

Shock

Cardiogenic myocardial infarction, myocarditis, vasculitis, valve dysfunction (e.g. critical aortic stenosis, mitral regurgitation, acute endocarditis), post cardiac bypass surgery, drug overdose (β -blockers, calcium antagonists)
Hypovolaemic: haemorrhage, burns, gastrointestinal fluid loss
Obstructive pulmonary embolus, cardiac tamponade, tension pneumothorax
Anaphylactic drugs, blood transfusion, insect sting
Septic bacterial infection, non-infective inflammatory conditions e.g. pancreatitis, burns, trauma
Neurogenic intracranial haemorrhage, brainstem compression, spinal cord injury

major categories

- surgical, radiological or endoscopic intervention may be required in haemorrhagic shock & should be undertaken in a timely fashion

- in most situations, fluid resuscitation precedes definitive intervention
- in some trauma patients outcome may be improved if fluid resuscitation is delayed until bleeding is controlled
- hypovolaemic shock due to other intraabdominal pathology may also require surgery; however, in these cases correcting hypovolaemia, hypoxia & anaemia preoperatively can significantly reduce perioperative mortality

specific measures in hypovolaemic shock

- Source control:
- infected fluid collections should be drained either radiologically or surgically
 - surgical intervention may also be required for other sources of sepsis such as bowel perforation

Antibiotics:
 - it is vital to select an appropriate antibiotic and to ensure that the dosing regimen is optimal
 - spectrum should be narrowed and directed at the identified organisms

Steroids:
 - large doses of steroids (eg 30-120mg/kg) given within 24 hours of septic shock result in haemodynamic improvement but not increased survival
 - while low dose steroids in patients with septic shock who had a sub-normal rise in synacthen appeared to improve outcome in one study, a larger follow-up study has not confirmed this benefit and revealed an increased risk of superinfection

L-NMMA:
 - the results of phase 1 & 2 trials of N-methyl-L-arginine (L-NMMA), a non-selective nitric oxide synthase inhibitor in septic shock appeared promising with a 60-80% reduction in noradrenaline requirements to maintain a MAP of 70; however, subsequent phase 3 trials demonstrated increased mortality which was due to cardiac failure precipitated by increased systemic & pulmonary vascular resistance

Vasopressin:
 - in cases of septic shock with refractory hypotension, despite high doses of catecholamines, the addition of an intravenous infusion of vasopressin (0.04U/min) can increase blood pressure, SVR & urinary output
 - in septic shock vasopressin levels may be low
 - use of vasopressin in this circumstance has not been well studied & potential concerns about tissue ischaemia and cardiac function exist

Activated Protein C:
 - an endogenous protein capable of promoting fibrinolysis and inhibiting thrombosis and inflammation; in sepsis the conversion of protein C from an inactive form to an active form is impaired due to downregulation of thrombomodulin by inflammatory cytokines
 - in patients with severe sepsis and APACHE-II >25 infusing APC at 24mcg/kg/hr for up to 96 hours reduces absolute risk of death by 6%. This effect was not seen in patients on heparin & it has subsequently been shown to increase mortality in patients with severe sepsis with low risk of death and in children

high volume haemofiltration:
 - numerous studies have demonstrated that haemodynamic status often improves following commencement of haemofiltration & it is postulated that this is due to cytokine removal in the ultrafiltrate & by adsorption onto the filter
 - in patients with severe, there is some evidence that higher dose haemofiltration (45ml/kg/hr) may improve outcome; however, a rigorous, randomised trial has yet to be performed

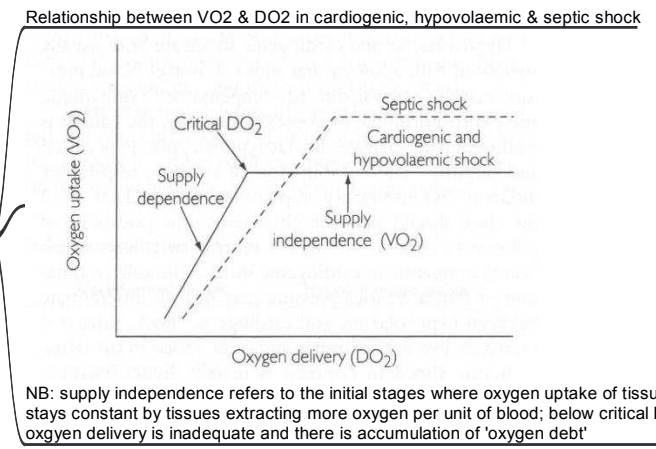
revascularisation:
 - cardiogenic shock complicating AMI carries a high mortality rate which is not reduced to any significant extent by thrombolytic therapy (55% at 30 days) & angiography, angioplasty or CABG should be undertaken without delay

IABP:
 - IABP provides a useful bridge to surgery in cases of cardiogenic shock due to papillary muscle rupture and ischaemic VSD
 - it may also be useful in other patients with cardiogenic shock with an AMI

specific measures in septic shock

specific measures in cardiogenic shock

pathophysiology



general
 - traditionally, hyperlactataemia in critically ill patients and particularly those in shock was normally interpreted as a marker of secondary anaerobic metabolism
 - a number of papers have suggested that lactate formation during sepsis is not due to hypoxia but rather to metabolic processes

- Arterial lactate concentration is dependent on the balance between its production and consumption.
 - In general, this concentration is less than 2 mmol/l, although daily production of lactate is actually 1500 mmol/l.
 - In physiological conditions, lactate is produced by muscles (25%), skin (25%), brain (20%), intestine (10%) and red blood cells (20%), which are devoid of mitochondria.
 - Lactate is essentially metabolized by liver and kidney.

- Lactate is produced in the cytoplasm according to the following reaction:
 $Pyruvate + NADH + H^+ \leftrightarrow lactate + NAD^+$
 - This reaction favours lactate formation, yielding a 10-fold lactate/pyruvate ratio.
 - Lactate increases when production of pyruvate exceeds its utilization by the mitochondria. Pyruvate is essentially produced via glycolysis; hence any increase in glycolysis, regardless of its origin, can increase lactataemia.

- Pyruvate is essentially metabolized by the mitochondrial aerobic oxidation pathway via the Krebs cycle:
 $Pyruvate + CoA + NAD \rightarrow acetyl\ CoA + NADH + H^+ + CO_2$
 - This reaction leads to the production of large quantities of ATP (36 molecules of ATP for one molecule of pyruvate).
 - Generated lactate can be transformed into oxaloacetate or alanine via the pyruvate pathway or can be utilized directly by periportal hepatocytes (60%) to produce glycogen and glucose (neoglucogenesis and neoglucogenesis; Cori cycle).

- The kidney also participates in the metabolism of lactate (30%), with the cortex classically acting as the metabolizer by neoglucogenesis and the medulla as a producer of lactate. The threshold of renal excretion is 5-6 mmol/l, meaning that, physiologically speaking, lactate is not excreted in the urine.

Oxygen & mechanical ventilation:
 - all shocked patients should be given high flow oxygen via a facemask with the aim of improving arterial oxygen saturation and DO₂ to the tissues
 - mechanical ventilation has much to commend it in the patient with high work of breathing as it will reduce VO₂ by the respiratory muscles
 - intubation will facilitate insertion of lines and monitoring which may be difficult in a confused, agitated patient

Fluid therapy:
 - optimising preload and restoring circulating volume are fundamental aspects of correcting tissue hypoxia in patients with shock
 - in patients with severe sepsis, aggressive volume replacement within 6 hours of presentation in conjunction with targeting an SvO₂>70 can reduce hospital mortality by up to 16%
 - it is logical to replace the fluid which is lost; however, a restrictive transfusion strategy with a transfusion threshold of 70 appears to reduce in hospital mortality in patients with critical illness. The benefit of a restrictive transfusion strategy appears to be greatest for patients with APACHE scores of 20 or less and those aged less than 55 years.
 - human albumin has been shown to be safe in a large clinical trial and in the subgroup of patients with leaky capillaries it appears to restore circulating volume more efficiently; however, it is associated with increased morbidity and mortality in patients with traumatic brain injury
 - MMW-HES 200kda and HMW-HES 450kda have been associated with renal impairment & clotting abnormalities respectively
 - hypertonic crystalloids have been studied in initial resuscitation of head injured patients; however, no benefits have been demonstrated

general measures