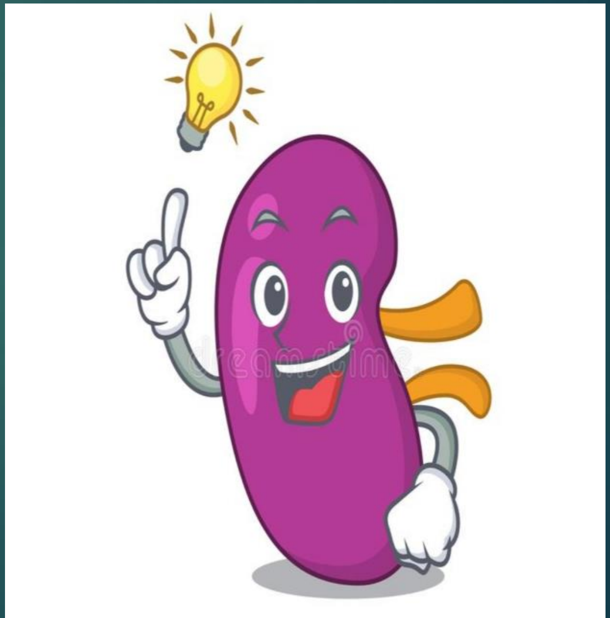
ACID-BASE DISORDERS IN PEDIATRICS



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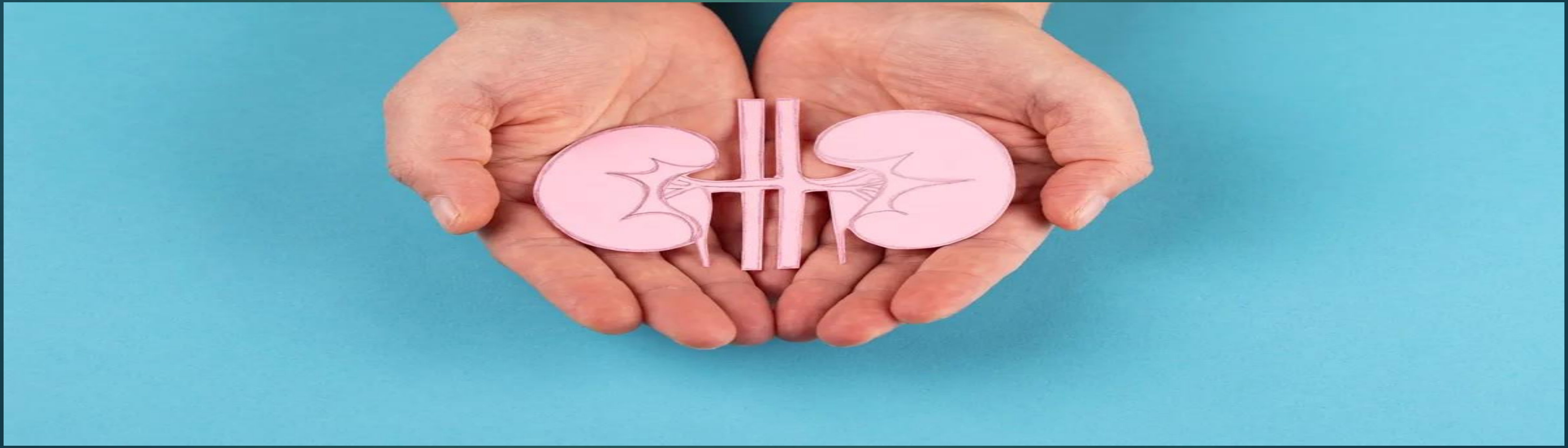

ABG Interpretation

- First, does the patient have an acidosis or an alkalosis
- Second, what is the primary problem – metabolic or respiratory
- Third, is there any compensation by the patient – respiratory compensation is immediate while renal compensation takes time.

- It would be extremely unusual for either the respiratory or renal system to overcompensate
- The pH determines the primary problem
- After determining the primary and compensatory acid/base balance, evaluate the effectiveness of oxygenation

Normal Values

- pH 7.35 to 7.45.
- paCO_2 36 to 44 mm Hg.
- HCO_3 22 to 26 meq/L.

Abnormal Values :

- pH < 7.35 .. Acidosis (metabolic and/or respiratory)
- pH > 7.45 .. Alkalosis (metabolic and/or respiratory)
- $paCO_2$ > 44 mmHg .. Respiratory acidosis (alveolar hypoventilation)
- $paCO_2$ < 36 mmHg .. Respiratory alkalosis (alveolar hyperventilation)
- HCO_3 < 22 meq/L .. Metabolic acidosis
- HCO_3 > 26 meq/L .. Metabolic alkalosis

Putting It Together

- Respiratory

- $paCO_2 > 44$ with a $pH < 7.35$ represents a respiratory acidosis
- $paCO_2 < 36$ with a $pH > 7.45$ represents a respiratory alkalosis
- For a primary respiratory problem, pH and $paCO_2$ move in the opposite direction
- For each deviation in $paCO_2$ of 10 mm Hg in either direction, 0. 08 pH units change in the opposite direction.

Putting It Together

- Metabolic

- $HCO_3 < 22$ with a $pH < 7.35$ represents a metabolic acidosis
- $HCO_3 > 26$ with a $pH > 7.45$ represents a metabolic alkalosis
- For a primary metabolic problem, pH and HCO_3 are in the same direction, and $paCO_2$ is also in the same direction

Compensation

The body's attempt to return the acid/base status to normal (i.e. pH closer to 7.4)

Primary Problem	Compensation
respiratory acidosis	metabolic alkalosis
respiratory alkalosis	metabolic acidosis
metabolic acidosis	respiratory alkalosis
metabolic alkalosis	respiratory acidosis

Expected Compensation

Respiratory acidosis

- Acute

-- the pH decreases 0.08 units for every 10 mm Hg increase in $paCO_2$.

-- HCO_3 ↑0.1-1 mEq/liter per ↑10 mm Hg $paCO_2$

- Chronic

– the pH decreases 0.03 units for every 10 mm Hg increase in$paCO_2$

-- HCO_3 ↑1.1-3.5 mEq/liter per ↑10 mm Hg $paCO_2$

Expected Compensation

Respiratory alkalosis

- Acute
  – the pH increases 0.08 units for every 10 mm Hg decrease in $paCO_2$
  -- HCO_3 ↓0-2 mEq/liter per ↓10 mm Hg $paCO_2$
- Chronic
  – the pH increases 0.17 units for every 10 mm Hg decrease in $paCO_2$
  --HCO_3 ↓2.1-5 mEq/liter per ↓10 mm Hg $paCO_2$

Expected Compensation

- Metabolic acidosis

$paCO_2 = 1.5(HCO_3) + 8\ (\pm 2)$

$paCO_2$ ↓1-1.5 per ↓1 mEq/liter HCO_3

- Metabolic alkalosis

$paCO_2 = 0.7(HCO_3) + 20\ (\pm 1.5)$

$paCO_2$ ↑0.5-1.0 per ↑1 mEq/liter HCO_3

Classification of primary acid-base disturbances and compensation

Acceptable ventilatory and metabolic acid-base status

- Respiratory acidosis (alveolar hypoventilation) – acute, chronic
- Respiratory alkalosis (alveolar hyperventilation)-- acute, chronic
- Metabolic acidosis – uncompensated, compensated
- Metabolic alkalosis – uncompensated, partially compensated

Acute Respiratory Acidosis

- $paCO_2$ is elevated and pH is acidotic
- The decrease in pH is accounted for entirely by the increase in $paCO_2$
- Bicarbonate and base excess will be in the normal range because the kidneys have not had adequate time to establish effective compensatory mechanisms

Acute Respiratory Acidosis

Causes

- Respiratory pathophysiology - airway obstruction, severe pneumonia, chest trauma/pneumothorax
- Acute drug intoxication (narcotics, sedatives)
- Residual neuromuscular blockade
- CNS disease (head trauma).

Chronic Respiratory Acidosis

- $paCO_2$ is elevated with a pH in the acceptable range
- Renal mechanisms increase the excretion of H^+ within 24 hours and may correct the resulting acidosis caused by chronic retention of CO_2 to a certain extent

Chronic Respiratory Acidosis

Causes

- Chronic lung disease (BPD, COPD)
- Neuromuscular disease
- Extreme obesity
- Chest wall deformity.

Acute Respiratory Alkalosis

- paCO2 is low and the pH is alkalotic
- The increase in pH is accounted for entirely by the decrease in paCO2.
- Bicarbonate and base excess will be in the normal range because the kidneys have not had sufficient time to establish effective compensatory mechanisms.

Respiratory Alkalosis

Causes

- Pain
- Anxiety
- Hypoxemia
- Restrictive lung disease
- Severe congestive heart failure
- Pulmonary emboli
- Drugs
- Sepsis
- Fever
- Thyrotoxicosis
- Pregnancy
- Overaggressive
- mechanical ventilation
- Hepatic failure

Uncompensated Metabolic Acidosis

- Normal $paCO_2$ low HCO_3 and a pH less than 7.30
- Occurs as a result of increased production of acids and/or failure to eliminate these acids
- Respiratory system is not compensating by increasing alveolar ventilation (hyperventilation)

Compensated Metabolic Acidosis

- $paCO_2$ less than 30, low HCO_3 with a pH of 7.3-7.4
- Patients with chronic metabolic acidosis are unable to hyperventilate sufficiently to lower $paCO_2$ for complete compensation to 7.4

Metabolic Acidosis
Elevated Anion Gap

Causes

- Ketoacidosis - diabetic, alcoholic, starvation
- Lactic acidosis - hypoxia, shock, sepsis, seizures
- Toxic ingestion – salicylates, methanol, ethylene glycol, ethanol, isopropyl alcohol, paraldehyde, toluene
- Renal failure - uremia

Metabolic Acidosis
Normal Anion Gap

Causes

- Renal tubular acidosis (RTA).
- Post respiratory alkalosis
- Hypoaldosteronism
- Potassium sparing diuretics
- Pancreatic loss of bicarbonate
- Diarrhea
- Carbonic anhydrase inhibitors
- Acid administration (HCl, NH_4Cl, arginine HCl)Sulfamylon
- Cholestyramine
- Ureteral diversions

Effectiveness of Oxygenation

- Further evaluation of the arterial blood gas requires assessment of the effectiveness of oxygenation of the blood
- Hypoxemia – decreased oxygen content of blood - paO_2 less than 60 mm Hg and the saturation is less than 90%
- Hypoxia – inadequate amount of oxygen available to or used by tissues for metabolic needs

Mechanisms of Hypoxemia

- Inadequate inspiratory partial pressure of oxygen
- Hypoventilation
- Right to left shunt
- Ventilation-perfusion mismatch
- Incomplete diffusion equilibrium

Assessment of Gas Exchange

Alveolar-arterial O2 tension difference

- A-a gradient
- PAO_2-PaO_2
- $PAO_2 = FIO_2(PB - PH_2O) - PaCO_2/RQ$

arterial-Alveolar O2 tension ratio

- PaO_2/PAO_2
- arterial-inspired O2 ratio
- PaO_2/FIO_2
- P/F ratio

*RQ=respiratory quotient= 0.8

Assessment of Gas Exchange

	ABG		A-a grad	
	PaO2	PaCO2	RA	100%
Low FIO2	↓	↓	N*	N
Alveolar hypoventilation	↓	↑	N	N
Altered gas exchange Regional V/Q mismatch	↓	↑/N/↓	↑	N/↑
Intrapulmonary R to L shunt	↓	N/↓	↑	↑
Impaired diffusion	↓	N/↓	↑	N
Anatomical R to L shunt (intrapulmonary or intracardiac)	↓	N/↓	↑	↑

Summary

- First, does the patient have an acidosis or an alkalosis

  Look at the pH

- Second, what is the primary problem – metabolic or respiratory

  Look at the pCO2

- If the pCO2 change is in the opposite direction of the pH change, the primary problem is respiratory

Summary

- Third, is there any compensation by the patient - do the calculations

For a primary respiratory problem, is the pH change completely accounted for by the change in pCO_2

○ if yes, then there is no metabolic compensation

○ if not, then there is either partial compensation or concomitant metabolic problem

Summary

For a metabolic problem, calculate the expected pCO_2

- if equal to calculated, then there is appropriate respiratory compensation
- if higher than calculated, there is concomitant respiratory acidosis
- if lower than calculated, there is concomitant respiratory alkalosis

Summary

- Next, don’t forget to look at the effectiveness of oxygenation, (and look at the patient)

your patient may have a significantly increased work of breathing in order to maintain a “normal” blood gas

metabolic acidosis with a concomitant respiratory acidosis is concerning.

Case 1

Sara has had vomiting and diarrhea for 3 days. In her mom’s words, “She can’t keep anything down and she’s runnin’ out.” She has had 1 wet diaper in the last 24 hours.

She appears lethargic and cool to touch with a prolonged capillary refill time. After addressing her ABC’s, her blood gas

reveals: pH=7.34, pCO_2=26, HCO_3=12

Case 1

What is the acid/base abnormality?

1. Uncompensated metabolic acidosis
2. Compensated respiratory alkalosis
3. Uncompensated respiratory acidosis
4. Compensated metabolic acidosis

What is the acid/base abnormality?

1. Uncompensated metabolic acidosis
2. Compensated respiratory alkalosis
3. Uncompensated respiratory acidosis
4. Compensated metabolic acidosis

Case 1

Compensated metabolic acidosis

The prolong history of fluid loss through diarrhea has caused a metabolic acidosis. The mechanisms probably are twofold. First there is lactic acid production from the hypovolemia and tissue hypo perfusion. Second, there may be significant bicarbonate losses in the stool. The body has compensated by “blowing off” the $CO_2$with increased respirations.

Case 2

You are evaluating a 15 year old female in the ER who was brought in by paramedics from school because of abdominal pain and vomiting. Review of system is negative except for a 5 kg. weight loss over the past 2 months and polyuria for the past 2 weeks. She has no other medical problems . On exam, she is alert and oriented, afebrile, HR 115, RR 26 and regular, BP 114/75, pulse ox 95% on RA.

Case 2

Exam is unremarkable except for mild abdominal tenderness on palpation in the mid epigastric region and capillary refill time of 3 seconds. The ER Doctor has already seen the patient and has sent off “routine” blood work. She hands you the result of the blood gas.

pH = 7.21 pCO_2=24 pO_2 = 45 HCO_3 = 10 BE = -10

saturation = 72%.

Case 2

What is the blood gas interpretation?

1. Uncompensated respiratory acidosis with severe hypoxia
2. Uncompensated metabolic alkalosis
3. Combined metabolic acidosis and respiratory acidosis with severe hypoxia
4. Metabolic acidosis with respiratory compensation

What is the blood gas interpretation?

- Uncompensated respiratory acidosis with severe hypoxia
- Uncompensated metabolic alkalosis
- Combined metabolic acidosis and respiratory acidosis with severe hypoxia
- Metabolic acidosis with respiratory compensation

Case 2

Metabolic acidosis with respiratory compensation

This is a patient with new onset diabetes mellitus in ketoacidosis. Her pulse oximetry saturation and clinical examination do not reveal any respiratory problems except for tachypnea which is her compensatory mechanism for the metabolic acidosis. The nurse obtained the blood gas sample from the venous stick when she sent off the other labs

Questions….????

Thank you…