

Shock

- Shock : a life threatening disorder of the circulatory system that results in inadequate organ perfusion and tissue hypoxia leading to metabolic disturbances and ultimately irreversible organ damage (O_2 delivery < O_2 consumption)
- Hallmark of shock is reduced tissue oxygenation
- Shock index = Heart Rate / Systolic Pressure ... if > 1 then positive for shock
- Body systems reaction to shock
 - Hypotension and hypoxia are sensed by baroreceptors and chemoreceptors which contribute to an autonomic response : norepinephrine release will induce arterial vasoconstriction - reduced vagal activity will increase heart rate and cardiac output
 - The renin angiotensin system is also activated : vasopressin causes vasoconstriction
 - Relative increase in pulmonary vascular resistance
 - The complement and coagulation cascades are activated
- Signs of end organ hypoperfusion
 - Brain : altered level of consciousness like lethargy, confusion or coma
 - Kidney : oliguria or anuria (atypical feature is to have polyuria) plus abnormal KFTs
 - Skin : slow capillary refill, diaphoresis, cold
 - Liver : abnormal LFTs
- In all patients with shock, immediately measure ABGs, lactate levels, capillary glucose, perform an ECG, and order a chest x-ray and general laboratory studies
- Complications
 - Cardiovascular collapse
 - Acute renal failure
 - Delirium
 - Airway obstruction in anaphylactic shock
 - Pulmonary edema in cardiogenic shock
 - DIC in hemorrhagic and septic shock
 - Death
- Capillary flow is low in all types of shock
- Cardiac output is low in all types of shock except warm septic
- Arterial constriction is high in all types of shock except warm septic
- Stages of Shock : Compensated > Uncompensated > Irreversible
- Regardless of etiology we have to give fluid boluses
 - 5 ml/kg for cardiac causes
 - 10 ml/kg for trauma
 - 20 ml/kg for sepsis
- Vasopressors increase vasoconstriction, which leads to increased systemic vascular resistance (SVR). Increasing the SVR leads to increased mean arterial pressure (MAP) and increased perfusion to organs

- Inotropes increase cardiac contractility, which improves cardiac output (CO), aiding in maintaining MAP and perfusion to the body

Hypovolemic Shock (Including Hemorrhagic Shock)

- A type of shock characterized by circulatory failure due to Intravascular volume depletion
- Etiology : Fluid loss either from GI, skin, kidneys, burns or hemorrhage resulting in decreased venous return and preload and thus the cardiac output
- Typical hemodynamic parameters
 - Low cardiac output (due to volume depletion thus low stroke volume)
 - High systemic vascular resistance
 - High heart rate
- Clinical features
 - Features of dehydration : cold extremities / slow capillary refill / decreased skin turgor / dry mucous membranes
 - Features of the underlying etiology like signs of GI bleeding
- Investigations
 - CBC and cross match (if hemorrhagic)
 - FAST scan and CXR to identify bleeding site
 - KFTs and Electrolytes
- Treatment
 - Fluid resuscitation
 - Blood transfusion
 - Hemostatic control
 - If massive transfusion is expected consider transfusing packed RBC, FFP, and platelet concentrate in a 1:1:1 ratio
- Classification of hemorrhagic shock
 - Grade 1
 - ◆ < 15% blood loss = 750 ml
 - ◆ Heart rate < 100
 - ◆ Normal blood pressure, pulse pressure and respiratory rate
 - ◆ Urine output > 30 ml/hour
 - ◆ Normal mental status
 - Grade 2
 - ◆ 15-30% blood loss = 750-1500 ml
 - ◆ Heart rate 100-120
 - ◆ Normal blood pressure
 - ◆ Low pulse pressure
 - ◆ Respiratory Rate 20-30

- ◆ Urine output 20-30 ml/hour
- ◆ Mildly anxious
- Grade 3
 - ◆ 30-40% blood loss = 1500-2000 ml
 - ◆ Heart rate 120-140
 - ◆ Low blood pressure and pulse pressure
 - ◆ Respiratory Rate 30-40
 - ◆ Urine output 5-15 ml/hour
 - ◆ Anxious or confused
- Grade 4
 - ◆ > 40% blood loss = > 2000 ml
 - ◆ Heart rate > 140
 - ◆ Low blood pressure and pulse pressure
 - ◆ Respiratory Rate > 35
 - ◆ Urine output is absent
 - ◆ Confused or lethargic
- We can use Permissive Hypotension approach for uncontrolled hemorrhage since aggressive volume loading might be harmful and in order to maintain adequate vasoconstriction, organ perfusion and prevent an undesired coagulopathy during initial fluid resuscitation
- If massive transfusion is anticipated : transfusing 6 units of packed RBCs, 6 units of fresh frozen plasma, and 6 units of random donor platelets (or 1 unit of apheresis platelets) should be administered

Cardiogenic Shock

- A condition of circulatory failure that results from the heart's inability to maintain adequate cardiac output
- Etiology : Myocardial infarction / arrhythmias / valvulopathy / cardiotoxins / heart failure
- Typical hemodynamic parameters
 - Very low cardiac output
 - High systemic vascular resistance
 - Variable heart rate
- Clinical features
 - Features of heart failure : dyspnea / orthopnea / edema / fatigue / elevated JVP and distended neck veins / cold extremities / slow capillary refill
 - Features of underlying etiology : chest pain / syncope / palpitations / new or worsening murmur
- Investigations
 - BNP and ANP
 - ECG

- Cardiac markers
- Echocardiography
- Treatment
 - Administration of IV fluids according to fluid responsiveness
 - Inotropic support
 - Vasopressors
 - Diuretics
 - Treatment of refractory acute heart failure

Obstructive Shock

- A type of shock caused by physical obstruction of blood flow in central vessels of the systemic or pulmonary circulation that leads to reduced cardiac output.
- Etiology
 - Impairment of diastolic filling of the right ventricle : cardiac tamponade or pericarditis
 - Obstruction of venous return : tension pneumothorax or Intrathoracic tumor
 - Increased Ventricular afterload : massive pulmonary embolism / aortic stenosis or dissection
- Typical hemodynamic parameters
 - Very low cardiac output due to low stroke volume
 - High systemic vascular resistance
 - High heart rate
- Clinical features
 - Features of underlying etiology : chest pain, diminished breath sounds, tracheal deviation, muffled heart tones or features of DVT
 - Elevated JVP and distended neck veins
 - Cold clammy extremities and poor capillary refill
- Investigations
 - Echocardiography
 - CXR or chest CT
 - CT pulmonary angiogram or V/Q scan
- Treatment
 - Fluid resuscitation
 - Interventions to relieve obstruction
 - ◆ Pericardiocentesis
 - ◆ Needle thoracostomy followed by tube thoracostomy
 - ◆ Thrombolysis

Distributive (Vasodilatory) Shock

- A circulatory failure caused by an insult to blood vessels that results in fluid extravasation from the vasculature (excess vasodilation) and loss of adequate intravascular fluid volume
- Etiologies include septic shock, anaphylactic shock, and neurogenic shock
- Other forms
 - Adrenal insufficiency
 - Myxedema coma : severe hypothyroidism state
 - Drug reactions
 - Toxic shock syndrome : a rare toxin-mediated shock caused by toxin-producing strains of *Streptococcus pyogenes* and *Staphylococcus aureus*

Septic Shock

- A type of distributive shock caused by an excessive inflammatory response to disseminated infection
- Diagnostic criteria include
 - The requirement of vasopressors to maintain a median arterial pressure ≥ 65 mmHg despite adequate fluid therapy
 - Lactate > 2 mmol/L (> 18 mg/dL) in a normovolemic patient with sepsis
- Typical hemodynamic parameters
 - Very low systemic vascular resistance
 - Variable cardiac output
 - ◆ Early : high cardiac output
 - ◆ Late : low cardiac output
 - High heart rate
- Clinical features
 - Early : flushed warm skin with normal capillary refill
 - Late : cold pale skin with delayed capillary refill
 - Features of sepsis : fever and SIRS criteria
 - Features of underlying infection like pneumonia
- Investigations
 - Cultures of blood or urine or sputum
 - Septic workup : CBC / serum lactate / CRP / coagulation profile / electrolytes
- Treatment
 - Fluid resuscitation
 - Vasopressors : norepinephrine or vasopressin or dopamine
 - Antibiotics
 - Infectious source control like abscess drainage
 - Corticosteroids for shock refractory to the first vasopressor
 - There should be 20% decrease in serum lactate every 2–4 hours until normal

- Mortality of septic shock exceeds 40%

Anaphylactic Shock

- Anaphylaxis is a severe type 1 hypersensitivity reaction that can cause life-threatening and multisystem effects due to IgE-mediated mast cell activation leading to massive histamine release and peripheral vasodilation
- Typical hemodynamic parameters : same as septic shock
- Clinical features : acute onset within minutes of exposure to allergen
 - Skin : Flushing, erythema, Urticaria, pruritus
 - Swelling of the eyelids and angioedema
 - Nasal congestion and sneezing
 - Chest tightness, dyspnea, hoarseness and Cyanosis
 - Nausea, vomiting, diarrhea and abdominal pain
 - Hypotension and tachycardia with weak peripheral pulses
- Management
 - Stabilize the patient : ABCDE
 - Administer epinephrine IM
 - Fluid resuscitation
- Adjunctive treatment (antihistamines and corticosteroids) should only be administered after the initial resuscitation (IM epinephrine, fluids or vasopressors) have been given.

Neurogenic Shock

- Etiology : CNS injury : spinal cord injury or intracranial hemorrhage leading to loss of sympathetic vascular tone and unopposed vagal tone causing peripheral vasodilation
- Typical hemodynamic parameters
 - Low cardiac output
 - Low heart rate
 - Low systemic vascular resistance
- Clinical features
 - Flushed warm skin
 - Priapism
 - Features of underlying etiology : neurological deficits or flaccid paralysis
- Investigations : Neuroimaging studies
- Treatment
 - Fluid resuscitation
 - Vasopressors
 - Atropine for bradycardia