Chapter 9: Acid Base Balance

Ashleigh N. Rushing, MD and C. Lydia Wraight, MD

A. Blood Gases

- pH, pCO_2, pO_2 are measured directly
- HCO_3, O_2 saturation are calculated

Normal Blood Gas Values	
pH	7.35-7.45
pCO_2	35-45*
HCO_3	22-26
Base Excess	-1 to -3

* For infants ventilated > 7 days, permissive hypercapnea (pCO_2 45-60) is accepted to decrease barotrauma.

- Acid-base balance is maintained with buffers

$$HCO_3^- + H^+ \longleftrightarrow H_2CO_3 \longleftrightarrow H_2O + CO_2$$

B. Interpretation of blood gases

- **Step 1:** Is the pH acidic or basic?

pH < 7.35	Acidosis
pH > 7.45	Alkalosis

- **Step 2:** Is the disturbance respiratory or metabolic? Look at pCO_2.
  - Respiratory = pH and pCO_2 change in **opposite** directions
  - Metabolic = pH and pCO_2 change in the **same** direction

	Acidosis		Alkalosis	
	pH	*pCO_2*	*pH*	*pCO_2*
Respiratory	↓	↑	↑	↓
Metabolic	↓	↓	↑	↑

- **Step 3:** Is there compensation?
  - Compensation occurs to bring the pH closer to normal when the derangement is chronic, it will not correct the pH to normal.

	Acute		Compensation	
	pCO_2	HCO_3	pCO_2	HCO_3
Respiratory Alkalosis	< 40	normal	< 40	low
Respiratory Acidosis	> 40	normal	> 40	high
Metabolic Alkalosis	normal	> 26	> 40	> 26
Metabolic Acidosis	normal	< 22	< 40	< 22

- **Step 4:** Is there an anion gap?

$$\text{Anion Gap} = [Na+] - ([Cl-] + [HCO_3])$$

  – Normal anion gap < 15 mEq/L

C. Respiratory Acidosis

- Most common cause of acidosis
- Poor ventilation results in CO_2 retention (CO_2 is high)

D. Respiratory Alkalosis

- Often iatrogenic, resulting from hyperventilation (ie we are giving the baby more support than they need)

E. Metabolic Acidosis

- Results from excess acid production or increased loss of base.
- **Normal anion gap:**
  - Renal: Immaturity, Renal Tubular Acidosis, Obstruction, Dysplasia
  - GI: Diarrhea, Short Gut

- Endo: Congenital Adrenal Hyperplasia
- High Protein Formula
- Administration of Cl- containing compounds:
  - TPN, NH_4Cl, $CaCl_2$ especially in ELBW
- Compensation of respiratory alkalosis

- **Increased anion gap:**
  - Lactic acidosis: Shock with poor tissue perfusion and oxygenation
  - Acute renal failure
  - Inborn errors of metabolism: Organic acidemias, mitochondrial disorders, glycogen storage disease (type 1), galactosemia
  - Toxins
- **Systemic effects of Metabolic Acidosis:**
  - Pulmonary vasoconstriction (Pulmonary hypertension)
  - Decreased myocardial contractility
  - Respiratory compensation: Increased work of breathing
  - CNS damage with severe acidosis
- **Management**
  - Treat the underlying cause when possible
  - TPN associated mild acidosis may be treated with decreasing chloride and increasing acetate for a few days.
  - Volume expansion if signs of hypovolemia
    - Excessive volume expansion is poorly tolerated in presence of decreased myocardial contractility
    - May use normal saline, packed RBCs or FFP as appropriate
  - Pharmacologic options
    - $NaHCO_3$
      - Only use when infant has excellent ventilation
      - Risks of $NaHCO_3$ administration

- Acute expansion of intravascular volume with risk of IVH
- Shift of Hgb dissociation curve to left (↑ binding of O_2 to Hgb)
- Increased Na load and increased CO_2

- THAM – an organic buffer
  - Can consider with severe acidosis with Na overload and high CO_2/poor ventilation
  - Associated with risk of apnea and hypoglycemia and is not as effective

F. Metabolic Alkalosis

- Commonly iatrogenic, resulting from diuretic use (ex: furosemide)
- Other etiologies:
  - Loss of gastric fluid: large gastric aspirates, emesis or diarrhea with Cl^- loss
  - Compensation for chronic respiratory acidosis
  - Excessive administration of alkali (acetate in TPN)
- **Management**
  - Replace Cl- deficit, remove any acetate in TPN
  - Replace ongoing fluid and electrolyte losses
  - Adjust ventilator if respiratory acidosis

eferences:

1. Brodsky, D. and Martin, C. **Acid Base Balance**. *Neonatology Review 3rd Ed.* 2020.Vol 4: 34-3.