The Annual General Pediatric Review & Self-Assessment

CRITICAL CARE

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Miami, FL

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Disclosure of Relevant Relationship

Dr. Totapally has not had (in the past 24 months) any relevant conflicts of interest or relevant financial relationship with the manufacturers of products or services that will be discussed in this CME activity or in his presentation.

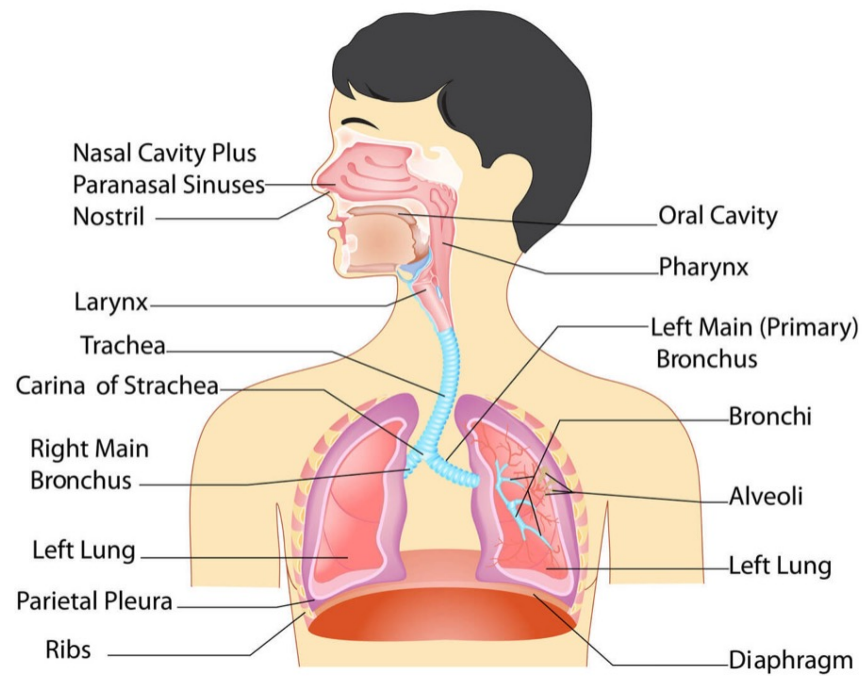
Dr. Totapally will support this presentation and clinical recommendations with the "best available evidence" from medical literature.

Dr. Totapally does not intend to discuss an unapproved/investigative use of a commercial product/device in this presentation.

Objectives

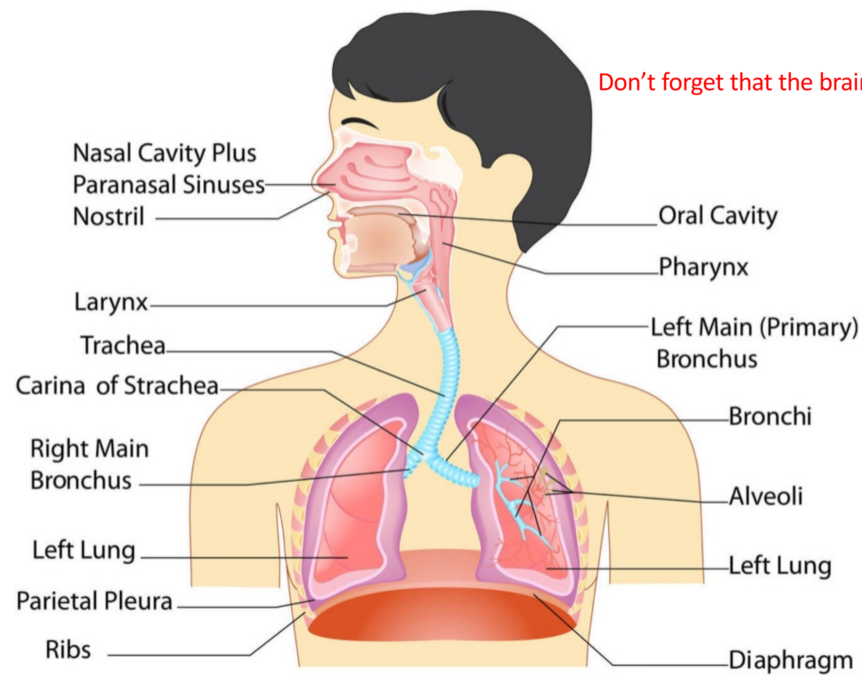
- Understand the definition of respiratory failure
- Recognize the progression to respiratory failure and understand the treatment options
- Understand the definition of shock
- Recognize shock and understand the treatment of its subtypes
- Recognize the common signs and symptoms associated with organ failure

Respiratory System

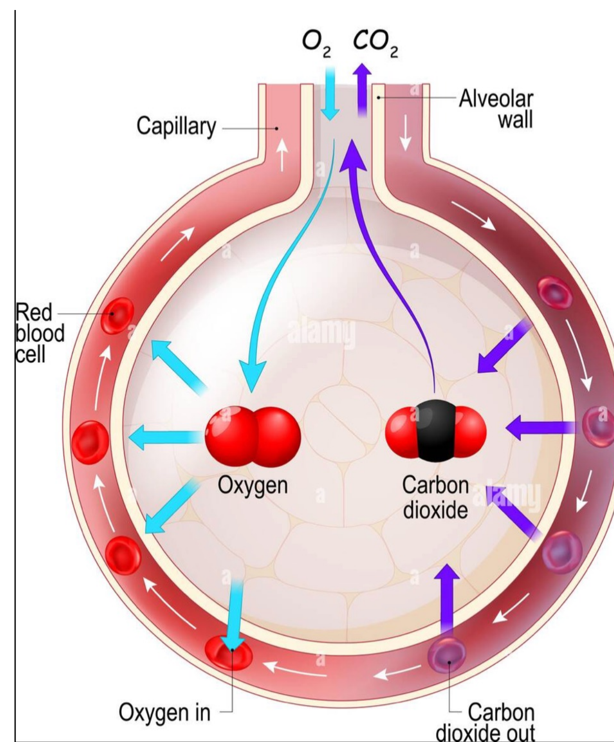


Respiratory System

Don’t forget that the brain is the control center for respirations



Respiratory System - O_2 in and CO_2 out



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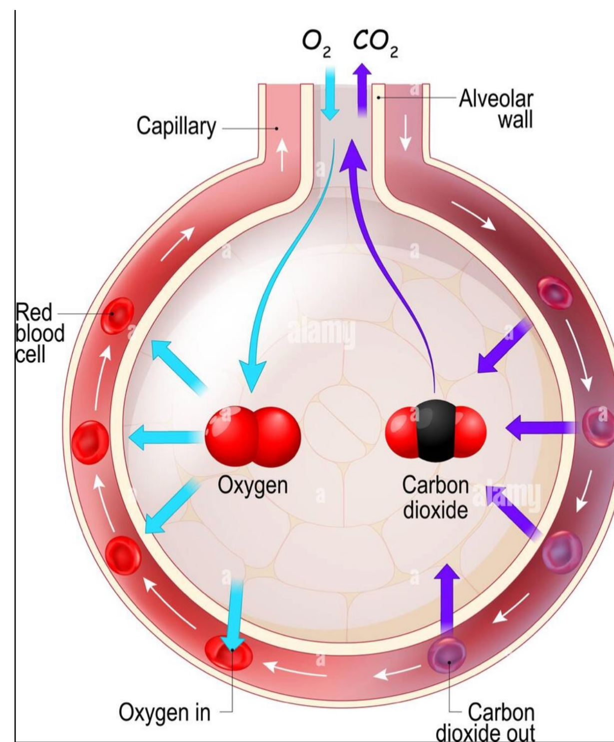
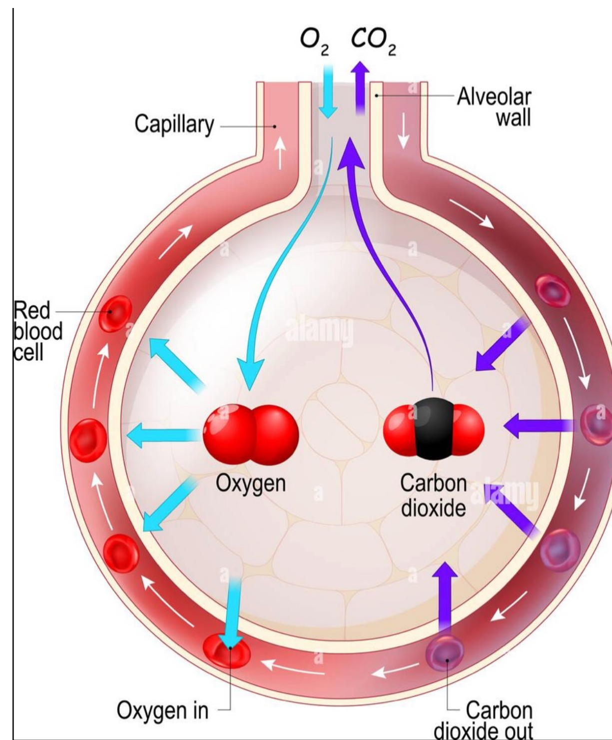


The solubility of CO2 is 20x that of O2

Respiratory System - O_2 in and CO_2 out

A-a gradient = $P_A - P_a$
(normally 10 mm Hg)



Minute ventilation = RR x TV

A patient in room air with hypoventilation will have hypoxemia prior to significant hypercapnia because of the solubility of CO2 versus O2

Acute Respiratory Failure - Definition

- Characterized by the acute inability to oxygenate or ventilate
- Broadly speaking
  - $SpO_2 \leq 90\%$ (PaO2 $\leq$ 60 mmHg)

    And/or
  - $PaCO_2$ or $PcCO_2 \geq 50$ mmHg
- Most common predisposition to cardiac arrest in the pediatric population

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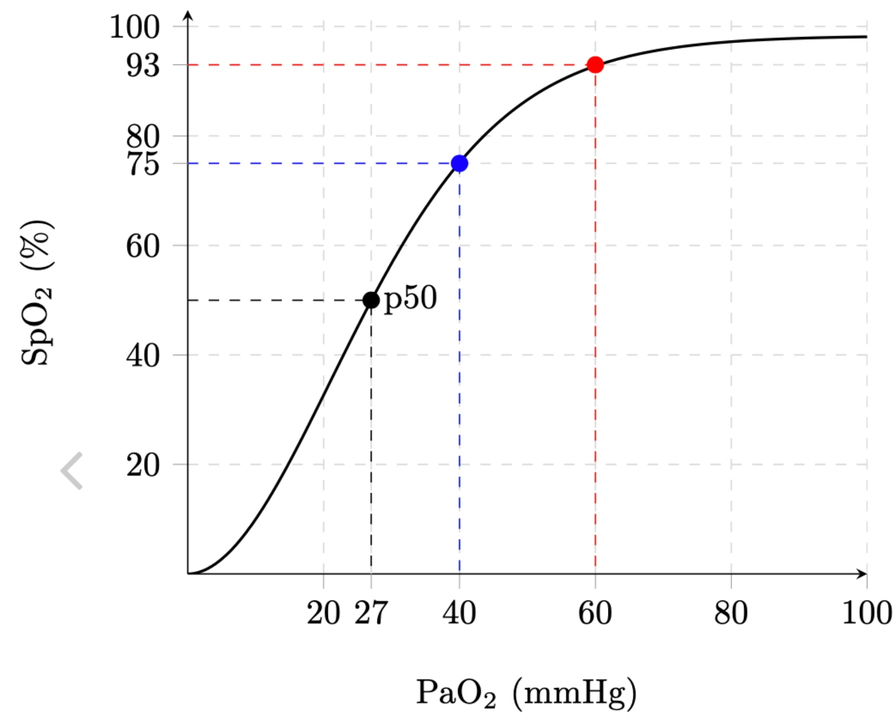
Consider the *relative* relationship of PCO2 to respiratory rate when evaluating a patient for acute respiratory failure – A child with tachypnea and a "normal PCO2" probably has significant V/Q mismatch

Acute Respiratory Failure – Hemoglobin Dissociation Curve



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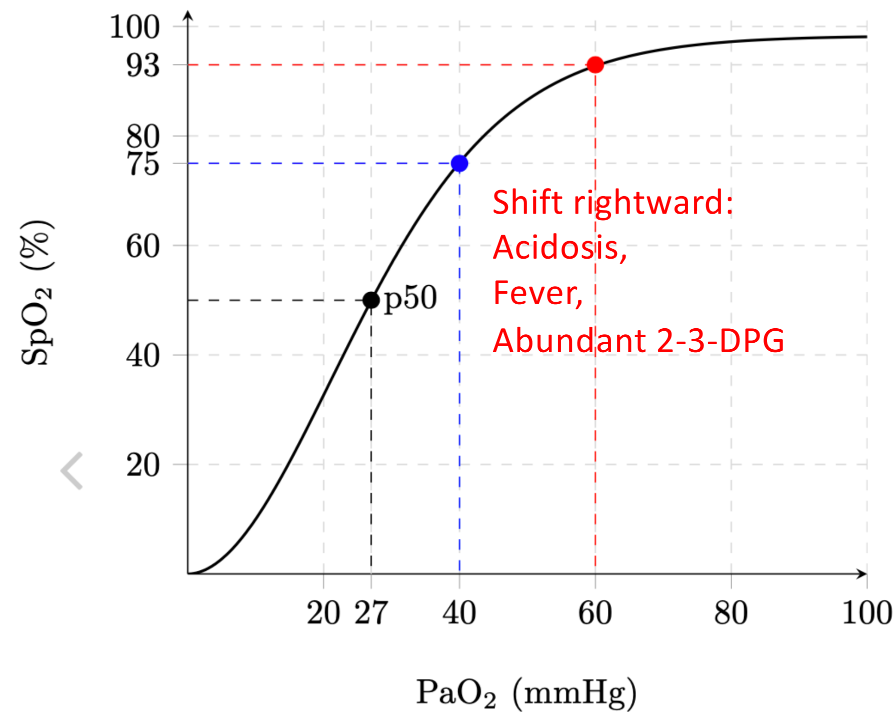

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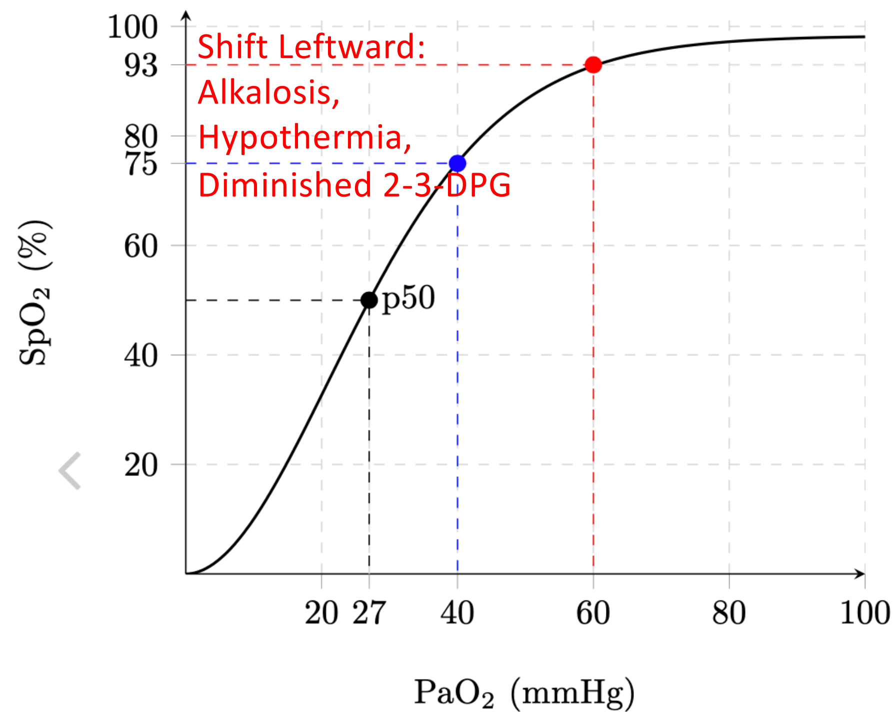
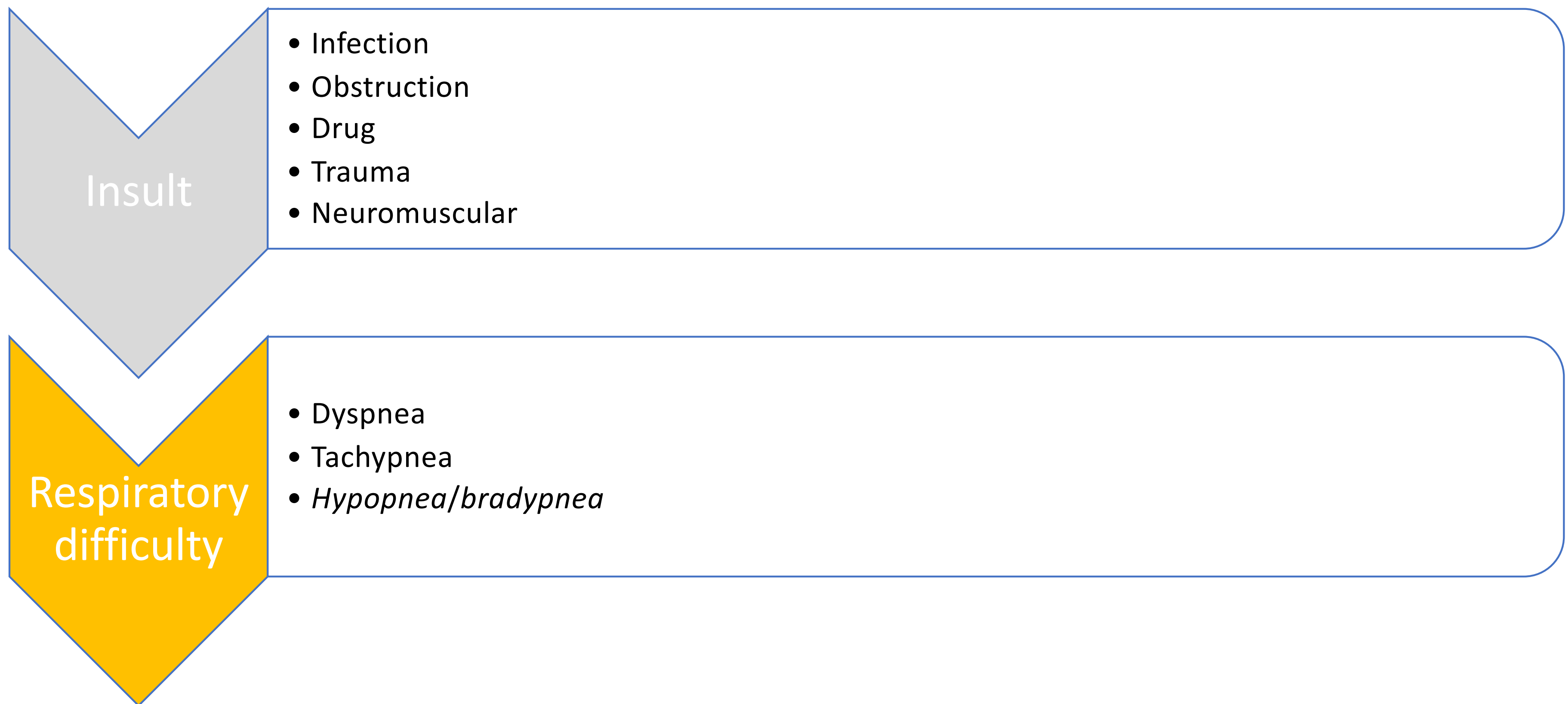


Acute Respiratory Failure - Progression

- Infection
- Obstruction
- Drug
- Trauma
- Neuromuscular

Acute Respiratory Failure - Progression



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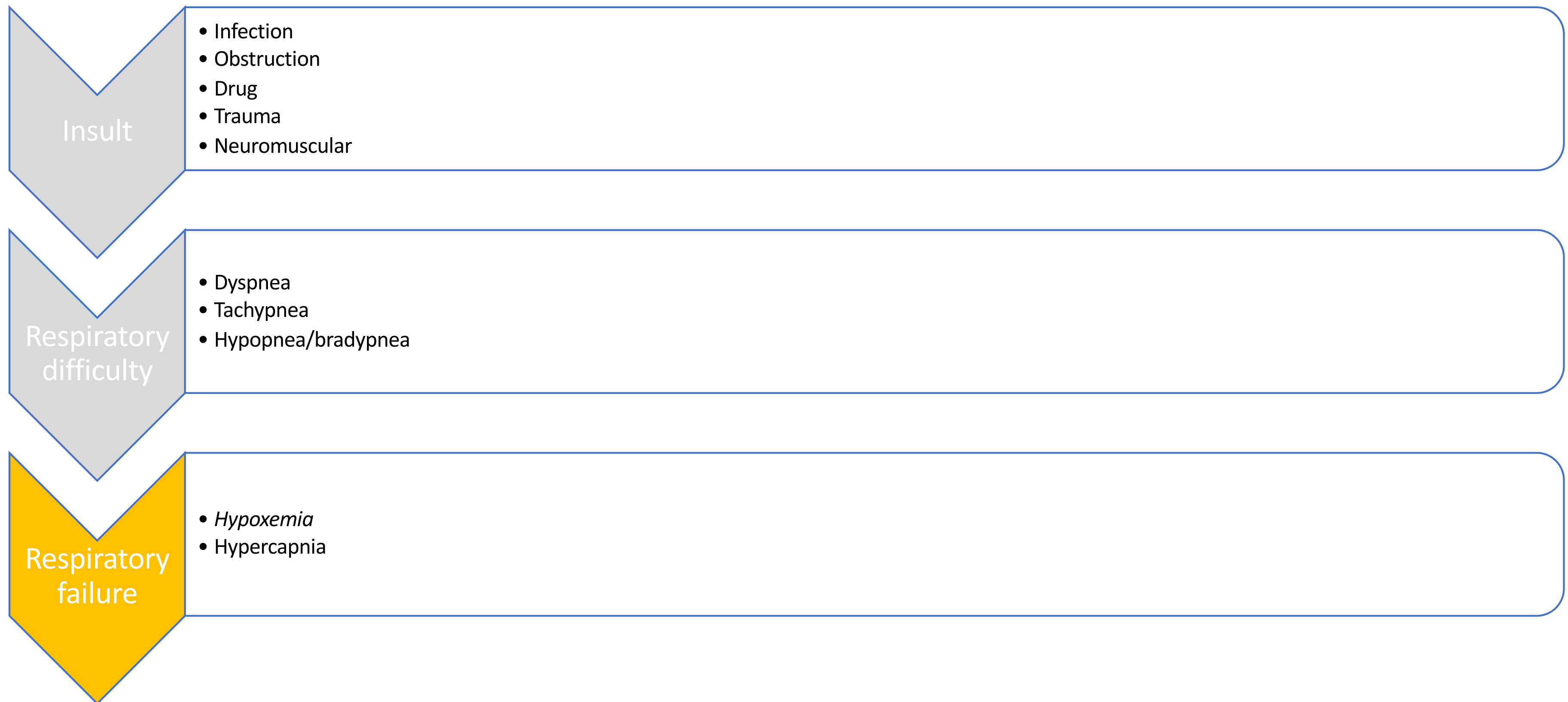

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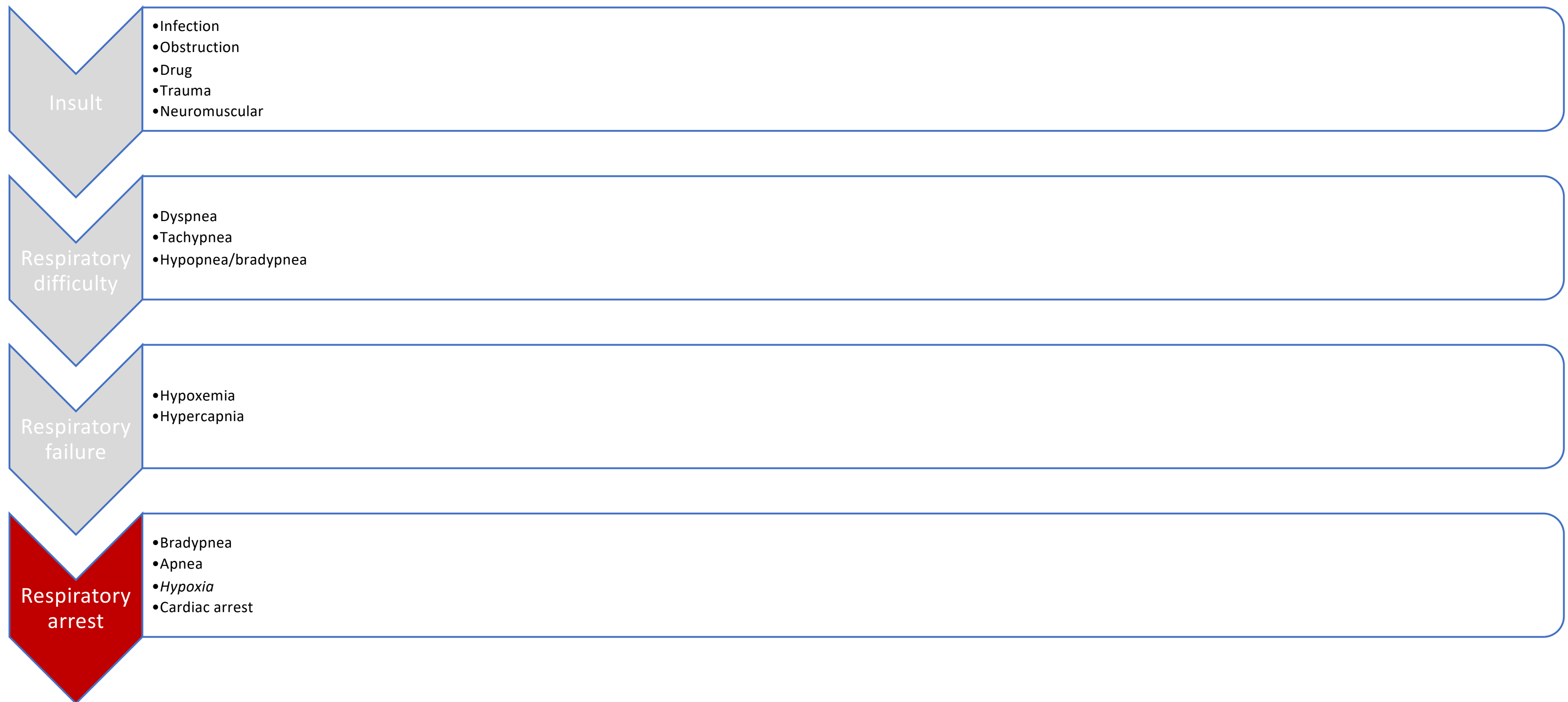

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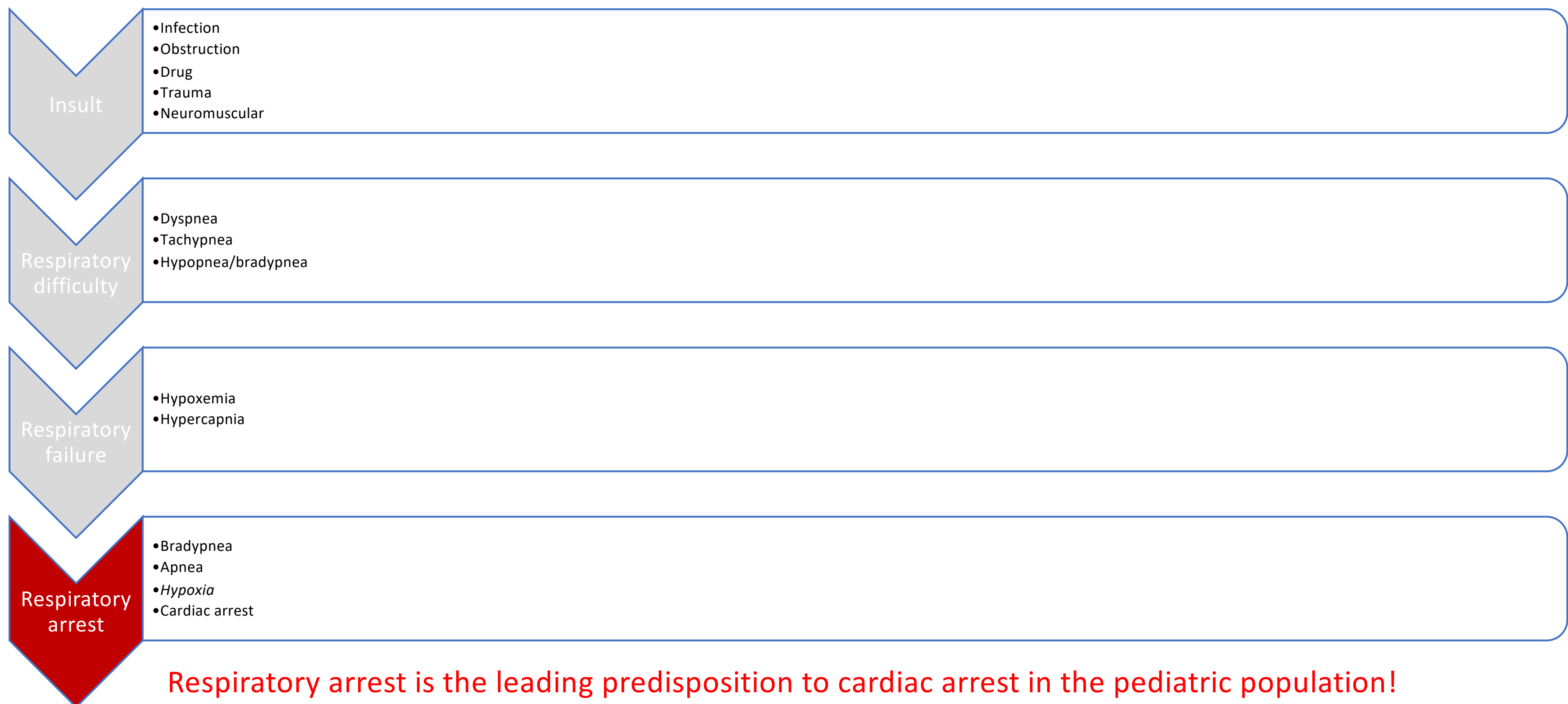
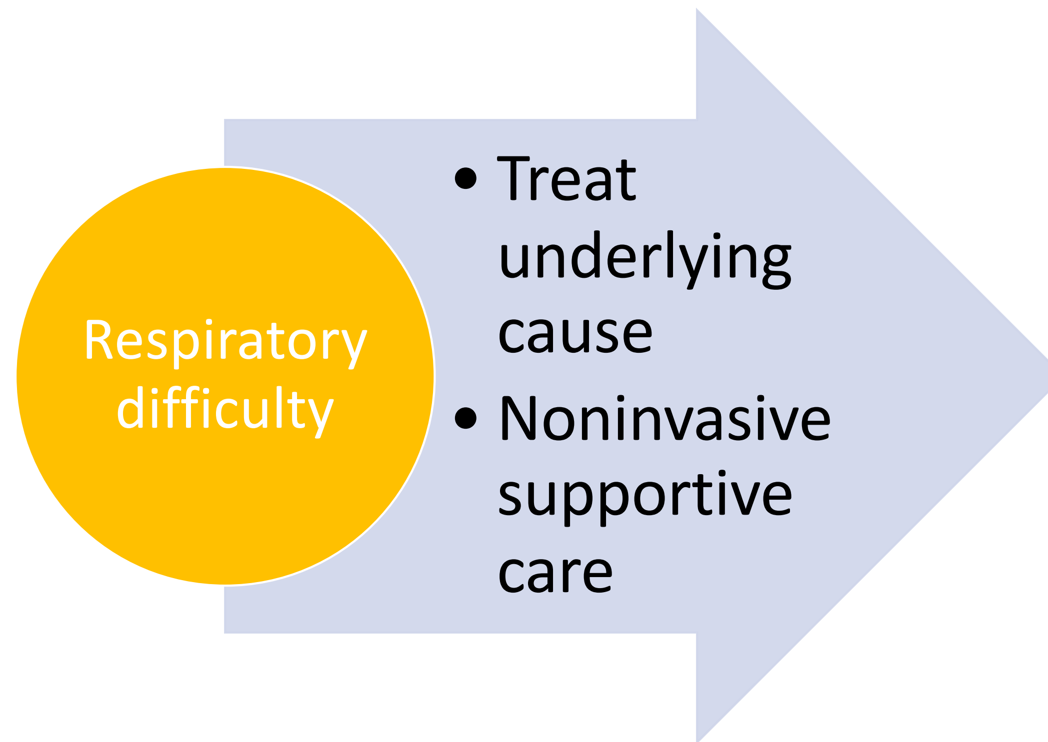


Acute Respiratory Failure - Treatment



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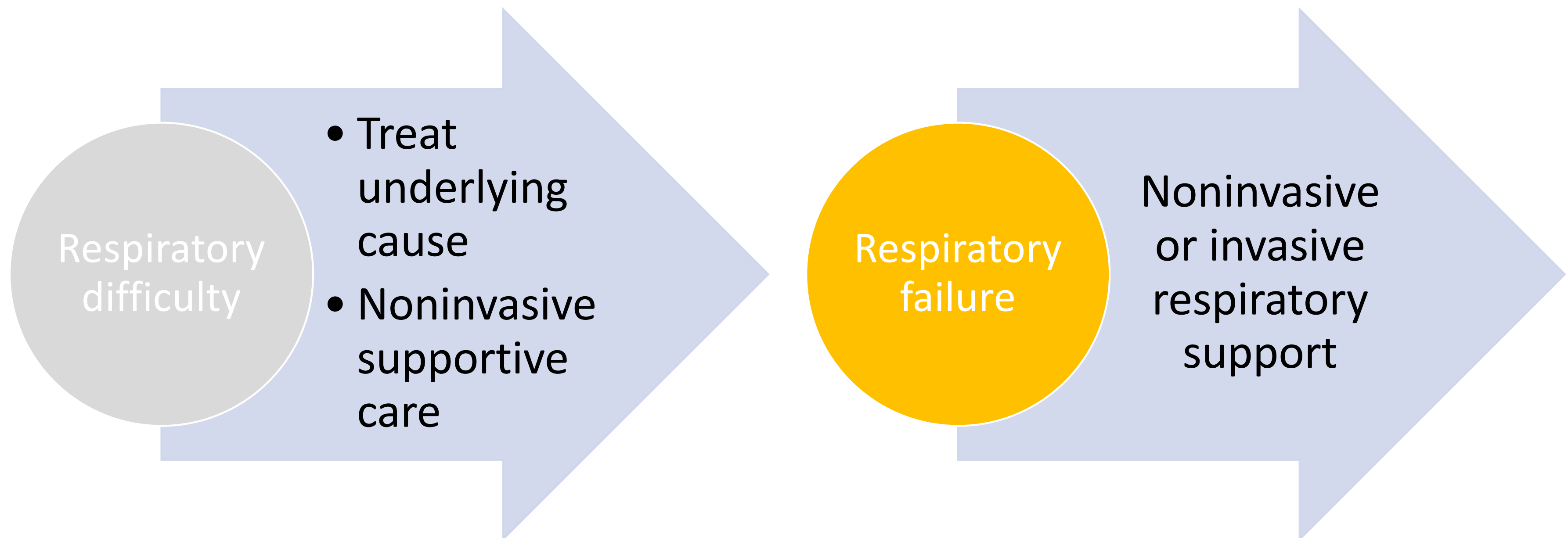

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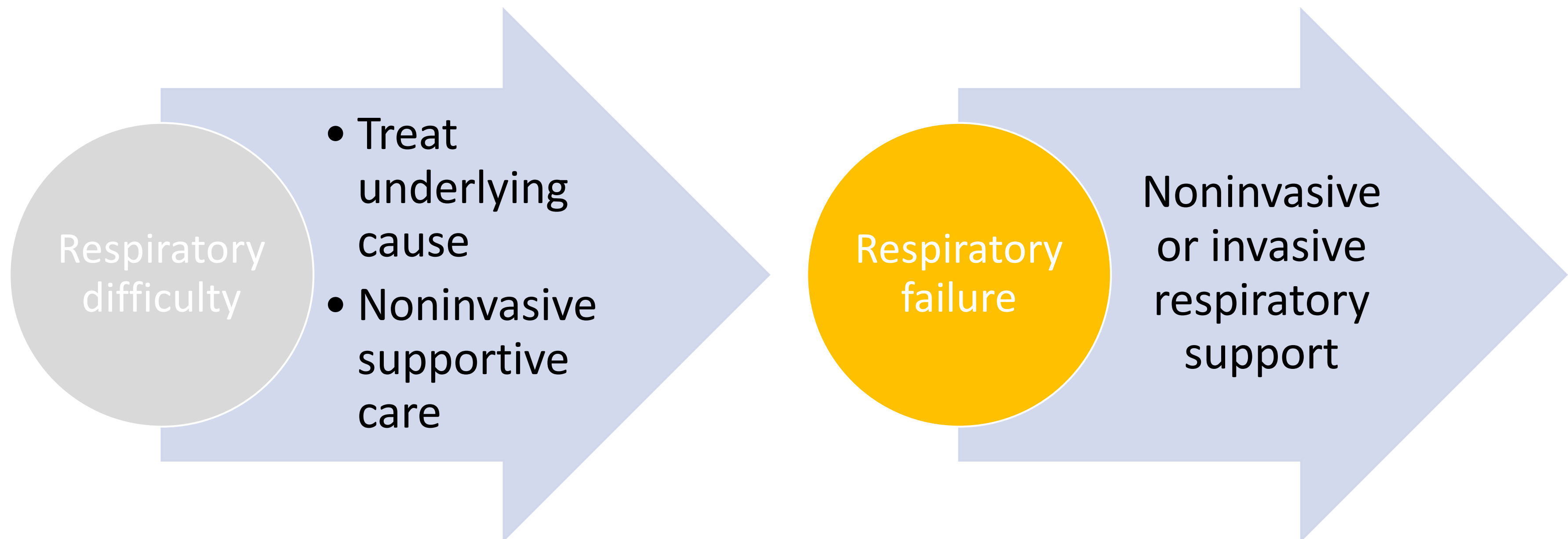
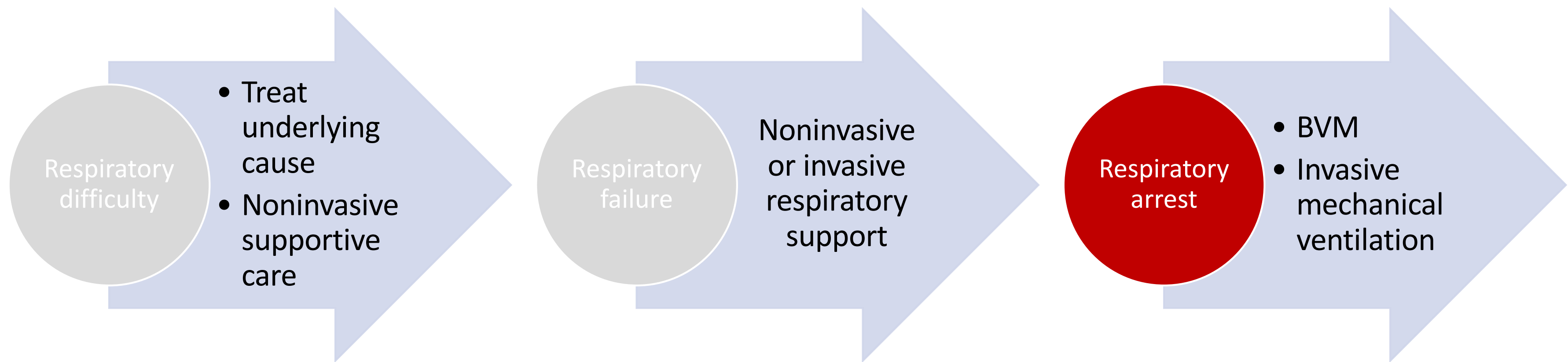


Invasive respiratory support is a clinical decision – primarily one based upon the neurologic state of the patient

Acute Respiratory Failure - Treatment



Acute Respiratory Difficulty - Mimics

- Metabolic acidosis
  - DKA
  - Ingestion/intoxication
  - Infection (non-pulmonary)
  - Metabolic/IEM
  - Renal
- Cardiac disease
- CNS
- Pain
- Anxiety

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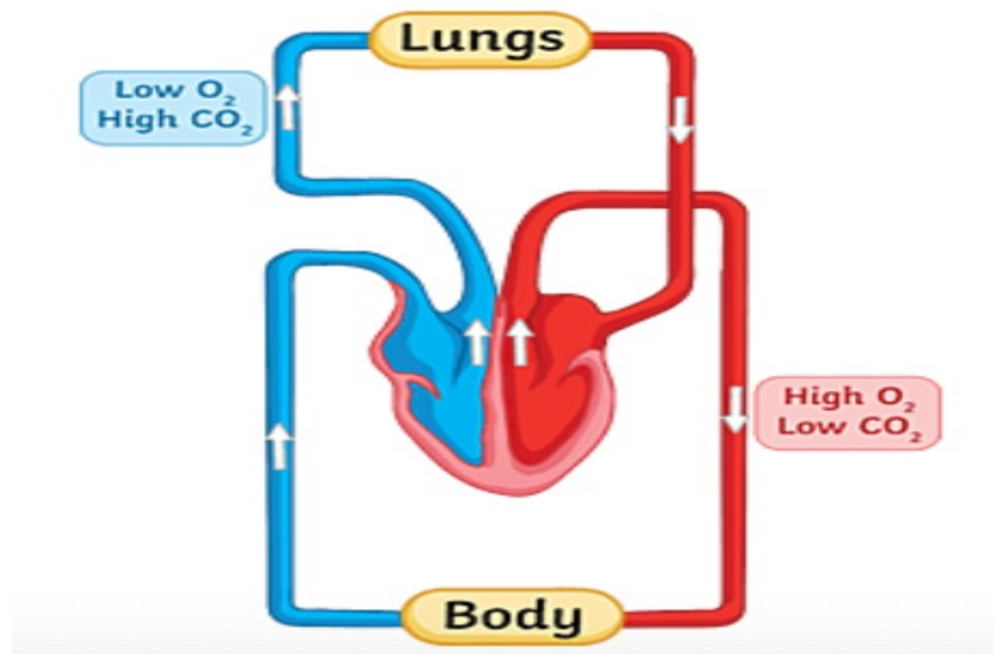
Winters formula: Adjusted $PCO_2 = (HCO_3 \times 1.5 + 8) \pm 2$

Extreme caution with airway management for a child with severe metabolic acidosis.

These children, if neurologically okay and stable, do best by matching their own needs.

If not neurologically well and IMV is necessary then must use Winter's formula to adjust ventilation to meet the metabolic demand (match PCO_2 to HCO_3).

Circulatory System



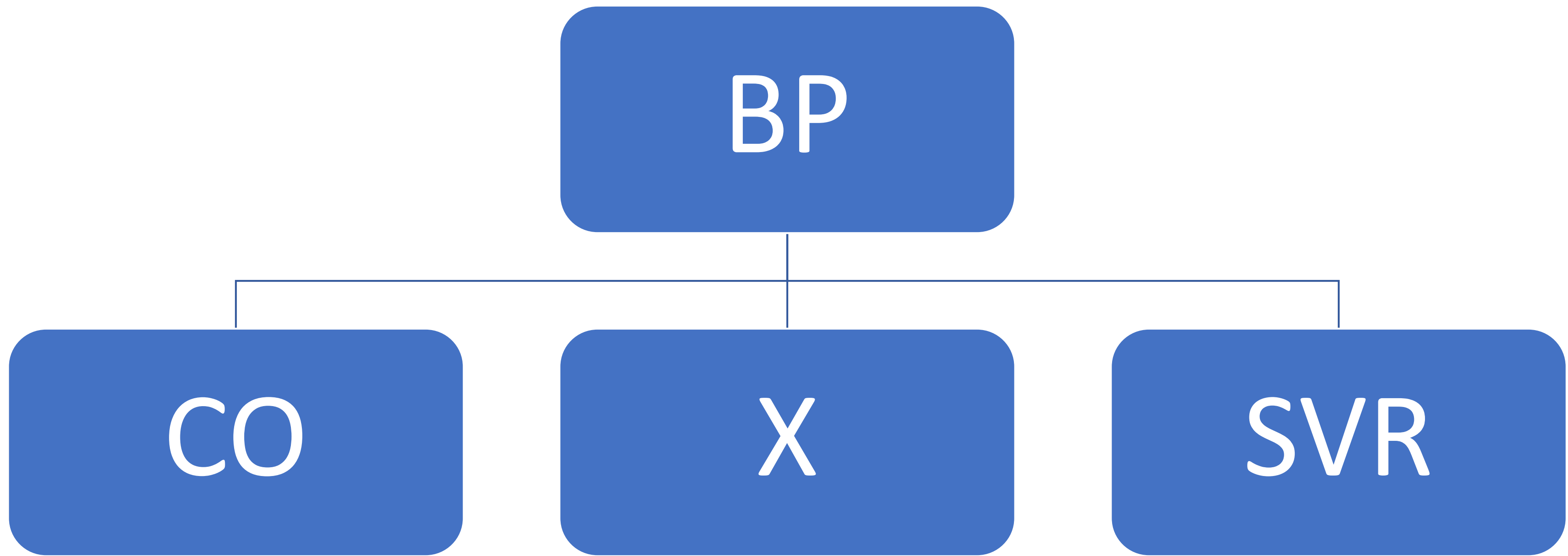
Shock:
Oxygen delivery
vs
Oxygen consumption

DO_2 vs VO_2

Shock - Definition

- Circulatory failure
- The inability of the body to meet the metabolic requirements of end-organs
  - The inability of the circulatory system to *deliver* adequate oxygen
  - The inability of the cells to *extract* adequate oxygen
- *Compensated* versus *Uncompensated*

Blood Pressure



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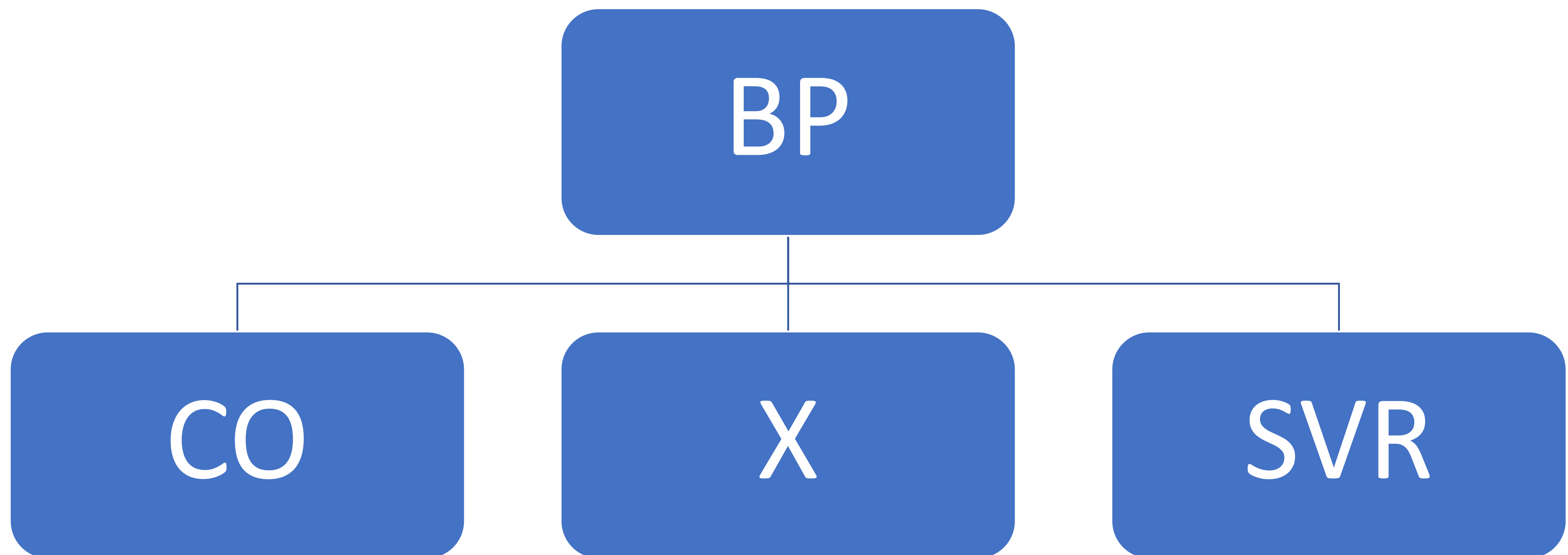
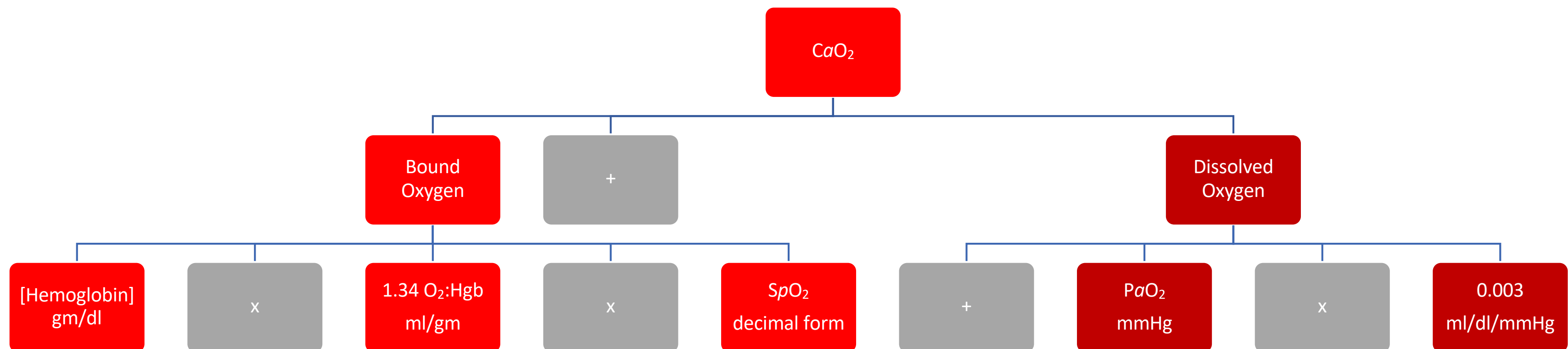


BP may be preserved (compensated shock) because CO and SVR can compensate for each other

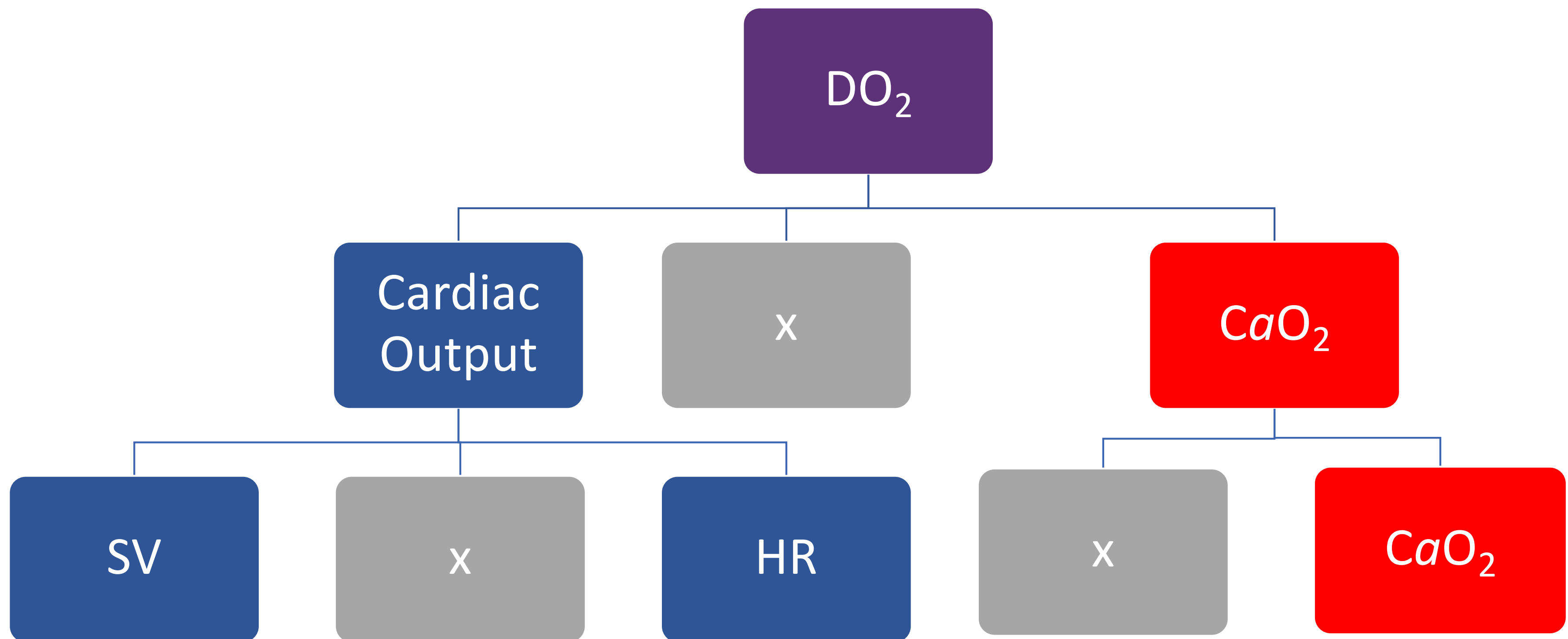
Oxygen Delivery

$DO_2 = CO \times C_aO_2$

Shock – Arterial Oxygen Content



Shock – Oxygen Delivery



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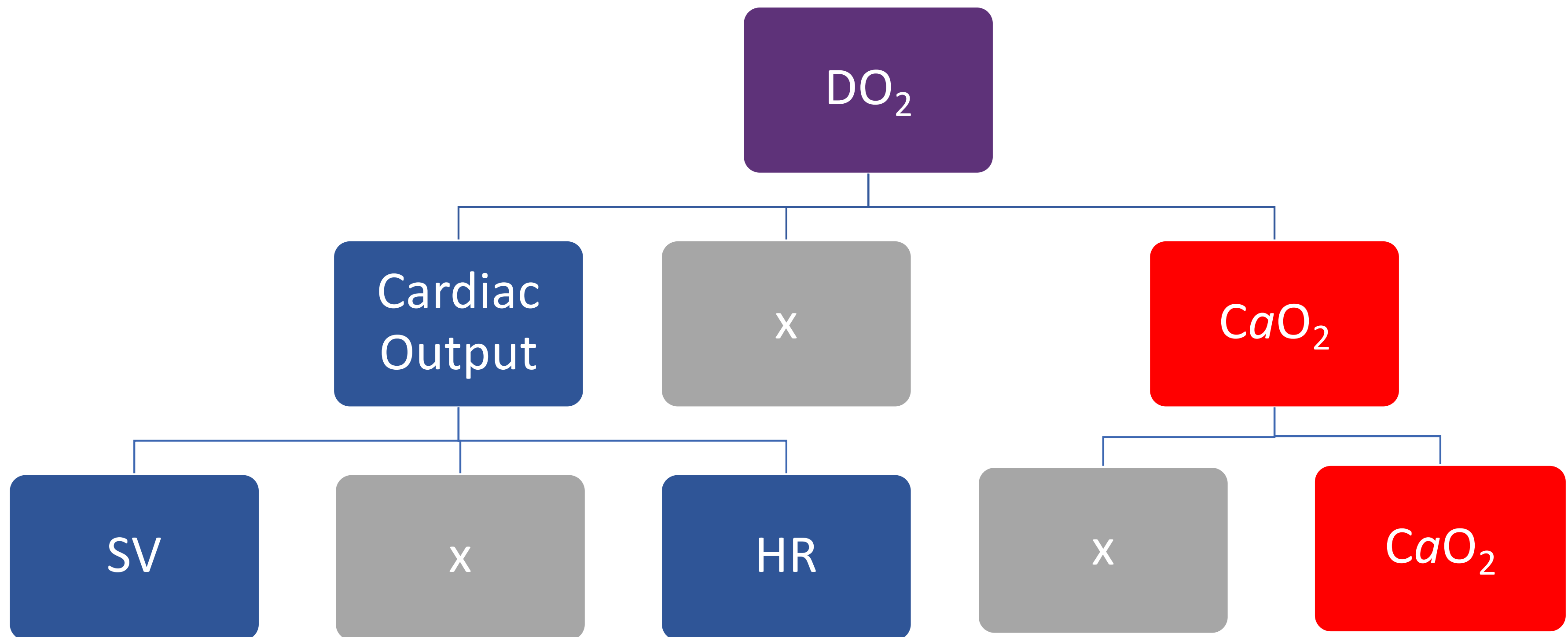
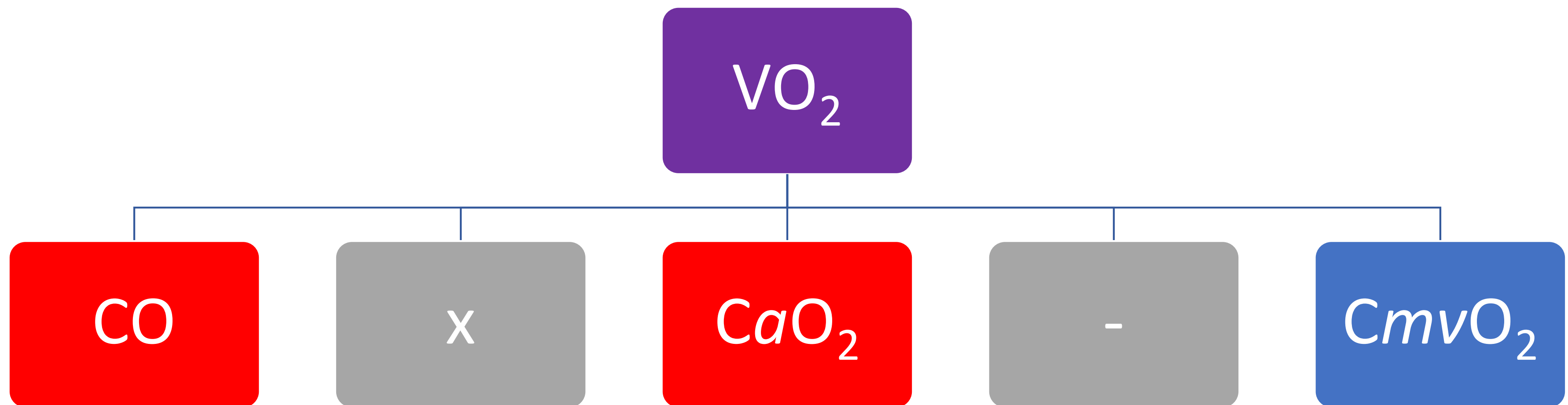


Means to increase DO2: fluids, inotropes, chronotropes, PRBC transfusion, supplemental oxygen, positive pressure ventilation

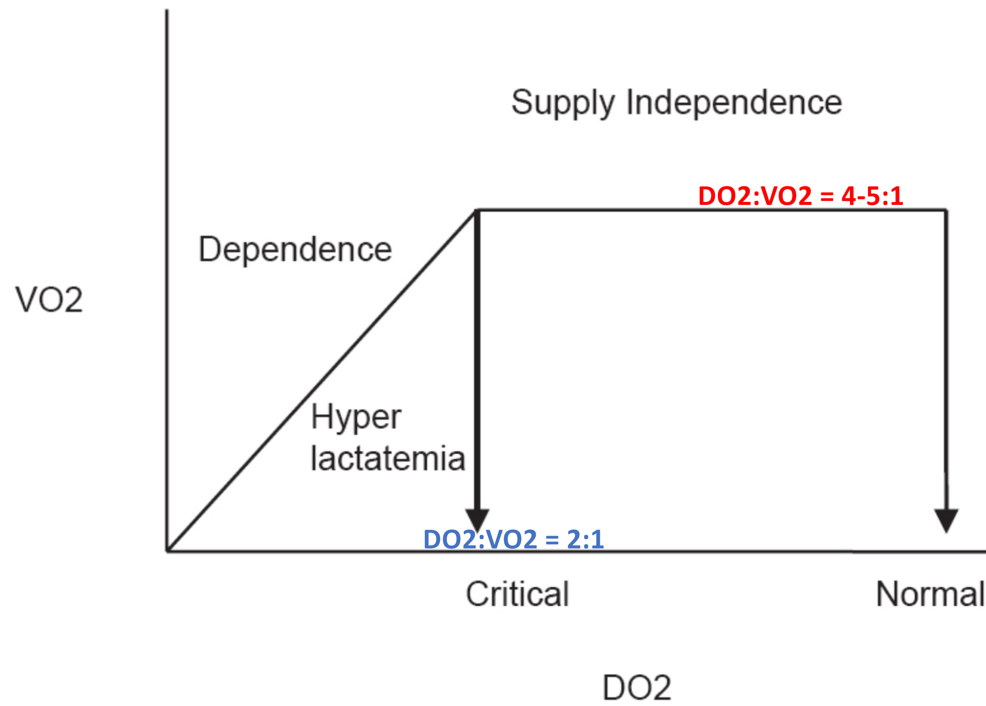
Oxygen Consumption

$VO2 = CO \times (C_{a}O2 - C_{mv}O2)$

Shock – Oxygen Consumption



Shock – VO_2 versus DO_2



Shock - Hypovolemic

- Most common type of shock in pediatric population
- History
  - Increased fluid loss and/or decreased fluid intake
  - Diminished urine production
  - Blood loss
  - Trauma
- Signs
  - Diminished peripheral perfusion, cool extremities
  - Dry mucous membranes
  - Weight loss
- Treatment
  - Fluids
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- Treatment
  - Fluids
  - Fluids — Improve SV to increase CO and thereby increase DO2 to tissues
  - Fluids

Shock - Distributive

- History
  - Fever, rash (infection)
  - Sudden onset, rash, pruritis, dyspnea, dysphagia (anaphylaxis)
  - Trauma (neurogenic)
- Signs
  - Fever, rash
  - Warm extremities with flash capillary refill
  - Cool extremities with delayed capillary refill
  - Rash (urticaria), wheezing
  - Evidence of trauma, bradycardia (relative)

Septic Shock - Treatment

- Fluids
  - Up to 60 ml/kg within 15 – 60 minutes
- Antibiotics
  - Within one hour of presentation
- Vasopressor +/- epinephrine or norepinephrine
  - If hypotension persists despite fluid resuscitation
- Hydrocortisone +/-
  - If hypotensive despite vasoactive medication or if hypoglycemic

Septic Shock - Treatment

- Fluids Improve SV to increase CO to increase DO_2
  - Up to 60 ml/kg within 15 – 60 minutes
- Antibiotics
  - Within one hour of presentation
- Vasopressor +/- epinephrine or norepinephrine Increase SVR if necessary to increase BP OR Increase CO if cardiac dysfunction
  - If hypotension persists despite fluid resuscitation
- Hydrocortisone +/-
  - If hypotensive despite vasoactive medication or if hypoglycemic

Anaphylactic Shock – Treatment

- Manage airway
- Beta-adrenergic (aerosolized)
- Epinephrine IM
- Antihistamine
- Steroid IV
- Fluids
- Vasopressor +/- epinephrine

Anaphylactic Shock – Treatment

- Manage airway
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- Steroid IV
- Fluids
- Vasopressor +/- epinephrine

Neurogenic Shock - Treatment

- Maintain in-line cervical stabilization and protect spine
- Manage airway
- Fluids
- Vasopressor - norepinephrine or phenylephrine (via central line)

  Increase SVR to increase BP

Shock - Cardiogenic

- History
  - Neonate, infant
  - Poor feeding
  - Diaphoresis
  - Suboptimal weight gain (or weight loss)
  - Underlying history of cardiac disease
- Signs
  - Tachypnea
  - Crackles or wheezes
  - Cool extremities with delayed capillary refill
  - Hepatomegaly

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  - Cool extremities with delayed capillary refill
  - Hepatomegaly

Reconsider diagnosis of bronchiolitis for the infant whose condition worsens despite appropriate supportive care!

Cardiogenic Shock – Treatment

- Cautious fluid resuscitation
- Prostaglandin E_1 (neonate, infant)
- Vasoactive medication +/- low-dose epinephrine or dobutamine
- Manage airway
- Positive pressure ventilation +/-
- Prepare for eCPR

Shock - Dissociative

- Pathologic state heralded by a failure of oxygen extraction at the cellular level
- Infection
  - May be related to *sepsis* – cellular dysregulation
- Fire or burn victim
  - May be secondary to *toxin* – cellular poisoning – cyanide toxicity
- Ingestion
  - Aspirin, cyanide

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Antidote is the remedy for cyanide

Alkalization of urine and/or hemodialysis for aspirin toxicity

Shock – Obstructive - neonate

- Rarest form of shock
- In neonates – usually occurs secondary to ductal dependent lesion
  - Coarctation
  - Valvular atresia
- Prostaglandin E_1 to preserve ductal-dependent circulation:
  - Systemic – AV, MV atresia
  - Pulmonary – PV, TV atresia

Shock – Obstructive – non-neonate

- In children and adults - usually occurs secondary to saddle pulmonary embolus or cardiac tamponade
  - May be associated with trauma, malignancy, prolonged period of immobility, or central line
- Emergent treatment includes fluid resuscitation and vasopressor until underlying condition can be corrected
- Thrombolytic medication is an option if high index of suspicion for pulmonary embolus
- Pericardiocentesis emergently if pericardial effusion is suspected

Organ Failure - Definition

- The inability of an organ to perform in its usual, expected capacity
- Single organ
  - Most commonly encountered
  - Good prognosis
- Multiple organs ($\geq$ 2 systems)
  - Worse prognosis especially as more systems become involved

Organ Failure - Brain

- Altered mental status
- Glasgow Coma Scale
  - 15 – Best
  - 3 – "Just for showing up"

<table>
<tr><th colspan="5">PEDIATRIC GLASGOW COMA SCALE (PGCS)</th></tr>
<tr><th></th><th colspan="2">> 1 Year</th><th>< 1 Year</th><th>Score</th></tr>
<tr><td rowspan="4">EYE OPENING</td><td colspan="2">Spontaneously</td><td>Spontaneously</td><td>4</td></tr>
<tr><td colspan="2">To verbal command</td><td>To shout</td><td>3</td></tr>
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<tr><td rowspan="5">VERBAL RESPONSE</td><td>Oriented</td><td>Appropriate words/phrases</td><td>Smiles/coos appropriately</td><td>5</td></tr>
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Organ Failure - Brain

- Altered mental status
- Glasgow Coma Scale
  - 15 – Best
  - 3 – "Just for showing up"

In general, for GCS equal to or less than 8, consider endotracheal intubation

PEDIATRIC GLASGOW COMA SCALE (PGCS)				
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	No response	No response	No response	1
			TOTAL PEDIATRIC GLASGOW COMA SCORE (3-15):	

Organ Failure – Acute Kidney Injury

- Rise in serum creatinine (increase by 0.3 mg/dl)
- Cystatin-C is a better predictor than sCr, but not in neonate/infant
- Diminished urine production (less than 0.5 ml/kg/hr)
- Uremia
- Metabolic acidosis
- Fluid retention
- Hypertension

Organ Failure – Acute Liver Injury

- Diminished synthetic function
    - PT prolonged, INR increased
    - Hypoalbuminemia
- Diminished metabolic function
    - Hyperammonemia
    - Metabolic acidosis
    - Hypoglycemia
    - Jaundice
- Other symptoms
    - Bleeding
    - Pruritis
    - Altered mental status

Organ Failure - Hematologic

- Bone marrow failure
  - Anemia, leukopenia, thrombocytopenia
- Endothelial activation (failure)
  - Platelet activation
  - Platelet aggregation in the microcirculation (thrombocytopenia)
  - Stasis of blood flow in the microcirculation
  - Impaired perfusion to end organs
  - Consumptive coagulopathy
  - WBC aggregation

Organ Failure - Treatment

- Recognize impending organ failure
- Activate Rapid Response Team early
- Escalate level of care urgently if necessary
- Supportive care acutely as necessary
- Definitive care as soon as the diagnosis has been established

Thank You