

6. Fluid and hemodynamic disorders

Background

Total Body Water [Fig. 6-1]

- Human body is 60 % fluid (water) by weight
 - Total Body Water (TBW) = 42 liters (70kg M)
- Body has two major compartments (inside cell or outside)
- 2/3 of TBW is located inside cells
 - intracellular fluid compartment [28 l]
- 1/3 of TBW is located outside cells
 - extra-cellular fluid compartment [14 l]
 - 1/4 ECF is located inside blood vessels (intra-vascular) [3.5 l]
 - 3/4 ECF is located in extra-vascular (interstitial) space [9.5 l]

Movement of fluid

- Distribution of water between ICF and ECF compartments is determined by distribution of electrolytes
- Distribution of water within the ECF between the intra-vascular and interstitial space is determined by proteins
- Fluid constantly moves between compartments
 - fluid moves out of capillaries due to hydrostatic pressure in the capillary and osmotic pressure in ECF
 - fluid moves into capillaries due to oncotic pressure in the vessel and hydrostatic pressure in the ECF
- Lymphatics remove excess fluid not returned to vessels

Fluid and hemodynamic disorders

Edema

- Edema is the accumulation of excess fluid in ECF space
 - edema may be localized or systemic
 - edema fluid may be a Transudate or an Exudate
- Exudate
 - an exudate has a high protein content and lots of white blood cells
 - an exudate forms due to inflammation
- Transudate
 - a transudate has a low protein content and few white blood cells
 - a transudate forms due to imbalance of forces across vessel walls
- The cause of edema is often multifactorial
- Terminology
 - anasarca is severe generalized edema
 - ascites is excess fluid in abdominal cavity
 - hydrothorax is excess fluid in pleural cavity
 - hydrocardia is excess fluid in pericardial cavity
- Edema may have serious consequences
 - cerebral edema may result in herniation of the brain and death
 - pulmonary edema may result in impaired air exchange and death

Fluid and hemodynamic disorders

Edema

pathogenesis [Fig. 6-2]

- Presence of edema is an important sign of disease
 - edema may be first indication of problem with an organ
- Cardiac disease (congestive heart failure) [Fig. 6-3]
 - edema fluid may occur in CHF, the cause is often multifactorial
 - increased pressure in veins because heart not pumping effectively
 - anoxia in venous system results in increased permeability
 - Na retention results in water retention
- Renal disease
 - edema fluid may occur in renal disease
 - plasma proteins lost in urine due to renal diseases
 - relative increase in osmotic (protein) pressure of ECF

Hyperemia

- Hyperemia is an increased volume of blood in a tissue
 - active hyperemia occurs due to dilation of arterioles & capillaries
 - exercise, inflammation
 - passive hyperemia (congestion) occurs due to increased venous pressure that occurs with impaired outflow of blood from the area
- Cyanosis is a bluish discoloration of the lips and skin indicating a lack of oxygen

Hemorrhage

- Hemorrhage is the loss of blood [Fig. 6-5]
- In external hemorrhage blood exits the body
- In internal hemorrhage blood remains in the body
 - blood may enter a body cavity
 - hemothorax is blood in thoracic cavity
 - hemoperitoneum is blood in peritoneal cavity
 - hemopericardium is blood in pericardial cavity
 - a hematoma is coagulated blood in tissue (bruise)
 - petechiae is a pinpoint hemorrhage due to rupture of a capillary
 - purpura is a bruise >3mm in size
 - echymoses are larger hemorrhagic spots on skin and mucosa
- Terminology [Fig. 6-5]
 - hemoptysis refers to coughing up blood from lungs
 - hematemesis refers to vomiting blood from upper GI tract
 - hematochezia refers to passing bright red blood per rectum
 - melena refers to passage of dark (black) stools (UGI bleed)
 - hematuria refers to passage of blood in urine
 - metrorrhagia refers to excessive menses
- Symptoms depend on amount, site, duration of blood loss
 - rapid loss of less than 20 % of blood volume is compensatable
 - massive loss (>1500 ml) results in hypovolemia and shock
 - chronic loss results in anemia
 - hemorrhage into brain may result in herniation of the brain

Fluid and hemodynamic disorders

Thrombosis (clot formation)

- Blood clots in order to prevent loss of blood [Fig. 6-6]
 - if endothelium is damaged then a “plug” is made to fill hole
 - vessel constriction, platelet plug, reinforced by fibrin
- Clotting requires platelets, endothelium, plasma proteins
 - normally there is a balance of clot formation and clot lysis
- Thrombus is formation of clot within vessel during life
 - formation of a thrombus may cause complications [Fig. 6-7]
 - certain factors predispose to thrombus formation (Virchow’s triad)
 - stasis of blood (CHF, dehydration)
 - hypercoagulable states (inherited, malignancy)
 - endothelial injury (thrombogenic surface revealed)
- A thrombus has 4 major fates [Fig. 6-9]
 - lysis of the thrombus removal of thrombus by fibrinolysis
 - organization and recanalization replacement of the thrombus by granulation tissue and creation of new channels through thrombus
 - propagation is complete occlusion of a vessel with extension of the thrombus proximal in vein
 - embolus formation is detachment of a thrombus and impaction lodge distally
- Types of thrombus
 - venous
 - deep vein thrombosis
 - arterial

Embolus

- An embolus is a thrombus or other movable intravascular mass that may cause obstruction of a vessel
- Types of emboli
 - thromboemboli (99%)
 - fat emboli
 - gas emboli
 - solid emboli
 - liquid emboli
- An embolus causes ischemia to organs distal to the site of embolus impaction
- Pulmonary emboli [Fig. 6-10]
 - thrombus may form in deep veins of legs
 - the thrombus may dislodge and enter the inferior vena cava
 - thromboembolus passes through heart and impacts in vessels in lung
 - saddle embolus
 - pulmonary infarcts
- Arterial thromboemboli [Fig. 6-10]
 - cerebral infarcts may result from arterial thrombi in carotids dislodging and impacting in vessel feeding area of the brain
 - infarct of distal extremity may result from arterial thrombus in the aorta dislodging and impacting in vessel supplying distal extremity

Fluid and hemodynamic disorders

Infarction

- Infarction is irreversible ischemic necrosis of cells usually due to occlusion of arterial supply
- Factors influencing outcome of vessel occlusion include
 - pattern of vascular supply (presence of dual blood supply)
 - rate of development of occlusion
 - vulnerability of tissue to hypoxia
 - oxygen content of blood
- End result of an infarct depends on tissue's ability to repair
 - heart heals an infarct by fibrosis
 - liver is able to replace damaged tissue over time
 - brain is unable to regenerate or create a scar and forms

Shock

- Shock is inadequate perfusion (blood supply) to tissue
- Normal tissue perfusion requires a functioning pump (heart), intact pipes (vessels) and adequate fluid (blood)
- Causes of shock
 - S septic shock
 - H hypovolemic shock
 - O obstructive shock
 - C cardiogenic shock
 - K anaphylactic shock
 - S spinal/neurogenic shock

pathophysiology [Fig. 6-14]

- Cardiogenic shock
 - results from heart not pumping adequately
 - myocardial infarction
 - arrhythmia
- Hypovolemic shock
 - results from loss of blood volume
 - hemorrhage
 - water loss (burn)
- Hypotonic shock
 - results from pooling of blood in the periphery
 - anaphylaxis
 - sepsis

clinical

- Compensated (nonprogressive) phase
 - compensatory mechanisms able to maintain perfusion
- Decompensated (progressive) phase
 - compensatory mechanisms unable to maintain perfusion
 - hypotension, oliguria, acidosis, short of breath
- Irreversible shock
 - circulatory collapse, hypoperfusion of vital organs, loss of vital functions