RDCR - SHOCK PHYSIOLOGY
Shock is bad for you
Level of shock is correlated with outcome


Level of shock – correlated with level of coagulopathy and inflammation


Hess et al, J Trauma 2008 (ACOTS)

Hypoperfusion and shock is probably the primary initiator of coagulopathy (ACoT)

Blood doesn’t coagulate

“Blood failure”

Definitions

• Shock:
  • A physiologic state where oxygen delivery (DO₂) is not sufficient to meet the metabolic requirements (VO₂) of the body.

• Critical DO₂
  • Level of DO₂ below which anaerobic metabolism begins and cellular function deteriorates
  • Lactate increases

• Compensated Shock:
  • A physiologic state where DO₂ is decreased but oxygen extraction increases to continue to meet VO₂ demands of the body.

Oxygen requirement (VO₂) beyond oxygen supply (DO₂) organ failure

Definitions

• Oxygen deficit:
  • *The difference between the metabolic demand and supply at a certain time.*

• Oxygen debt:
  • *The magnitude and length of the oxygen deficit.*
  • “*The time spent below critical DO₂*”
  • *Oxygen debt kills you!*
Ficks equation
\[ D_{O_2} = 1.34 \times Hgb \times SaO_2 \times CO \]

**CO** = Cardiac output = Heart rate/min x Stroke volume

**SaO_2** = Oxygen saturation

**Hgb** = Hemoglobin concentration
Compensation/consequences of decreased $D\text{O}_2$ (due to bleeding)

$$D\text{O}_2 = Hgb \times SaO_2 \times CO$$

- Tachycardia
- Cold, clammy
- Weak/absent pulses
- Increased RR, due to lactacidosis
- Slow mentation
- Urine output $\downarrow$
Poiseuille's law

\[ F = \frac{\Delta P}{R} = \frac{(P_A - P_V)}{R} \]
\[ \text{DO}_2 = 1.34 \times \text{Hgb} \times \text{SaO}_2 \times \text{CO} \]
No cellular damage
Bolus – Immediate 100% Repayment

Minimal/moderate cellular damage
Bolus – Immediate 64% Repayment

Severe organ injury, early death
Bolus – Immediate 28% Repayment


“TOO little, too late!”
To sum up:

What is “Shock?”

- Inadequate blood flow to the body tissues
- Leads to inadequate oxygen delivery and cellular dysfunction
- Reduced oxygen delivery over time – “oxygen debt”/”Shock dose”
- Leads to organ failure including “blood failure”
- Blood failure = Coagulopathy
- May cause death
- Shock can have many causes, but on the battlefield, it is typically caused by severe blood loss

- **Hemorrhagic shock is the leading cause of preventable death on the battlefield**