3 minutes
  - Induction agents

- Induction agents
  - Etomidate (Amidate™)
    - Dose
      - 0.3 mg/kg IV/IO
    - Onset
      - 15 – 45 sec
    - Duration
      - 3 – 12 min
  - Midazolam (Versed™)
    - Dose
      - 0.2 – 0.3 mg/kg IVP
        - 5 mg
    - Onset
      - 30 – 60 sec
    - Duration
      - 15 – 30 minutes
    - Considerations
      - Variable response
      - Hypotension
      - Apnea at high doses
      - Caution in elderly, renal patients
  - Ketamine (Ketalar™)
    - Dose
      - 2 mg/kg IVP
    - Onset
      - 30 – 45 sec
    - Duration
      - 10 – 20 min
  - Propofol (Diprivan™)
    - Dose
      - 1.5 – 3 mg/kg IVP
    - Onset
      - 15 – 45 sec
    - Duration
      - Mean duration following a single bolus dose of 2 to 2.5 mg per kg of body weight is 3 to 5 minutes
  - Depolarizing neuromuscular blocking agents
    - Succinylcholine (Anectine™)
      - Dose
        - Adult
          - 1 – 2 mg/kg IV/IO
          - 3 – 4 mg/kg IM if IV access impossible
        - Child
          - 2 mg/kg IVP

        - Newborn (< 12 months)
            - 3 mg/kg IVP
    - Onset
        - 30 – 60 sec
    - Duration
        - 3 – 5 minutes
- Non-depolarizing neuromuscular blocking agents:
    - Vecuronium (Norcuron™)
        - Dose
            - 0.1 – 0.15 mg/kg
            - 0.3 – 0.4 mg/kg for induction (considered to decrease time to paralysis)
        - Onset
            - 90 – 120 sec
        - Duration
            - 35 – 60 min
    - Pancuronium (Pavulon™)
        - Dose
            - 0.1 mg/kg IVP
            - 0.01 mg/kg for long-term paralysis
        - Onset
            - 120 – 300 sec
                - Considered long
        - Duration
            - 120 – 150 min
    - Rocuronium (Zemuron™)
        - Dose
            - 1 mg/kg
        - Onset
            - 60 – 90 sec
        - Duration
            - 30 – 100 min
- Discontinue intubation attempt when SaO_2 decreases to 90%
- Long-term paralysis
    - Non-depolarizing neuromuscular agents
        - Vecuronium dose is 0.1 – 0.15 mg/kg
        - Pancuronium dose 0.01 mg/kg

    *** Always refer to local protocols when applicable**

3.2 Mechanical Ventilation:

- Normal tidal volume is about 5-8 ml/kg (variance from 4-10 ml/kg, but average is about 7 ml/kg)
    - IBW 100ml/kg/min
- Primary goals of mechanical ventilation
    - Maintain an adequate PaO_2 and $PaCO_2$
    - Return arterial blood gases to patient's baseline
    - Improve ventilation to meet existing clinical demands
    - Decrease work of breathing
- Pressure – cycled ventilation
    - Deliver a preset pressure of gas to the lungs over time
    - Volume of air delivered varies based upon compliance of the lungs and airway resistance
    - TV is variable
- Volume – cycled ventilation
    - Deliver a pre-set volume of gas (ml or L) over time
    - Pressure variable within a certain pre-set safe range
- Continuous positive airway pressure (CPAP) is non-invasive continuous level of positive airway pressure for a spontaneously breathing patient
- Modes of ventilation
    - Control or CMV (Controlled Mandatory Ventilation)
        - Definition: Preset volume or pressure delivered at a preset rate
            - Triggered ventilation by time only
            - Patient is "locked out" out from triggering a breath
            - Patient has no active role in the ventilator cycle
    - Assist control (A/C)
        - Definition: Preset volume or pressure is delivered for each patient inspiratory effort of set amount
            - If the patient fails to initiate a set amount of breaths per minute, the ventilator initiates breaths at a preset volume or pressure and rate (triggered ventilation by time and assist sensitivity)
            - Regardless of a patient-generated breath or a machine-generated breath the patient will receive the preset volume or pressure
    - Pressure control
        - Regulated during inspiration, so V_T delivered within a certain pressure limit
        - Calculates flow rate so pressure maximum is not exceeded (PRVC)
    - Volume control
        - Regulated during inspiration, so V_T delivered regardless of the pressure
    - Synchronized intermittent mandatory ventilation (SIMV)
        - Definition: Preset volume or pressure delivered at a preset rate
        - The patient may take additional breaths of any tidal volume without interference from mandatory breaths (synchronized)
        - Ventilator delivers machine breaths

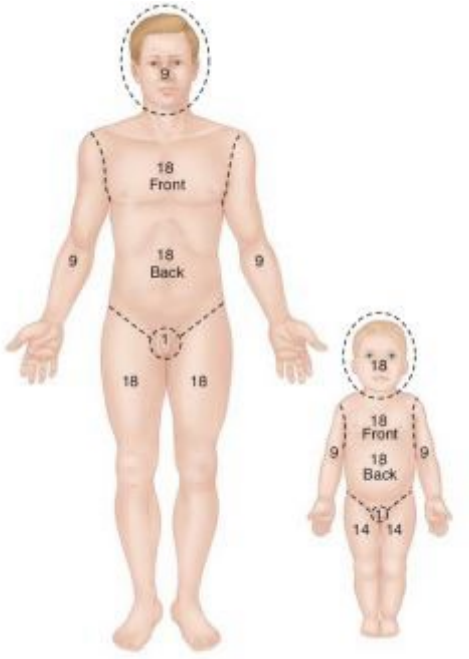
        - Spontaneous breaths possible through circuit
    - Inverse ratio ventilation (IRV)
        - Definition: Inspiratory time is greater than expiratory time (opposite of physiologic)
    - Pressure support ventilation (PSV)
        - Definition: Preset positive pressure is initiated by the patient's inspiratory effort
    - High frequency ventilation (HFV)
        - Definition: Preset low tidal volume delivered at preset high rates
            - Ventilates lungs at a frequency that is > 4 times the normal rate
- Overview of clinical parameters
    - FiO_2: 1.0 (based on ABG [PO_2] or SpO_2)
    - Tidal volume (V_T): 5 – 8 ml/kg
    - Respiratory rate (f): 10 – 20 breaths per minute
    - I:E ratio: 1-1.5:2
    - Flowrate: 30 – 60 lpm (depends on I:E ratio)
    - PIP: <40 lpm
    - Sigh: 1.5 – 2 times V_T
    - Sensitivity: -2 - 5cm H_2O, adjust as tolerated
    - High pressure limit: 10 – 15 cm above PIP
    - Low pressure limit: 10 – 15 cm below PIP
- Characteristic signs of oxygen toxicity include V/Q mismatch, diffuse pulmonary infiltrates on chest x-ray, and oxygen saturations falling despite increase FiO_2
- Goal of oxygen toxicity prevention is to decrease FiO_2 as early as possible without causing hypoxemia
- Airway obstruction
    - Causes (DOPE)
        - Displaced endotracheal tube
        - Obstructions
        - Pneumothorax
        - Equipment

4.1BTrauma:

- "The Big Three" major trauma imaging studies
  - Cervical spine
  - Chest x-ray
  - Pelvis
- Incomplete cord syndromes
  - Anterior spinal cord syndrome
    - Involves complete motor paralysis and loss of temperature and pain perception distal to the lesion
  - Central spinal cord syndrome
    - Characterized by weakness, greater in the upper extremities than the lower extremities and more pronounced in the distal aspect of extremity
  - Brown-Séquard syndrome
    - Involves injury to only 1 side of spinal cord
- Massive hemothorax or continued high rate of blood loss through the chest tube are indications for immediate surgical intervention
  - 1500 ml of blood loss upon chest tube insertion
  - Continued loss of 250 ml of blood for 3 consecutive hours
- Withdrawal of just 20 ml's of blood from a pericardiocentesis can provide relief to the patient
- Rhabdomyolysis is the rapid breakdown of skeletal muscles
  - The death of muscle leads to the release of damaged muscle cells into the bloodstream and the byproduct of the cells breaking down (myoglobin)
- An anaphylactic reaction requires prior sensitization to an allergen with later re-exposure, producing symptoms via an over-aggressive immunologic response
- An anaphylactoid reaction produce a response similar to an anaphylactic reaction but is not immune-mediated (prior sensitization is not required)

4.2 Burn Care:

- Be able to assess TBSA based on the "Rule of Nines"



- Lund and Browder chart is most accurate for determining TBSA
- Determining burn severity
    - Partial thickness burns greater than 10% TBSA
    - Burns to face, feet, hands, genitalia, perineum, or major points
    - 3rd degree burns in any age group
    - Electrical burns
    - Chemical burns
    - Inhalation injury
    - Burn injury in patients with pre-existing conditions that complicate management
    - Any patient with burns and concomitant trauma
    - Burned children that need qualified personnel or equipment
    - Burn injury in patients requiring special social, emotional or rehabilitative intervention
- Cyanide Antidote Kit (CAK) contains amyl nitrite pearls, sodium nitrite, and sodium thiosulfate
- Succinylcholine should be used judiciously in patients who are 24 hours post-burn because of the potential for hyperkalemia and malignant hyperthermia
- Parkland formula for adults: (4 ml/kg/TBSA) / 2
- The goal of fluid resuscitation is to assure adequate urinary output
    - 0.5 ml/kg/hr for adults (20 – 50 ml/hr)
    - 1 ml/kg/hr in adults with electrical burns (75 – 100 ml/hr)
    - 1 ml/kg/hr in children weighing less than 40 kg
    - 1-2 ml/kg/hr in neonates

5.1 High Risk Obstetrics:

- Umbilical cord contains two arteries and one vein (artery-vein-artery)
- Magnesium sulfate can be given to arrest pre-term contractions
    - Must monitor deep tendon reflexes (DTRs) and respiratory status
    - Antidote is calcium gluconate 1gm IV over 3 minutes
- Hypertension is the most common medical complication during pregnancy
- Chronic hypertension is defined as blood pressure exceeding 140/90 mmHg before pregnancy or before 20 weeks gestation
- Magnesium sulfate is administered to prevent and treat subsequent seizures in women with eclampsia
    - Given intravenously as a loading dose of 4 – 6 g over 20 minutes followed by a maintenance dose of 2 – 4 g/h as a continuous intravenous infusion
- HELLP is an abbreviation of the main findings
    - Hemolytic anemia
    - Elevated Liver enzymes
    - Low Platelet count
- Postpartum hemorrhage is classified as early, late, and severe
    - Early
        - More than 500 mL blood loss within 24 hours of delivery
    - Late
        - More than 500 mL blood loss within 6 weeks of delivery
    - Severe
        - More than 1,000 mL blood loss
- "STABLE" mnemonic
    - Stay calm
    - Triage
    - Assess
    - Baby
    - Launch
    - Evaluate and Evacuate

5.2 Pediatrics:

- "Rule of thumb" for determining blood pressure
  - Normal systolic blood pressure = 90 + (2 x the child's age in years)
  - Hypotension (5^{th} percentile) = 70 + (2 x the child's age in years)
- For every degree Celsius in temperature elevation, the respiratory rate will increase 5 – 10 breaths per minute
- There are three keys to pediatric impressions that form a triangle
  - Appearance
  - Work of breathing
  - Circulation to skin
- Cardiac arrest in children is most often a secondary event and the consequence of progressive shock, respiratory failure or cardiovascular failure
- The dose of succinylcholine is higher in children than adults (2 mg/kg compared to 1 – 1.5 mg/kg in adults)
- Ketamine is used more prevalently in pediatric intubations because the drug is tolerated better, and pediatrics do not experience reemergence reactions with the same frequency as adults
- Formula for determining endotracheal tube size (16 + age in years) / 4
- Croup is a viral respiratory tract infection that most commonly involves the larynx and trachea, but may extend to the bronchi
- Epiglottitis is a bacterial infection of the epiglottis and / or the supraglottic tissues
- With epiglottitis, lateral radiographs of the neck will show the classic "thumbprint" sign indicating a swollen epiglottis
- RSV is a viral infection that is limited to the respiratory tract, and is most often a clinical entity of bronchiolitis
- Because of the fall in PVR at birth, the ductus arteriosus begins to close
- Patent ductus arteriosus is one of the fetal circulatory pathways which diverts the desaturated blood from the main pulmonary artery into the descending aorta and placenta for oxygenation
- In TGA, the aorta rises from the right ventricle and the pulmonary artery rises from the left ventricle
- Hypotension is not evident in pediatric patients until there is 20 – 25% blood loss
- Fluid resuscitation should be titrated to maintain normal urinary output of 1 – 2 cc/kg/hour
- Always measure the amount of intravenous fluid that is given to a child
  - Syringe pump is optimal
  - Syringe pushes
  - IV pumps

5.3 Sepsis:

- Sepsis is defined as a syndrome that is characterized by an overwhelming systemic response to infection
- Bacteremia is the presence of bacteria in the blood
- Sepsis patients will commonly require 2 large bore IV's or a central venous catheter
- Difference between sepsis and severe sepsis is the presence of organ dysfunction (seen with severe sepsis)
- Respiratory tract and urinary tract infections are the two leading causes of sepsis
- Septic shock can result in severe complications such as ARDS, DIC, renal failure, liver failure and heart failure
- Septic shock is defined as sepsis with hypotension that is refractory to fluid resuscitation