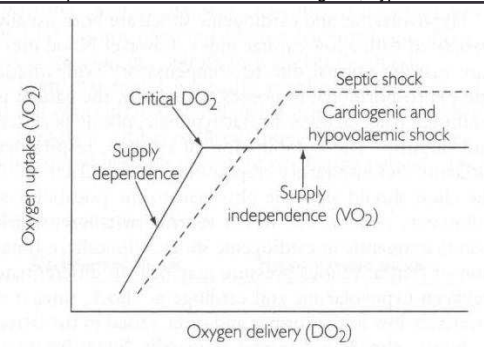
Shock

major categories

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

pathophysiology

Relationship between VO2 & DO2 in cardiogenic, hypovolaemic & septic shock



NB: supply independence refers to the initial stages where oxygen uptake of tissues stays constant by tissues extracting more oxygen per unit of blood; below critical DO2 oxgyen delivery is inadequate and there is accumulation of 'oxygen debt'

specific measures in hypovolaemic shock

- 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 septic 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 shownto 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

specific measures in cardiogenic shock

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

lactate

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+ <--> 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 ---> acetyl CoA + NADH + H+ + CO2
- 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 (neoglycogenesis and neoglucogenesis; Cori cycle).

- The kidney also participates in the metabolism of lactate (30%), with thecortex 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.

general measures

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 targetting 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 abnormalites respectively
- hypertonic crystalloids have been studied in initial resuscitation of head injured patients; however, no benefits have been demonstrated