



Septic Shock

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What is Shock?

Shock is a critical condition manifested by a failure of the circulatory system to maintain adequate perfusion to vital organs resulting in anaerobic metabolism and if uncorrected is incompatible with life.

Basic Hemodynamics

$$CO = (HR) (SV)$$

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“Volume”

CVP
PAWP

“Contractility”

Basic Hemodynamics

$$\begin{aligned} \text{BP} &\approx (\text{SVR})(\text{CO}) \\ &\approx (\text{SVR})(\text{HR})(\text{SV}) \end{aligned}$$

Different types of shock

| | CVP | Contractility | CO | Peripheral Resistance |
|-------------|-----|---------------|----|-----------------------|
| Cardiogenic | | | | |
| Hypovolemic | | | | |

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Cardiogenic and Hypovolemic shock are **PUMP PROBLEMS**. The bodies hemodynamic responses are **INTACT**.

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| Hypovolemic | Decrease | Increase | Decrease | Increase |
| Septic | | | | |

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| Septic | Depends | Depends | Depends | Decrease |

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| Septic | Decrease | Depends | Decrease | Decrease |

Septic shock causes direct effects on end organs

The Spectrum of Sepsis

- Infection
 - Bacteremia
 - Systemic Inflammatory Response Syndrome (SIRS)
 - Sepsis
 - Severe Sepsis
 - Septic Shock
 - Multiorgan Dysfunction Syndrome (MODS)
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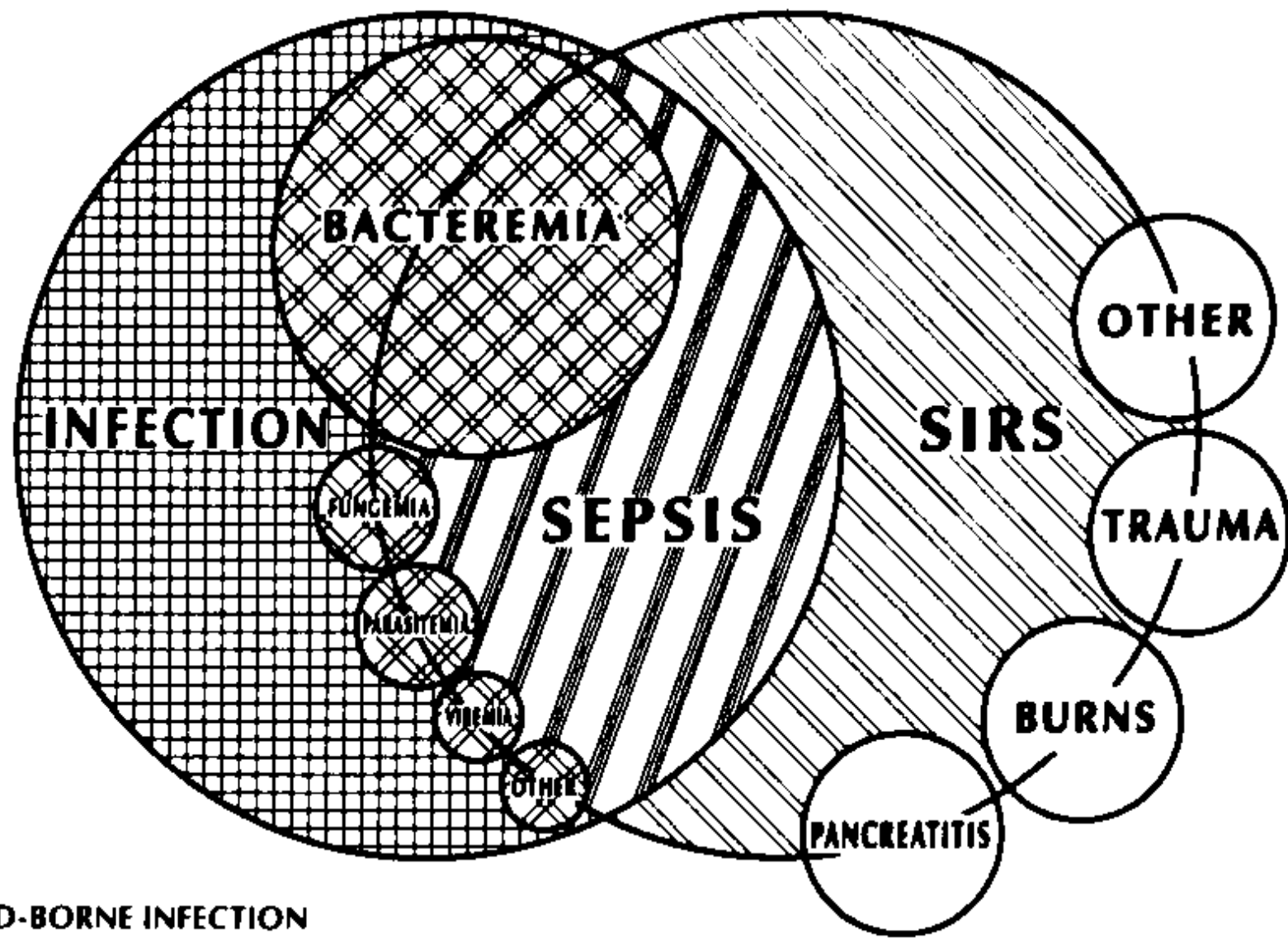


Figure 1. Interrelationships among systemic inflammatory response syndrome (*SIRS*), sepsis, and infection.

Early Recognition of Shock

- You can have shock with “normal” blood pressure
 - Shock will present with signs of end organ hypoperfusion
 - Decreased urine output
 - Altered mental status
 - Increased lactate
 - Increased BUN/Cr
 - Acute lung injury
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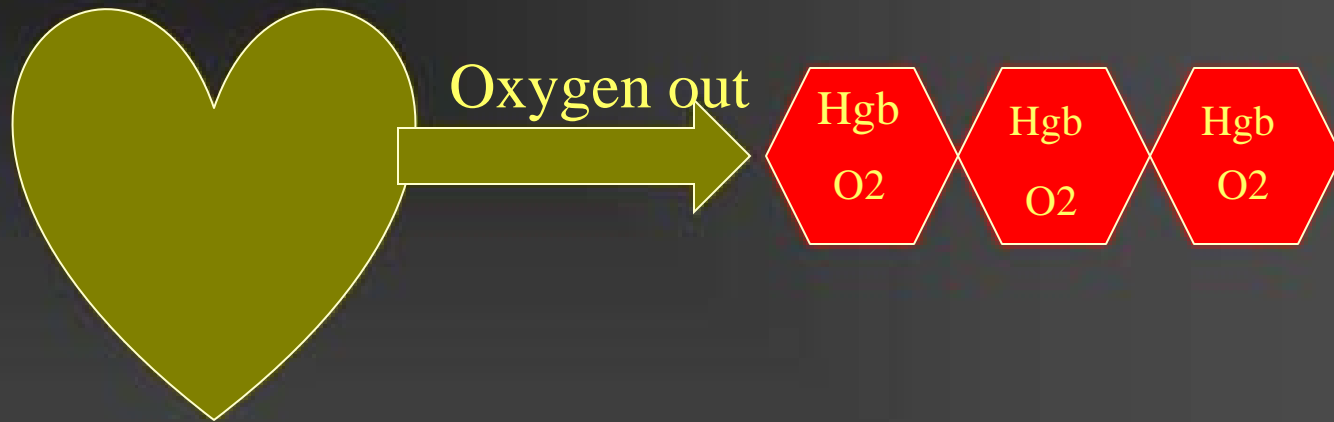
Early Treatment of Shock

- Resuscitation
 - Find the source
 - Blood cultures before antibiotics
 - Early broad spectrum antibiotics
 - Pop the pimple
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Laboratory Examination

- CBC/D
 - Lactate
 - Lytes, BUN, Cr, LFT
 - PT/PTT
 - Blood cultures
 - Any relevant x-ray studies
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Oxygen Delivery

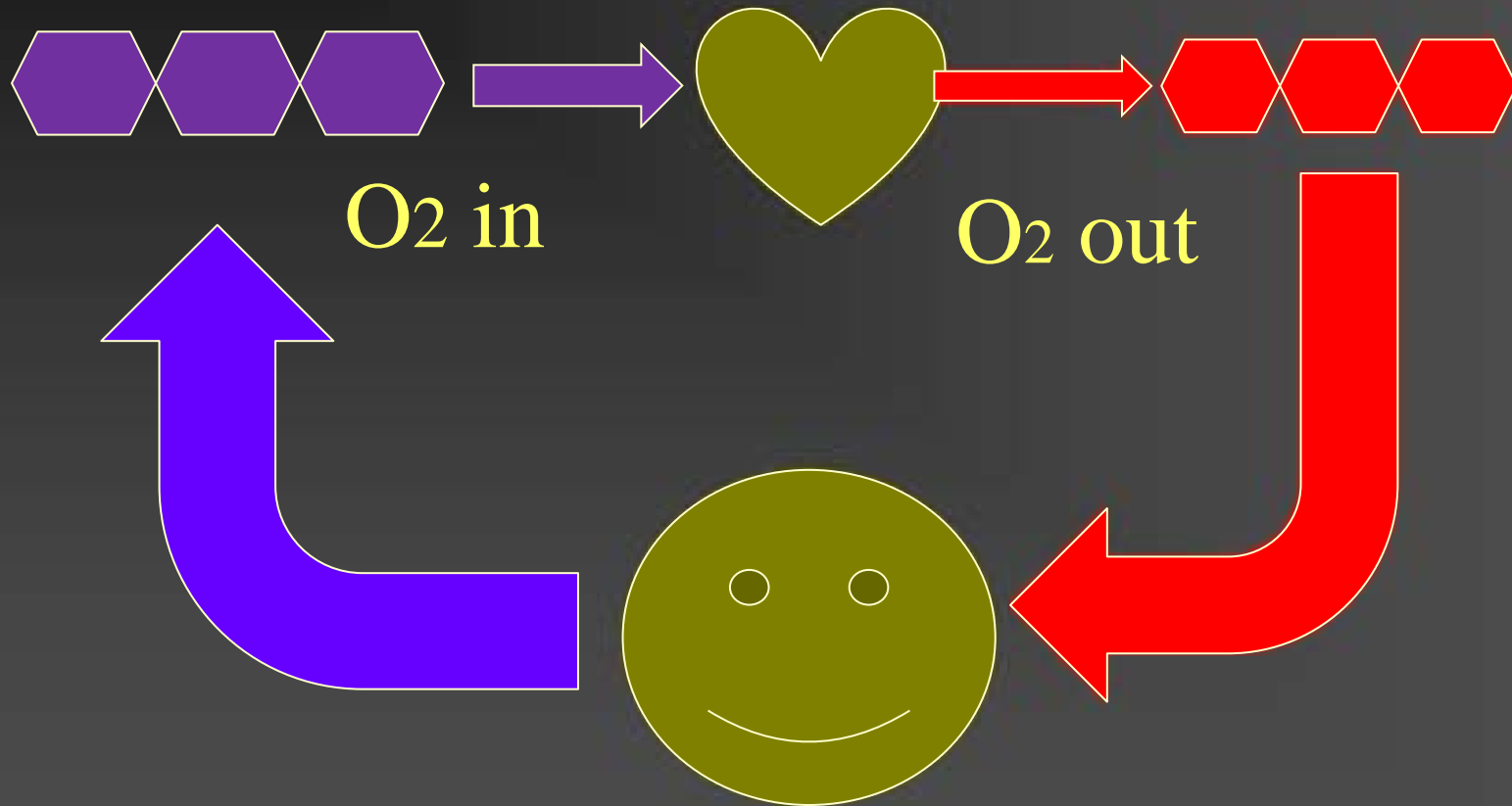


$$DO_2 = c(CO)(Hgb)(SaO_2)$$

Oxygen Delivery

- $CO = (HR)(SV)$
- Oxygen delivery
 - Oxygen saturation
 - Hgb
 - Cardiac output
- $DO_2 = (Hgb)(CO)(SaO_2)$

Oxygen Consumption

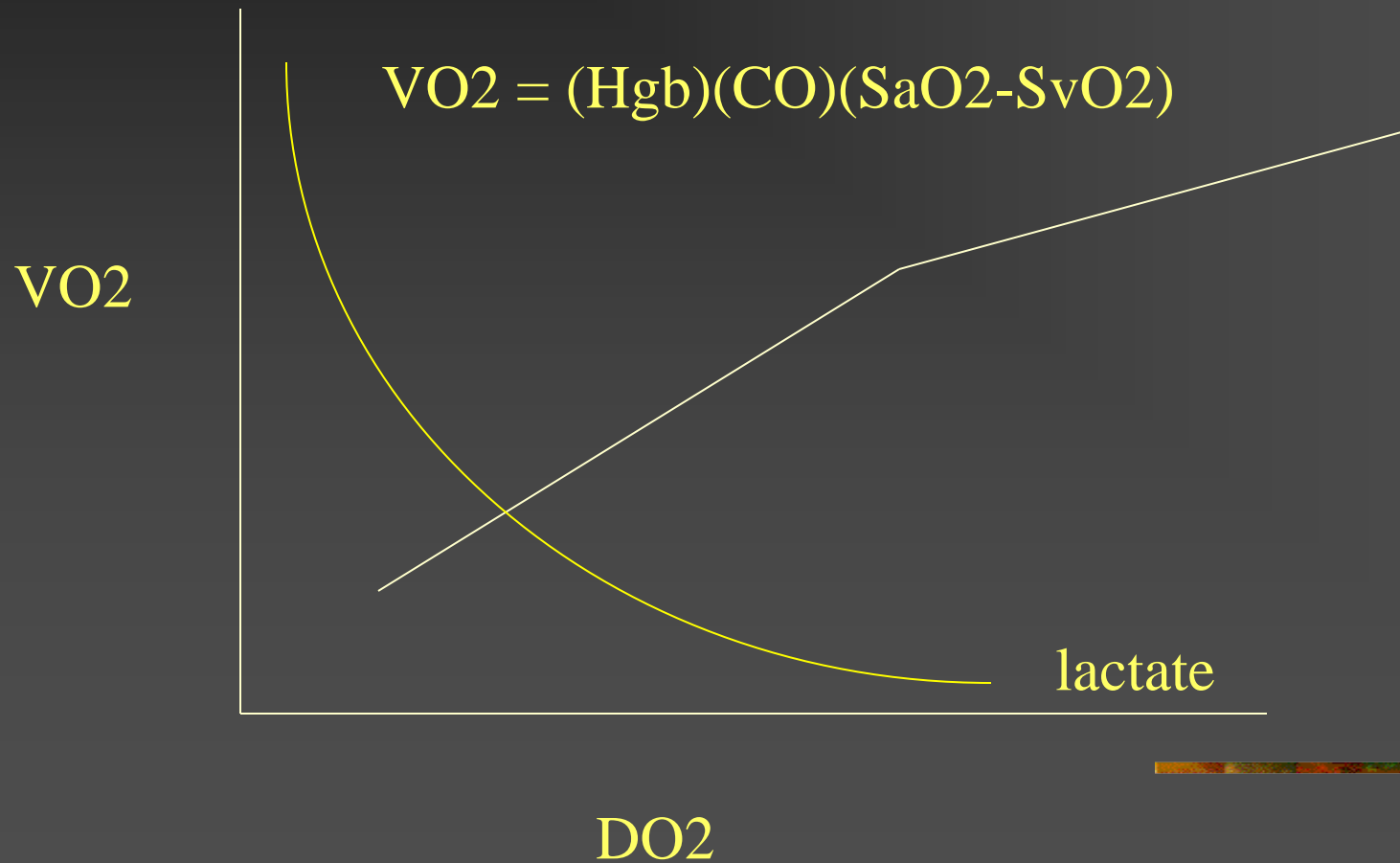


$$\text{Oxygen consumption} \\ (VO_2) = (O_2 \text{ out}) - (O_2 \text{ in})$$

Oxygen Consumption

- Oxygen consumed by the body
 - Measure oxygen out of the heart minus oxygen into the heart
 - $VO_2 = DO_2 \text{ (out)} - DO_2 \text{ (in)}$
 - $VO_2 = (Hgb)(CO)(SaO_2 - SvO_2)$
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DO₂ and VO₂ in sepsis



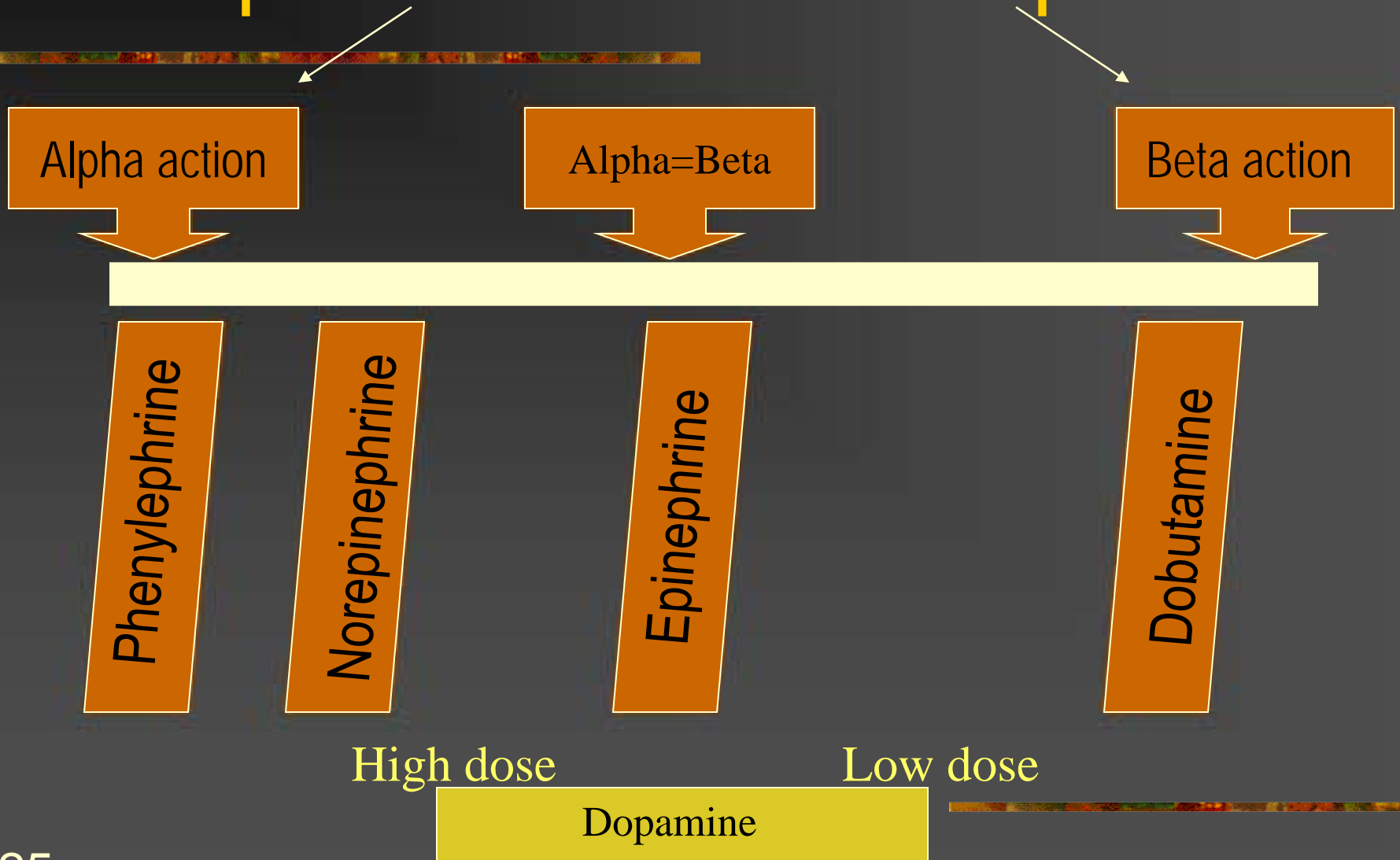
Mixed Venous Oxygen Saturation

- SvO₂ is the oxygen saturation returning to the right heart (ScvO₂ for regular central lines)
 - Determinants of SvO₂
 - Oxygen delivery
 - Oxygen extraction
 - High values indicate ($\geq 70\%$):
 - Adequate tissue perfusion
 - Poor tissue extraction of oxygen
 - Goal values in shock
 - ScvO₂ $\geq 70\%$, SvO₂ $\geq 65\%$

Early-Goal Directed Therapy in Septic Shock

- Assure $\text{SaO}_2 \geq 92\%$ or $\text{PaO}_2 \geq 60$
- Fluids until CVP 8-12 mmHg
- If $\text{MAP} < 65$ mmHg, add norepinephrine or dopamine
- $\text{ScvO}_2 < 70\%$
 - Transfuse patient until $\text{Hct} \geq 30\%$
- If persistent $\text{SvO}_2 < 65\%$ or $\text{ScvO}_2 < 70\%$
 - Start dobutamine at 3-5 mcg/kg/min and titrate up to 20 mcg/kg/min

Vasopressors and Inotropes



Role of Steroids in Septic Shock

- IV Hydrocortisone 200-300 mg/day in divided doses should be considered only for adult septic shock patients after adequate fluid resuscitation and vasopressor therapy to maintain blood pressure.
 - ACTH stimulation test should not be used to identify the subset of adults with septic shock who should receive hydrocortisone.
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Glycemic Control in Septic Shock

- Following initial stabilization, patients with severe sepsis and hyperglycemia who are admitted to the ICU should receive intravenous insulin therapy to reduce blood glucose levels to <150 mg/dl
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Recombinant Human Activated Protein C (rhAPC)

- RhAPC may be considered in adult patients with sepsis-induced organ dysfunction associated with a clinical assessment of high risk of death, most of whom will have Acute Physiology and Chronic Health Evaluation (APACHE) II ≥ 25 or multiple organ failure.
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Acute Lung Injury and ARDS

- Target tidal volumes ≤ 6 mL/kg
 - Target plateau pressures ≤ 30 cm water
 - Hypercapnia is allowed
 - ARDSnet protocol
 - Head of bed > 30 degrees
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Blood Products

- In the absence of an oxygen delivery problem, routine transfusion in the ICU unless Hgb < 7
 - Give FFP only for patients with bleeding or planned invasive procedures
 - Give platelets only for counts < 5000 unless bleeding or planned procedure
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Sedation, Analgesia, Neuromuscular Blockade

- Sedation protocols should be used in all ventilated patients
 - Daily weaning trials and daily awakening
 - Neuromuscular blocking agents used sparingly if at all.
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Bicarbonate Therapy

- Bicarbonate therapy should be only be given in severe acidosis ≤ 7.15

DVT and Stress Ulcer Prophylaxis

- DVT prophylaxis with LMWH or UFH should be used. In high risk patient use in conjunction with mechanical compression
 - Stress ulcer prophylaxis with H2RA or PPI should be considered in all ventilated and high risk patients
 - H2RA are preferred
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Consideration of Limitation of Support

- Discuss advance care planning with patients and families. Describe likely outcomes and set realistic expectations.
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Take Home Points

- Think about sepsis and shock early
 - Treat shock early
 - The longer you wait the greater chance the patient will have of dying.
 - Don't wait until the patient is in the ICU to treat
 - Did I mention treat early?
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