Shock

Definition of shock

- Circulatory shock: an abnormality of the circulatory system that results in reduced organ perfusion and tissue oxygenation
- Emotional shock: an acute stress reaction arising in response to a traumatic event, often erroneously used interchangeably with the term 'shock' in popular culture; this will not be discussed further

Causes of shock

Reduced cardiac output (CO):

- Hypovolaemic shock
  - Haemorrhage
    - External, including gastrointestinal
    - Internal
      - Chest
      - Abdomen
      - Pelvis
      - Retroperitoneum
      - Long bones
  - Vomiting
  - Diarrhoea
  - Diuresis
  - Burns
- Cardiogenic shock
  - Myocardial infarction
  - Myocardial contusion
  - Myocarditis
  - Cardiac arrhythmia
    - Unstable tachyarrhythmias
    - Unstable bradyarrhythmias
  - Negatively inotropic drug overdose
    - Beta blockers
    - Calcium channel blockers
- Obstructive shock
  - Tension pneumothorax
  - Massive PE
  - Cardiac tamponade

Reduced systemic vascular resistance (SVR):

- Septic shock
- Anaphylactic shock
- Neurogenic shock

Pathophysiology of shock

- Blood pressure (BP) is related to cardiac output (CO) and systemic vascular resistance (SVR) by the following equation:

$$BP = CO \times SVR$$

- CO is the volume of blood pumped by the heart per minute and is in turn related to heart rate (HR) and stroke volume (SV) as follows:

$$CO = HR \times SV$$

- SV is the volume of blood pumped by the heart per contraction and is determined by
  - Preload
  - Myocardial contractility
  - Afterload
- Preload is the ventricular wall tension at the end of diastole and reflects the degree of myocardial muscle fibre stretch; it is determined by volume status, venous capacitance and the difference between mean venous pressure and right atrial pressure
- Preload is related to SV by the Frank-Starling mechanism; increased fibre length initially leads to an increased SV but above a certain point, the fibres become overstretched and further filling results in a decreased SV, as is the case in cardiac failure
- Myocardial contractility is the intrinsic ability of the heart to work independently of preload and afterload; positive inotropes increase the contractility, shifting the Frank-Starling curve upwards
- Afterload is the ventricular wall tension at the end of systole and is the resistance to anterograde blood flow
- Regardless of the cause of shock, inadequate organ perfusion and tissue oxygenation results in cells switching from aerobic to anaerobic metabolism
- This generates a lactic acidosis that disrupts the cellular environment and causes myocardial depression

History in a shocked patient

- Assessment of severity
  - Dyspnoea
  - Confusion
  - Light-headedness
  - Drowsiness
  - Oliguria/anuria
- Symptoms of the cause

Examination of the shocked patient

- Airway
  - May be compromised by reduced conscious level
- Breathing
  - Hypoxia secondary to:
    - Cause
    - Airway compromise
    - Apparent hypoxia due to ineffective pulse oximetry from peripheral shutdown
  - Tachypnoea
  - Kussmaul's breathing: hyperventilation to compensate for metabolic acidosis manifesting as 'air hunger'
- Circulation
  - Cold, pale peripheries
  - Prolonged capillary refill times (CRT >2 s)
  - Tachycardia
  - Hypotension

- Oliguria
- Anuria

- Disability
  - Confusion
  - Drowsiness
  - Unconsciousness
- Signs of the cause

Classification of haemorrhagic shock

- Type I
  - Volume of blood loss (ml): <750
  - Percentage blood loss (%): <15
  - Heart rate (beats/min): <100
  - Blood pressure: normal
  - Pulse pressure: normal/increased
  - Respiratory rate (breaths/min): 14-20
  - Urine output (ml/hour): >30
  - Mental state: slightly anxious
- Type II
  - Volume of blood loss (ml): 750-1500
  - Percentage blood loss (%): 15-30
  - Heart rate (beats/min): 100-120
  - Blood pressure: normal
  - Pulse pressure: decreased
  - Respiratory rate (breaths/min): 20-30
  - Urine output (ml/hour): 20-30
  - Mental state: mildly anxious
- Type III
  - Volume of blood loss (ml): 1500-2000
  - Percentage blood loss (%): 30-40
  - Heart rate (beats/min): 120-140
  - Blood pressure: decreased
  - Pulse pressure: decreased
  - Respiratory rate (breaths/min): 30-40
  - Urine output (ml/hour): 5-15
  - Mental state: anxious, confused
- Type IV
  - Volume of blood loss (ml): >2000
  - Percentage blood loss (%): >40
  - Heart rate (beats/min): >140
  - Blood pressure: decreased
  - Pulse pressure: decreased
  - Respiratory rate (breaths/min): >35
  - Urine output (ml/hour): negligible
  - Mental state: confused, lethargic

Investigation of shock

- Bloods including blood gas to check pH and lactate
- Electrocardiogram (ECG)

- Chest radiograph (CXR)
- Echocardiography
- In trauma
    - Pelvic XR
    - CT chest/abdo/pelvis as indicated
    - FAST

Initial management of shock

- Assess the patient from an ABCDE perspective
- Maintain a patent airway
    - Use manoeuvres, adjuncts, supraglottic or definitive airways as indicated and suction any sputum or secretions
- Deliver high flow oxygen 15L/min via reservoir mask to keep sats over 94%
- Attach monitoring
    - Pulse oximetry and non-invasive blood pressure
    - Three-lead cardiac monitoring
- Request 12 lead ECG and portable CXR
- Obtain large-bore intravenous (IV) access and take bloods including blood gas to check pH and lactate
- Fluid resuscitation IV
- Urethral catheterisation and fluid balance monitoring aiming for a urine output >0.5 ml/kg/hour
- If BP fails to respond consider referral to HDU/ICU for
    - Central line insertion with central venous pressure (CVP) and central venous oxygen saturation ($S_{cv}O_2$) monitoring
    - Arterial line insertion and invasive arterial BP monitoring
    - Vasopressor and/or inotrope infusion

Further management of shock

- Identify and treat the cause
    - Haemorrhagic shock
        - Identify the source(s) of bleeding and achieve haemorrhage control e.g. direct compression, pelvic binder, splinting of long bone fractures, surgical ligation of bleeding vessels
        - Restoration of adequate circulating volume
            - Cross-match blood and activate the major haemorrhage protocol
            - Transfuse O negative blood initially, followed by type-specific and fully cross-matched blood as soon as it is available; aim for permissive hypotension
        - Correct coagulopathy by transfusion of platelets, fresh frozen plasma and cryoprecipitate as appropriate
        - RBC: FFP ratio should be between 1:1 and 1:2, the optimum ratio is uncertain. The key is to give FFP early with RBC. Cryo if fibrinogen<1.5.
    - Antibiotics and source control for septic shock
    - Adrenaline 0.5 mg intramuscular (IM) for anaphylactic shock
    - Needle thoracocentesis and intercostal chest drain insertion for tension pneumothorax
    - Pericardiocentesis and thoracotomy for cardiac tamponade
    - Thrombolysis for massive PE
    - Synchronised direct current (DC) cardioversion for unstable tachyarrhythmias
    - Pacing for unstable bradyarrhythmias