Project: Ghana Emergency Medicine Collaborative

Document Title: Acid-Base Disorders

Author(s): Nathan Brouwer (University of Michigan), MD 2012

License: Unless otherwise noted, this material is made available under the terms of the Creative Commons Attribution Share Alike-3.0 License: http://creativecommons.org/licenses/by-sa/3.0/

We have reviewed this material in accordance with U.S. Copyright Law and have tried to maximize your ability to use, share, and adapt it. These lectures have been modified in the process of making a publicly shareable version. The citation key on the following slide provides information about how you may share and adapt this material.

Copyright holders of content included in this material should contact open.michigan@umich.edu with any questions, corrections, or clarification regarding the use of content.

For more information about how to cite these materials visit http://open.umich.edu/privacy-and-terms-use.

Any medical information in this material is intended to inform and educate and is not a tool for self-diagnosis or a replacement for medical evaluation, advice, diagnosis or treatment by a healthcare professional. Please speak to your physician if you have questions about your medical condition.

Viewer discretion is advised: Some medical content is graphic and may not be suitable for all viewers.
## Attribution Key

For more information see: [http://open.umich.edu/wiki/AttributionPolicy](http://open.umich.edu/wiki/AttributionPolicy)

### Use + Share + Adapt

{ Content the copyright holder, author, or law permits you to use, share and adapt. }

- **Public Domain – Government**: Works that are produced by the U.S. Government. (17 USC § 105)
- **Public Domain – Expired**: Works that are no longer protected due to an expired copyright term.
- **Public Domain – Self Dedicated**: Works that a copyright holder has dedicated to the public domain.
- **Creative Commons – Zero Waiver**
- **Creative Commons – Attribution License**
- **Creative Commons – Attribution Share Alike License**
- **Creative Commons – Attribution Noncommercial License**
- **Creative Commons – Attribution Noncommercial Share Alike License**
- **GNU – Free Documentation License**

### Make Your Own Assessment

{ Content Open.Michigan believes can be used, shared, and adapted because it is ineligible for copyright. }

- **Public Domain – Ineligible**: Works that are ineligible for copyright protection in the U.S. (17 USC § 102(b)) *laws in your jurisdiction may differ*

{ Content Open.Michigan has used under a Fair Use determination. }

- **Fair Use**: Use of works that is determined to be Fair consistent with the U.S. Copyright Act. (17 USC § 107) *laws in your jurisdiction may differ*

  Our determination **DOES NOT** mean that all uses of this 3rd-party content are Fair Uses and we **DO NOT** guarantee that your use of the content is Fair.
  To use this content you should **do your own independent analysis** to determine whether or not your use will be Fair.
Objectives

• Understand importance of maintaining acid-base balance.
• Understand different ways the body maintains this balance.
• Develop differential diagnoses based on the acid-base disorder.
• Calculate primary acid-base disorders.
• Calculate mixed acid-base disorders.
Maintaining Acid-Base Balance

• Controlled by the Lungs, Kidneys and Buffers
• Disrupted by Vomiting, Diarrhea, Respiratory Failure, Kidney Failure, Infections and Ingestions
Principles of Acid-Base Disorders

• Kidneys, Lungs and Buffers maintain serum pH between 7.36 and 7.44
• Blood pH is determined by the ratio of serum bicarbonate concentration ([HCO₃⁻]) and partial pressure of CO₂ (PₐCO₂)
Principles of Acid-Base Disorders

• Metabolic acid-base disorders and secondary metabolic compensation alter $[\text{HCO}_3^-]$

• Respiratory acid-base disorders and secondary respiratory compensation alter $(\text{Pa}_{\text{O}_2})$
Principles of Acid-Base Disorders

• Subtle changes in pH cause large shifts in acid-base pair
• Determines how drugs disperse and bind and how enzymes react
• Proteins function within narrow spectrum of pH
Principles of Acid-Base Disorders

• Acidemia: serum pH < 7.36
• Alkalemia: serum pH > 7.44
• Acidosis: pathologic process that lowers $[\text{HCO}_3^-]$ or raises $\text{Pa}_{\text{CO}_2}$
• Alkalosis: pathologic process that raises $[\text{HCO}_3^-]$ or lowers $\text{Pa}_{\text{CO}_2}$
Physiologic Buffers

• Oppose significant changes in pH
• Bicarbonate/Carbonic acid system
  – Located primarily in RBCs
  – $H^+ + HCO_3^- \Leftrightarrow H_2CO_3 \Leftrightarrow H_2O + CO_2$
• Intracellular protein buffers
• Phosphate buffers
  – Located within bone
Pulmonary Compensation

• Peripheral chemoreceptors in the carotid bodies and central chemoreceptors in the medulla change minute ventilation
  – Decreased pH $\rightarrow$ increased minute ventilation
    $\rightarrow$ decreased $\text{Pa}_{\text{O}_2}$

• Compensatory processes return pH toward normal over many hours, but do not fully correct pH
Anion Gap

- Estimates unmeasured anions in plasma (albumin)
- \( AG = Na^+ - (Cl^- + HCO_3^-) \)
- Normal = 12 +/- 3 mEq/L
- \( \Delta G \) will be used in mixed disorders
Scenario 1

• A 38 year-old man comes in to the Emergency Department after being involved in a rollover motor vehicle crash. He is complaining of right sided chest pain and difficulty breathing. He is taking shallow breaths. He has symmetric breath sounds. He is very tender over the right upper chest. What acid-base disorder do you suspect?
Respiratory Acidosis

- Decreased pH due to pulmonary CO₂ retention
- Excess H₂CO₃ production leads to acidemia
  - \( H^+ + HCO_3^- \Leftrightarrow H_2CO_3 \Leftrightarrow H_2O + CO_2 \)
- Acute respiratory acidosis has normal HCO₃⁻
- Chronic respiratory acidosis has elevated HCO₃⁻ due to renal retention
Respiratory Acidosis

• What are some of the causes of Respiratory Acidosis?
Respiratory Acidosis

- What are some of the causes of Respiratory Acidosis?
- Anything that causes your minute ventilation to decrease
Respiratory Acidosis

- Airway
  - Obstruction, aspiration
- Drug-induced CNS depression
  - Alcohol, narcotics, IV sedation
- CNS origin
  - Myasthenia gravis, CNS injury, Guillain-Barré
- Pulmonary disease
  - Pneumonia, edema, COPD/emphysema
- Thoracic cage
  - Pneumothorax, flail chest
Respiratory Acidosis Compensation

• Would you expect the $[\text{HCO}_3^-]$ to increase or decrease when $\text{Pa}_\text{O}_2$ increases?
Respiratory Acidosis Compensation

• Would you expect the [HCO$_3^-$] to increase or decrease when Pa$_O_2$ increases?

• $H^+ + HCO_3^- \Leftrightarrow H_2CO_3 \Leftrightarrow H_2O + CO_2$
Respiratory Acidosis Compensation

• Acute
  – $\text{HCO}_3^-$ production from intracellular proteins
  – $[\text{HCO}_3^-]$ increases 1mEq/L for every 10mm Hg rise in Pa$_{\text{CO}_2}$

• Chronic
  – Renal retention of $\text{HCO}_3^-$
  – $[\text{HCO}_3^-]$ increases 3.5mEq/L for every 10mm Hg rise in Pa$_{\text{CO}_2}$
  – Takes 12 hours to many days for renal retention of $\text{HCO}_3^-$
  – Nearly normalizes pH
Management

• Correct the minute ventilation
  – Establish airway
  – Re-expand the lung
  – Correct the CNS disease
  – Bronchodilators
  – Antibiotics

• Chronic respiratory acidosis
  – Progressive decrease in sensitivity to CO$_2$ by respiratory centers
  – Cautious use of oxygen, because may lose hypoxic respiratory drive and develop CO$_2$ narcosis
What is this Acid-Base Disorder?

• 25 year-old male, heroin overdose
  – pH 7.10  Pa$_{\alpha}$ 80  HCO$_3^-$ 24
What is this Acid-Base Disorder?

• 25 year-old male, heroin overdose
  – pH 7.10  Pa$_{\alpha}$ 80  HCO$_3^-$ 24
  – Acidemic, Pa$_{\alpha}$ is elevated, acute change
  – Acute respiratory acidosis ([HCO$_3^-$] unchanged)
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.32  Pa\(_\alpha\) 70  HCO\(_3^-\) 35
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.32  \( \text{Pa}_\phi \) 70  \( \text{HCO}_3^- \) 35
  – Acidemic, \( \text{Pa}_\phi \) is elevated \( \rightarrow \) respiratory acidosis
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.32  $\text{Pa}_\text{CO}_2$ 70  $\text{HCO}_3^-$ 35
  – Acidemic, $\text{Pa}_\text{CO}_2$ is elevated $\rightarrow$ respiratory acidosis
  – Is the bicarb what you would expect?
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.32  \( \text{Pa}_\alpha \) 70  \( \text{HCO}_3^- \) 35
  – Acidemic, \( \text{Pa}_\alpha \) is elevated → respiratory acidosis
  – Is the bicarb what you would expect?
  – \( \text{Pa}_\alpha \) increased by 30, so would expect \([\text{HCO}_3^-]\)
    to increase by 10.5 (3.5 x 3)
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.32  \( \text{Pa}_\text{O}_2 \) 70  \( \text{HCO}_3^- \) 35
  – Acidemic, \( \text{Pa}_\text{O}_2 \) is elevated \( \rightarrow \) respiratory acidosis
  – Is the bicarb what you would expect?
  – \( \text{Pa}_\text{O}_2 \) increased by 30, so would expect \([\text{HCO}_3^-]\) to increase by 10.5 (3.5 x 3)
  – Yes, it is what you would expect
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.23  \( \text{Pa}_a \) 90  \( \text{HCO}_3^- \) 35
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.23  \( \text{Pa}_\alpha \) 90  \( \text{HCO}_3^- \) 35
  – Acidemic, \( \text{Pa}_\alpha \) is elevated \( \rightarrow \) respiratory acidosis
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.23  \( \text{Pa}_\alpha \) 90  \( \text{HCO}_3^- \) 35
  – Acidemic, \( \text{Pa}_\alpha \) is elevated \( \rightarrow \) respiratory acidosis
  – Is the bicarb what you would expect?
What is this Acid-Base Disorder?

• 55 year-old man with COPD
  – pH 7.23  \( \text{Pa}_\alpha \) 90  \( \text{HCO}_3^- \) 35
  – Acidemic, \( \text{Pa}_\alpha \) is elevated \( \rightarrow \) respiratory acidosis
  – Is the bicarb what you would expect?
  – \( \text{Pa}_\alpha \) increased by 50, so would expect \([\text{HCO}_3^-]\) to increase by 17.5 (3.5 x 5)
What is this Acid-Base Disorder?

- 55 year-old man with COPD
  - pH 7.23  Pa$_{$a$} 90  HCO$_3$ - 35
  - Acidemic, Pa$_{$a$} is elevated $\rightarrow$ respiratory acidosis
  - Is the bicarb what you would expect?
  - Pa$_{$a$} increased by 50, so would expect [HCO$_3$ -] to increase by 17.5 (3.5 x 5)
  - No, the bicarb has not compensated appropriately yet, indicating an acute respiratory acidosis on a chronic respiratory acidosis
Scenario 2

• An 18 year-old man comes in to the Emergency Department and is extremely anxious. He says his fingers and toes are tingling and his hands are cramping. He is breathing approximately 70 times per minute. Assuming he did not ingest anything, what acid-base disorder do you suspect?
Respiratory Alkalosis

• Increased minute ventilation leads to decreased $\text{Pa}_\omega$ and alkalosis

• Acute respiratory alkalosis has normal $\text{HCO}_3^-$

• Chronic respiratory alkalosis has decreased $\text{HCO}_3^-$ due to renal compensation
Respiratory Alkalosis

• What causes Respiratory Alkalosis?
Respiratory Alkalosis

• What causes Respiratory Alkalosis?
• Anything that increases your minute ventilation
Respiratory Alkalosis

• Hypoxia-mediated hyperventilation
  – High altitude, severe anemia, ventilation-perfusion mismatch
• CNS mediated
  – Psychogenic, CVA, increased ICP (tumor/trauma)
• Pharmacologic
  – Salicylates, caffeine, vasopressors, thyroxine
• Pulmonary
  – Pneumonia, PE, mechanical hyperventilation, atelectasis
• Hepatic
  – Encephalopathy
Respiratory Alkalosis Compensation

• Would you expect the \([\text{HCO}_3^-]\) to increase or decrease when \(\text{Pa}_{O_2}\) decreases?
Respiratory Alkalosis Compensation

• Acute
  – Plasma $[\text{HCO}_3^-]$ is lowered by 2mEq/L for every 10-mm Hg decrease in $\text{Pa}_\alpha$

• Chronic
  – Plasma $[\text{HCO}_3^-]$ is lowered by 5mEq/L for every 10-mm Hg decrease in $\text{Pa}_\alpha$
What is the Acid-Base Disorder?

• 62 year-old woman with pneumonia for 1 week
  – pH 7.46  \( \text{Pa}_\text{CO}_2 \) 20  \( \text{HCO}_3^- \) 14
What is the Acid-Base Disorder?

• 62 year-old woman with pneumonia for 1 week
  – pH 7.46  \( \text{Pa}_o \) 20  \( \text{HCO}_3^- \) 14
  – Alkalemic, \( \text{Pa}_o \) is decreased → respiratory alkalosis
What is the Acid-Base Disorder?

• 62 year-old woman with pneumonia for 1 week
  – pH 7.46  \( \text{Pa}_\text{CO}_2 \) 20  \( \text{HCO}_3^- \) 14
  – Alkalemic, \( \text{Pa}_\text{CO}_2 \) is decreased \( \rightarrow \) respiratory alkalosis
  – Is the bicarb what you would expect?
What is the Acid-Base Disorder?

- 62 year-old woman with pneumonia for 1 week
  - pH 7.46  \( \text{Pa}_\text{CO}_2 \) 20  \( \text{HCO}_3^- \) 14
  - Alkalemic, \( \text{Pa}_\text{CO}_2 \) is decreased → respiratory alkalosis
  - Is the bicarb what you would expect?
  - Yes, \( \text{Pa}_\text{CO}_2 \) decreased by 20, so would expect bicarb to decrease by 10 in chronic respiratory alkalosis
Scenario 3

• An 22 year-old man with diabetes comes in after vomiting for 3 days. His sugars have been “high” at home. He appears extremely dry and is moaning without answering questions. What acid-base disorder do you suspect?
Metabolic Acidosis

• Acidemia created by increase in \([H^+]\) or decrease in \([HCO_3^-]\)

• Compensated for by hyperventilation to reduce \(Pa_{\text{\O}}\)
Metabolic Acidosis

• Divided into elevated Anion Gap and normal Anion Gap
• AG = Na⁺ - (Cl⁻ + HCO₃⁻)
• Normal = 12 +/- 3 mEq/L
Anion Gap Metabolic Acidosis

- MUDPILES
  - Methanol
  - Uremia
  - DKA
  - Propylene glycol, Paraldehyde
  - Infection, Iron, Isoniazid
  - Lactic acidosis
  - Ethylene glycol, Ethanol
  - Salicylates
Non-Anion Gap Metabolic Acidosis

• GI $\text{HCO}_3^-$ loss
  – Diarrhea, colostomy, ileostomy
• Renal $\text{HCO}_3^-$ loss
  – Renal tubular acidosis
  – Hyperparathyroidism
• Ingestion
  – Acetazolamide, Calcium Chloride, Magnesium Sulfate
Metabolic Acidosis

• Compensation (Winter’s Formula)
  – $\text{Pa}_\infty = 1.5 \times [\text{HCO}_3^-] + 8 +/− 2$
  
  $= 1.5 \times [\text{HCO}_3^-] + 6 \text{ or } 10$
What is the Acid-Base Disorder?

• 23 year-old woman with seizure for 90 minutes.
  – pH 7.24  \( \text{Pa}_\alpha \) 36  \( \text{HCO}_3^- \) 14
What is the Acid-Base Disorder?

• 23 year-old woman with seizure for 90 minutes.
  – pH 7.24  \( \text{Pa}_\alpha 36 \)  \( \text{HCO}_3^- 14 \)
  – Acidemic, \( \text{Pa}_\alpha \) is decreased  \( \rightarrow \) metabolic acidosis
What is the Acid-Base Disorder?

• 23 year-old woman with seizure for 90 minutes.
  – pH 7.24  \( \text{Pa}_\alpha \) 36  \( \text{HCO}_3^- \) 14
  – Acidemic, \( \text{Pa}_\alpha \) is decreased → metabolic acidosis
  – What is the anion gap?
    • \( \text{Na}^+ \) 140  \( \text{Cl}^- \) 100  \( \text{HCO}_3^- \) 14
What is the Acid-Base Disorder?

• 23 year-old woman with seizure for 90 minutes.
  – pH 7.24  $\text{Pa}_{\infty}$ 36  $\text{HCO}_3^-$ 14
  – Acidemic, $\text{Pa}_{\infty}$ is decreased $\rightarrow$ metabolic acidosis
  – What is the anion gap?
    • $\text{Na}^+$ 140  $\text{Cl}^-$ 100  $\text{HCO}_3^-$14

• Anion Gap = 26
• Why is this elevated?
What is the Acid-Base Disorder?

• 23 year-old woman with seizure for 90 minutes.
  – pH 7.24   $\text{Pa}_\alpha$ 36   $\text{HCO}_3^-$ 14
  – Acidemic, $\text{Pa}_\alpha$ is decreased $\rightarrow$ metabolic acidosis
  – Is the $\text{Pa}_\alpha$ what you would expect?
What is the Acid-Base Disorder?

• 23 year-old woman with seizure for 90 minutes.
  – pH 7.24  Pa$_\omega$ 36  HCO$_3^-$ 14
  – Acidemic, Pa$_\omega$ is decreased → metabolic acidosis
  – Is the Pa$_\omega$ what you would expect?
  – Pa$_\omega$ = (1.5 x 14) + 8 +/- 2 = 27 – 31
  – You would expect the Pa$_\omega$ to be lower
Metabolic Acidosis

• Treatment
  – Treat the underlying condition and the pH will gradually normalize
Scenario 4

• An 29 year-old pregnant woman has been vomiting for 1 week. What acid-base disorder do you suspect?
Metabolic Alkalosis

- Alkalemia created by decrease in $[H^+]$ or increase in $[\text{HCO}_3^-]$
- Compensated for by hypoventilation to increase $\text{Pa}_{\text{CO}_2}$
Metabolic Alkalosis

• Volume-Contracted
  – Vomiting/gastric suction
  – Diuretics

• Normal Volume / Volume-Expanded
  – Severe potassium depletion
  – Hyperaldosteronism
  – Cushing’s syndrome
Metabolic Alkalosis

• Treatment
  – Treat the underlying disorder
  – Correct potassium if needed
  – Give fluids if urine Cl⁻ < 10mEq/L
  – Consider acetazolamide if edematous, will increase HCO₃⁻ secretion
Metabolic Alkalosis

• Compensation
  – $P_{a\to} = 0.9 \times [HCO_3^-] + 15$
What is the Acid-Base Disorder?

• 29 year-old pregnant woman who is vomiting.
  – pH 7.58  Pa$_{\alpha}$ 48  HCO$_3^-$ 40
What is the Acid-Base Disorder?

• 29 year-old pregnant woman who is vomiting.
  – pH 7.58  \( \text{Pa}_\alpha \) 48  \( \text{HCO}_3^- \) 40
  – Alkaletic, \( \text{Pa}_\alpha \) is increased \( \rightarrow \) metabolic alkalosis
What is the Acid-Base Disorder?

• 29 year-old pregnant woman who is vomiting.
  – pH 7.58  \( \text{Pa}_\infty \) 48  \( \text{HCO}_3^- \) 40
  – Alkalemic, \( \text{Pa}_\infty \) is increased \( \rightarrow \) metabolic alkalosis
  – Is the \( \text{Pa}_\infty \) what you would expect?
What is the Acid-Base Disorder?

- 29 year-old pregnant woman who is vomiting.
  - pH 7.58  \( \text{Pa}_\alpha \) 48  \( \text{HCO}_3^- \) 40
  - Alkalemic, \( \text{Pa}_\alpha \) is increased → metabolic alkalosis
  - Is the \( \text{Pa}_\alpha \) what you would expect?
  - \( \text{Pa}_\alpha = (0.9 \times 40) + 15 = 51 \)
Mixed Disorders

• Sometimes more than one acid-base disorder is present
• Metabolic and respiratory processes can both be present
• Metabolic acidosis and alkalosis can both be present
• Respiratory acidosis cannot be present with respiratory alkalosis
Mixed Disorders

- If the pH is near normal, and the $\text{Pa}_{\text{O}_2}$ and/or the $[\text{HCO}_3^{-}]$ is abnormal, assume a mixed disorder
What is the pH?

> 7.44

- Alkalosis
  - PCO₂ < 40 then respiratory alkalosis
  - PCO₂ > 40 then metabolic alkalosis

< 7.36

- Acidosis
  - PCO₂ > 40 then respiratory acidosis
  - PCO₂ < 40 then metabolic acidosis

Calculate anion gap:

\[ \text{Na}^+ - (\text{Cl}^- + \text{CO}_2) \]

...
Figure 122-3. Algorithm for acid-base calculation.
Scenario 5

• 22 year-old man, upset that he broke up with his girlfriend, was found confused, next to a bottle of pills. What is the acid-base disorder? What is the ingestion?
  – pH 7.53  \( \text{Pa}_\text{O}_2 \) 15  HCO\(_3\) \( - \) 12  Na\(^+\) 140  Cl\(^-\) 108  CO\(_2\) 13
Scenario 5

• pH 7.53  Pa\textsubscript{O\textsubscript{2}} 15  HCO\textsubscript{3}\textsuperscript{-} 12  Na\textsuperscript{+} 140  Cl\textsuperscript{-} 108  CO\textsubscript{2} 13

• What is the pH?
Scenario 5

- pH 7.53  Pa$_\alpha$ 15  HCO$_3^-$ 12  Na$^+$ 140  Cl$^-$ 108  CO$_2$ 13

- What is the pH?
  - Alkalosis

- What is the Pa$_\alpha$?
Scenario 5

- pH 7.53  \( \text{Pa}_{\text{CO}_2} \) 15  \( \text{HCO}_3^- \) 12  \( \text{Na}^+ \) 140  \( \text{Cl}^- \) 108  \( \text{CO}_2 \) 13

- What is the pH?
  - Alkalosis

- What is the \( \text{Pa}_{\text{CO}_2} \)?
  - Low → respiratory alkalosis

- What is the anion gap?
Scenario 5

- pH 7.53  \(\text{Pa}_{CO_2}\) 15  \(\text{HCO}_3^-\) 12  \(\text{Na}^+\) 140  \(\text{Cl}^-\) 108  \(\text{CO}_2\) 13

- What is the pH?
  - Alkalosis

- What is the \(\text{Pa}_{CO_2}\)?
  - Low → respiratory alkalosis

- What is the anion gap?
  - 19 → Anion gap metabolic acidosis
Scenario 5

• Metabolic acidosis with respiratory alkalosis
• What is the ingestion?
Scenario 5

• Metabolic acidosis with respiratory alkalosis
• What is the ingestion?
• Aspirin
Scenario 6

- 70 year-old man has been vomiting for 2 weeks. HR 140, BP 60/P.
- pH 7.40  Pa\(O_2\) 40  HCO\(_3\)\(^-\) 23  Na\(^+\) 150  Cl\(^-\) 87  CO\(_2\) 23
Scenario 6

- pH 7.40  \( \text{Pa}_{\text{CO}_2} \) 40  HCO\(_3^\cdot\) 23  Na\(^+\) 150  Cl\(^-\) 87  CO\(_2\) 23
- Normal pH
- What is the anion gap?
Scenario 6

• pH 7.40  \( \text{Pa}_{\text{CO}_2} \) 40  \( \text{HCO}_3^- \) 23  \( \text{Na}^+ \) 150  \( \text{Cl}^- \) 87  \( \text{CO}_2 \) 23

• Normal pH

• What is the anion gap?
  – 40 → anion gap metabolic acidosis

• What is the \( \Delta \) ratio?
\[\Delta \text{ratio}\]

- Used in a high anion gap metabolic acidosis to determine if a mixed disorder is present.
- \[\Delta \text{AG} / \Delta \text{HCO}_3^- = (\text{AG} - 12) / (24 - \text{HCO}_3^-)\]
- A value > 2:1 suggests less of a fall in \text{HCO}_3^- than would be expected with a metabolic acidosis \(\rightarrow\) metabolic alkalosis.
Scenario 6

- pH 7.40  \( \text{Pa}_{\text{CO}_2} \) 40  \( \text{HCO}_3^- \) 23  \( \text{Na}^+ \) 150  \( \text{Cl}^- \) 87  \( \text{CO}_2 \) 23

- Normal pH

- What is the anion gap?
  - 40 \( \rightarrow \) anion gap metabolic acidosis

- What is the \( \Delta \)ratio?
  - \((40 - 12) / (24 - 23) = 28:1\)
Scenario 6

- pH 7.40  \( Pa_{CO_2} \) 40  \( HCO_3^- \) 23  \( Na^+ \) 150  \( Cl^- \) 87  \( CO_2 \) 23
- Normal pH
- What is the anion gap?
  - 40 \( \rightarrow \) anion gap metabolic acidosis
- What is the \( \Delta \)ratio?
  - \((40 - 12) / (24 - 23) = 28:1\)
- This patient has anion gap metabolic acidosis (shock) with metabolic alkalosis (vomiting)
References

• Collings, JL. Rosen’s Emergency Medicine. 7\textsuperscript{th} ed. Ch. 122 Acid-Base Disorders. Elsevier 2010.
