Acid-Base Disorders

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Step 1

- Identify all abnormalities in pH, PCO_2, and HCO_3
- Then, decide which abnormalities are primary and which are compensatory
- Whichever side of 7.4 the pH is on, then the process that caused it to shift to that side is the primary abnormality

Normal Ranges

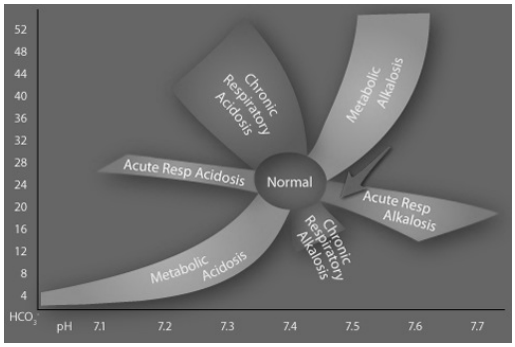
- Normal pH value: 7.35-7.45
  - < 7.35 = acidemia
  - > 7.45 = alkalemia
- PCO_2: 35-45 mmHg
  - < 35 = respiratory alkalosis
  - > 45 = respiratory acidosis
- HCO_3: 22-26 mmol/L
  - < 22 = metabolic acidosis
  - > 26 = metabolic alkalosis

Step 1

- A pH < 7.4 (acidosis) is either from an elevated PCO_2 (respiratory) or decreased HCO_3 (metabolic) as the primary disorder
- A pH > 7.4 (alkalosis) is either from a lowered PCO_2 (respiratory) or elevated HCO_3 as the primary disorder

ABG	BMP
PCO_2	Cl
HCO_3	CO_2

pH RR 7.35-7.45	**Respiratory** PCO_2 (RR 35-45)	**Metabolic** HCO_3 (RR 22-26)
Acidosis <7.35	>45	<22
Alkalosis >7.45	<35	>26



Example

- pH 7.59
- PCO_2 30
- HCO_3 23
- What is the acid-base abnormality?
- Respiratory alkalosis

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Example

- pH 7.1
- PCO_2 59
- HCO_3 23
- What is the acid-base abnormality?
- Respiratory acidosis

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Example

- pH 7.23
- PCO_2 43
- HCO_3 17
- What is the acid-base abnormality?
- Metabolic acidosis

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Example

- pH 7.51
- PCO_2 40
- HCO_3 31
- What is the acid-base abnormality?
- Metabolic alkalosis

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Compensation

- Respiratory compensation for metabolic disorders is rapid
- Full metabolic compensation for respiratory disturbances takes 3 to 5 days and is done by the kidney
- For chronic acid-base disorders, the body does not fully compensate. Eventually the pH will approach normal but not fully normalize.

	Metabolic Acidosis	Metabolic alkalosis	Respiratory acidosis	Respiratory alkalosis
Primary Disturbance	$\downarrow HCO_3$	$\uparrow HCO_3$	$\uparrow CO_2$	$\downarrow CO_2$
Compensation Mechanism	$\downarrow CO_2$	$\uparrow CO_2$	$\uparrow HCO_3$	$\downarrow HCO_3$

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Example

- pH 7.5
- PCO_2 31
- HCO_3 20
- What is the acid-base abnormality?
- Respiratory alkalosis w/ metabolic compensation

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Example

- pH 7.49
- PCO_2 53
- HCO_3 35
- What is the acid-base abnormality?
- Metabolic alkalosis w/ respiratory compensation

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Example

- pH 7.3
- PCO_2 33
- HCO_3 18
- What is the acid-base abnormality?
- Metabolic acidosis w/ respiratory compensation

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Example

- pH 7.19
- PCO_2 50
- HCO_3 28
- What is the acid-base abnormality?
- Respiratory acidosis w/ metabolic compensation

•Normal pH 7.35-7.45
•Normal CO_2 35-45
•Normal HCO_3 22-26

Step 2: Calculate the Anion Gap

- Anion gap (AG) = (Na) – (Cl + HCO_3)
  - AG ≥ 20 mmol/L = primary metabolic acidosis (regardless of pH or serum bicarbonate concentration)
  - The body does not generate a large AG to compensate for a primary disorder

Examples

- pH 7.16
- PCO_2 50
- HCO_3 30
- Na 140
- Cl 104
- Step 1:
- Respiratory acidosis w/ metabolic compensation
- Step 2: What is the anion gap?
- 140 - (104 + 30) = 6
- No further disorder

Examples

- pH 7.21
- PCO_2 58
- HCO_3 15
- Na 145
- Cl 100
- Step 1:
- Respiratory acidosis (primary)
- Metabolic acidosis (secondary)
- Step 2: What is the anion gap?
- 145 – (100 + 15)=30
- Metabolic acidosis
- Step 3: What is the excess anion gap?
- (30 – 12) + 15 = 33
- Metabolic alkalosis

Examples

- pH 7.51
- PCO_2 28
- HCO_3 21
- Na 143
- Cl 90
- Step 1:
- Respiratory alkalosis w/ metabolic compensation
- Step 2:
- 143- (90 + 21) = 32
- Metabolic acidosis

Examples

- pH 7.59
- PCO_2 31
- HCO_3 18
- Na 136
- Cl 99
- Step 1:
- Respiratory alkalosis w/ metabolic compensation
- Step 2: What is the anion gap?
- 136- (99 + 18) = 19
- No further abnormalities
- Step 3: What is the excess anion gap?
- (19 – 12) + 18 = 25
- No further abnormalities

Step 3: Calculate the Excess Anion Gap

- Excess AG =
  - [calculated AG - normal AG (~12 mmol/L)] + HCO_3
  - > 30 mmol/L = underlying metabolic alkalosis
  - < 23 mmol/L = underlying nonanion gap metabolic acidosis

Disease States/Medications

- Acid-base disturbances are manifestations of an underlying clinical disorder
- Acid-base treatment is best aimed at correcting the underlying cause of the acid-base abnormality

Causes of Respiratory Acidosis

- Sedatives
- Pneumonia
- Pulmonary edema
- Pulmonary embolus
- Cardiac arrest
- CNS depression
- Stroke
- Bronchospasm
- Spinal cord injury

Causes of Metabolic Alkalosis

- Urinary chloride < 10
  - Vomiting
  - Nasogastric suction
  - Diuretic use
- Urinary chloride > 20
  - Excess mineralocorticoid activity: hyperaldosteronism, Cushing's syndrome, exogenous steriods
  - Excess alkali administration

Causes of Respiratory Alkalosis

- Drug use: salicylates, catecholamines, progesterone, stimulants
- Anxiety
- Pain
- Hypoxia
- CNS disease (stroke, CNS tumor)
- Head injury
- Pregnancy
- Sepsis
- Hepatic encephalopathy

Treatment

Respiratory Acidosis	**Respiratory Alkalosis**	**Metabolic Acidosis**	**Metabolic Alkalosis**
•Correct Cause •Oxygen	•Correct Cause •Hypoventilation •Sedation	•Correct Cause •Sodium Bicarbonate •THAM* •Carbicarb (not available in U.S.)	•Correct Cause •Acetazolamide •HCl

*Tromethamine: potential of serious side effects of hyperkalemia, hypoglycemia, Ventilatory depression, & local injury in cases of extravasation

Causes of Metabolic Acidosis

- Anion Gap ≥ 20 (MUDPILES)
  - **M**ethanol
  - **U**remia
  - **D**KA
  - **P**ropylene glycol
  - **I**ntoxication/infection
  - **L**actic acidosis
  - **E**thylene glycol
  - **S**alicylate/sepsis
- Nonanion gap (F-USED CARS)
  - **F**istula (pancreatic)
  - **U**teroenteric conduits
  - **S**aline excess
  - **E**ndocrine (hyperparathyroid)
  - **D**iarrhea
  - **C**arbonic anhydrase inhibitors (acetazolamide)
  - **A**rginine, lysine, chloride
  - **R**enal tubular acidosis
  - **S**pironolactone

References

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Questions