Acid-Base Physiology

Emily Gilbert, MD
Pulmonary & Critical Care
Acid-Base definitions

• **Acidemia:**
  – increase in H+ and decrease in arterial pH to <7.36

• **Acidosis:**
  – a process that, if unopposed, leads to a decrease in pH

• **Alkalemia:**
  – a decrease in H+ and increase in arterial pH to >7.44

• **Alkalosis:**
  – a process, that if unopposed, leads to an increase in pH
<table>
<thead>
<tr>
<th>Primary Disorder</th>
<th>pH Change</th>
<th>Primary Change</th>
<th>Compensatory Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic Acidosis</td>
<td>↓</td>
<td>↓ HCO3</td>
<td>↓ pCO2</td>
</tr>
<tr>
<td>Respiratory Acidosis</td>
<td>↓</td>
<td>↑ pCO2</td>
<td>↑ HCO3</td>
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Normal $\text{HCO}_3 = 24\text{mmol/L}$

Normal $\text{pCO}_2 = 40\text{mmHg}$
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Normal $\text{HCO}_3 = 24 \text{mmol/L}$  
Normal $\text{pCO}_2 = 40 \text{mmHg}$

$\downarrow \text{HCO}_3 \quad \uparrow \text{pCO}_2 \quad \rightarrow \text{you have mixed acid base disorder}$
## Acidosis

<table>
<thead>
<tr>
<th>Metabolic</th>
<th>Respiratory</th>
<th>Alkalosis</th>
<th>Respiratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don’t forget the albumin!</td>
<td>1. Acute or chronic?</td>
<td>1. Check for respiratory compensation</td>
<td>1. Acute or chronic?</td>
</tr>
</tbody>
</table>

### High AG
- 2a. Winters
- 3a. $\Delta/\Delta$
- 4a. Osmol. gap

### Normal AG
- 2b. Winters
- 3b. Urine anion gap

### Acute
- $10 \Delta pCO_2$: - pH $\downarrow$ by 0.08
  - $HCO_3 \uparrow$ by 1

### Chronic
- $10 \Delta pCO_2$: - pH $\downarrow$ by 0.03
  - $HCO_3 \uparrow$ by 4

2. If expected pH does not equal actual pH, superimposed metabolic process

### Alkalosis

<table>
<thead>
<tr>
<th>Acute</th>
<th>Chronic</th>
</tr>
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<tbody>
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<td>$10 \Delta pCO_2$: - pH $\uparrow$ by 0.08</td>
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</tr>
<tr>
<td>$HCO_3 \downarrow$ by 2</td>
<td>$HCO_3 \downarrow$ by 5</td>
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2. If expected pH does not equal actual pH, superimposed metabolic process
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1. Gap or no gap?

<p>| | |</p>
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</table>
Metabolic acidosis

1. Calculate anion gap
2. Check for respiratory compensation
3. Check for co-existing non-gap acidosis or metabolic alkalosis
4. If gap acidosis and no clear reason for gap, measure osmolar gap
1. Measure Anion Gap

• $[\text{anions}] = [\text{cations}]$

\[ \text{Cl} + \text{HCO}_3 + \text{unmeas anions} = \text{Na} + \text{unmeas cations} \]

\[ \text{Na} - \text{Cl} - \text{HCO}_3 = \text{unmeas anions} - \text{unmeas cations} \]

Normal anion gap $= 12$
Don’t forget the albumin!

- Most of anion gap made up of albumin
- Low albumin $\rightarrow$ smaller anion gap
- For every 1g/dL below 4g/dL (nl albumin), the gap will decrease by 2.5
  - i.e., albumin 2g/dL $\rightarrow$ “normal gap” = 7
Calculated gap = 140 – 109 – 17 = 14
**albumin 2g/dL
This pt’s “normal” anion gap =
12 – [2.5 x (4-2)] = 7
\[ \Delta \text{ gap} = \text{calc gap} - \text{“normal” gap} = 14 - 7 = 7 \]

**ASSUME THE EXPECTED GAP IS ALWAYS 12**

Adjusted gap =
calculated gap + [2.5 x (4-meas albumin)]

Adj gap = 14 + [2.5 x (4-2)] = 19
\[ \Delta \text{ gap} = \text{adj gap} - \text{expected gap} = 19 - 12 = 7 \]
2. Check for Respiratory Compensation

- Metabolic acid-base disorder → almost immediate ventilatory response

Winter’s Formula:
Expected $pCO2 = 1.5[HCO3] + 8 (\pm 2)$

- Appropriate compensation → measured $pCO2 = \exp pCO2$

- Respiratory alkalosis → measured $pCO2 < \exp pCO2$ (Hyperventilation)

- Respiratory acidosis → measured $pCO2 > \exp pCO2$ (Hypoventilation)
3. Delta/Delta

- For every increase in AG from the baseline of 12, there should be a corresponding decrease in HCO3 from 24
- Assess for non-gap metabolic acidosis or metabolic alkalosis
- $\Delta$ anion gap - $\Delta$ HCO3
  - Normal = zero
  - Negative = non gap acidosis
  - Positive = metabolic alkalosis
- Measured HCO3 + $\Delta$gap
  - <24 = non gap acidosis
  - >24 = metabolic alkalosis
<p>| | | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>4</td>
<td>14</td>
<td>0.6</td>
</tr>
<tr>
<td>146</td>
<td>110</td>
<td>14</td>
</tr>
</tbody>
</table>

- Calculated gap = 22
- $\Delta$ anion gap = 22 - 12 = 10
- $\Delta$ bicarb = 24 - 14 = 10
- $\Delta$ AG - $\Delta$ bicarb = 0
Calculated gap = 22
\[ \Delta \text{ anion gap} = 22 - 12 = 10 \]
\[ \Delta \text{ bicarb} = 24 - 14 = 10 \]
\[ \Delta \text{ AG} - \Delta \text{ bicarb} = 0 \]

Simple anion gap acidosis
Calculated gap = 15
Δ anion gap = 15 - 12 = 3
Δ bicarb = 24 - 10 = 14
Δ AG - Δ bicarb = -9
Calculated gap = 15

Δ anion gap = 15 – 12 = 3

Δ bicarb = 24 – 10 = 14

Δ AG - Δ bicarb = -9

Anion gap acidosis + non-gap acidosis
Causes of High Anion Gap

• Added unmeasured anions
  – ketoacids, lactate, oxalate, formate dissipate to produce H+ and anions

• Decreased cationic charge of plasma proteins (severe metabolic alkalosis, pH>7.5)
Causes of high anion gap

- Methanol (formic acid)
- Uremia (ESRD $\rightarrow$ impaired H+ secretion)
- DKA (also alcohol and starvation ketoacidosis)
- Paraaldehyde, propylene glycol (high dose ativan)
- INH, Iron
- Lactic acid (type A and B)
- Ethylene glycol (oxalic acid)
- Salicylates (salicylic acid)
Modern pneumonic: GOLD MARK

- **Glycols** (ethylene or propylene)
- **Oxoproline** (AG acidosis seen in pts chronically taking tylenol)
- **L-lactic acidosis**
- **D-lactic acidosis** (AMS, ataxia, slurred speech)
- **Methanol**
- **Aspirin**
- **Renal failure**
- **Ketoacidosis**
L-Lactic acidosis – type A

• Marker of anaerobic metabolism due to tissue hypoperfusion
• Higher lactate $\rightarrow$ higher mortality

– Circulatory shock
  • Severe sepsis or septic shock
  • Cardiogenic shock
  • Hypovolemic shock
L-Lactic acidosis – type B

- No evidence of tissue hypoperfusion

<table>
<thead>
<tr>
<th>Increased lactate production</th>
<th>Increased production of pyruvate</th>
<th>Decreased lactate clearance</th>
<th>Mechanism unknown</th>
</tr>
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<tbody>
<tr>
<td>Seizures</td>
<td>Epinephrine</td>
<td>Hepatic dysfunction</td>
<td>Metformin</td>
</tr>
<tr>
<td>Asthma</td>
<td>Dobutamine</td>
<td>Propofol infusion</td>
<td>Linezolid</td>
</tr>
<tr>
<td>Leukemia</td>
<td>NRTIs</td>
<td></td>
<td>(extended course)</td>
</tr>
<tr>
<td>Lymphoma</td>
<td></td>
<td></td>
<td>Valproic acid</td>
</tr>
<tr>
<td>Propylene glycol toxicity (ativan, phenytoin)</td>
<td></td>
<td></td>
<td>overdose</td>
</tr>
</tbody>
</table>
Toxic Alcohol Ingestion

- **Ethylene Glycol** (antifreeze)
  - Oxalate
  - Urinary Crystals
  - Kidney Injury

- **Methanol** (moonshine, windshield wiper fluid)
  - Formate
  - Vision Loss

- **Isopropyl Alcohol** (rubbing alcohol)
  - Acetone
  - CNS Depression

EG and M can increase Anion Gap

All can result in increase Osmolal Gap
4. Osmolar Gap

- If no clear explanation for high anion gap metabolic acidosis, check osmolar gap

- Osm gap = serum osm – calc osm
- Calc osm = 2(Na) + \( \frac{\text{Gluc}}{18} + \frac{\text{BUN}}{2.8} + \frac{\text{ethanol}}{4.6} \)

- Normal Osm gap = 10-15
- >25 suggests toxic alcohol ingestion
### Acidosis

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<th>Metabolic</th>
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1. Gap or no gap?

#### High AG
- 2a. Winters
- 3a. $\Delta/\Delta$
- 4a. Osmol. gap

#### Normal AG
- 2b. Winters
- 3b. Urine anion gap

### Alkalosis
Normal anion gap

• Due to loss of bicarbonate or isolated reduction in renal acid excretion

• Anion gap = Na – Cl – HCO3
  – Lower [HCO3] is matched by an increase in [Cl]

• GI loss HCO3 $\rightarrow$ kidney retains NaCl
Causes of non-gap acidosis

• Ureterostomy
• Small bowel fistula
• Endocrine (adrenal insufficiency)
• Diarrhea
• Carbonic anhydrase inhibitors
• Alimentation (TPN)
• RTA
• Saline
Causes of non-gap acidosis

- **Renal** (RTA, early renal insufficiency)
- **Acetazolamide**, hyperal (TPN)
- **Gastrointestinal** (diarrhea, fistulas)
- **Endocrine** (adrenal insufficiency)
- **Saline** (high volume resuscitation)
Non-gap acidosis

2. Check for respiratory compensation with Winter’s formula:
   
   Expected pCO2 = 1.5 x [HCO3] + 8 (+/- 2)

3. GI loss versus renal loss of HCO3?
   - Urine anion gap
Urine anion gap

• Urine Na + K – Cl

• Normal gap is zero or slightly positive

• Negative urine anion gap (-20 to -50) indicates GI losses (ne-GUT-ive)
  – Diarrhea
  – Fistulas
Effects of Acidemia

- Increased cardiac output
- Decreased SVR
- Coronary vasodilation
- Increase in minute ventilation (comp)
- Hyperkalemia
- Decrease in mental status
- Possible decrease response to vasopressors
Lactic acidosis often challenges the intensivist and is associated with a strikingly high mortality. Treatment involves discerning and correcting its underlying cause, ensuring adequate oxygen delivery to tissues, reducing oxygen demand through sedation and mechanical ventilation, and (most controversially) attempting to alkalinize the blood with IV sodium bicarbonate. Here we review the literature to answer the following questions: Is a low pH bad? Can sodium bicarbonate raise the pH in vivo? Does increasing the blood pH with sodium bicarbonate have any salutary effects? Does sodium bicarbonate have negative side effects? We find that the oft-cited rationale for bicarbonate use, that it might ameliorate the hemodynamic depression of metabolic acidemia, has been disproved convincingly. Further, given the lack of evidence supporting its use, we cannot condone bicarbonate administration for patients with lactic acidosis, regardless of the degree of acidemia.

(CHEST 2000; 117:260–267)

Key words: acid-base; acidosis; alkalinizing therapy; bicarbonate; lactic acidosis; sodium bicarbonate

Abbreviations: DCA = dichloroacetate; DKA = diabetic ketoacidosis; SID = strong ion difference
Bicarbonate Administration

• Increase in pCO2
• Intracellular acidosis
• Decrease ion Ca
• Hypernatremia
• Excess volume


NOT recommended in lactic acidosis if pH >7.1 and HCO₃ >6
Sodium bicarbonate therapy for patients with severe metabolic acidaemia in the intensive care unit (BICAR-ICU): a multicentre, open-label, randomised controlled, phase 3 trial

Samir Jaber, Catherine Paugam, Emmanuel Futier, Jean-Yves Lefrant, Sigismond Lasocki, Thomas Lescot, Julien Pottecher, Alexandre Demoule, Martine Ferrandièvre, Karim Asehnoune, Jean Dellamonica, Lionel Velly, Paër-Sélim Abback, Audrey de Jong, Vincent Brunot, Fouad Belafia, Antoine Roquilly, Gérald Chanques, Laurent Muller, Jean-Michel Constantin, Helena Bertet, Kada Klouchi, Nicolas Molinari, Boris Jung, for the BICAR-ICU Study Group*

No difference in mortality in overall population

Sig improved mortality in those with AKI

<table>
<thead>
<tr>
<th>Number at risk</th>
<th>Days since inclusion</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Control group</td>
<td>194</td>
</tr>
<tr>
<td>Bicarbonate group</td>
<td>195</td>
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p=0.09

p=0.0283
Sodium bicarbonate therapy for patients with severe metabolic acidosis: a multicentre, randomised controlled trial

Samir Jaber, Catherine Paugam, I Martine Ferrandière, Karim Aslehi, Antoine Roquilly, Gérald Chanqu
BICAR-ICU Study Group*

Figure 3: Cumulative use of renal-replacement therapy from enrolment to day 28 in the overall population
Bicarbonate Administration

Treatability of various metabolic acidoses with bicarbonate

No
- Lactic acidosis
- Ketoacidosis

Maybe, yea
- Uremic acidosis (especially if hyperkalemia is present & treatment is with isotonic bicarb)

Yes
- NAGMA (a.k.a. hyperchloremic metabolic acidosis)

8.4% Sodium Bicarbonate Inj., USP
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<tr>
<td>2. Measure urine chloride</td>
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</table>
Causes of metabolic alkalosis

- Volume contraction
  - Vomiting
  - Diuretics
  - Dehydration

- NGT suction
- Post-hypercapnia
- Hypokalemia
- Primary aldosteronism
1. Check for Respiratory Compensation

- Metabolic acid-base disorder → almost immediate ventilatory response

\[ \Delta pCO2 = \frac{2}{3} \times [\Delta HCO_3] \]

*CO2 does not increase >55*

- Appropriate compensation → measured pCO2 = exp pCO2

- Respiratory alkalosis → measured pCO2 < exp pCO2

- Respiratory acidosis → measured pCO2 > exp pCO2
2. Measure Urine Chloride

| Chloride Responsive Urine Cl<20 | Chloride Unresponsive Urine Cl >20 |
2. Measure Urine Chloride

<table>
<thead>
<tr>
<th>Chloride Responsive Urine Cl &lt; 20</th>
<th>Chloride Unresponsive Urine Cl &gt; 20</th>
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<tbody>
<tr>
<td>• Vomiting</td>
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<tr>
<td>• Diuretics</td>
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<td>• Dehydration</td>
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<td>• Continuous NG suction</td>
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<tr>
<td>• Vomiting</td>
<td>• Pure hypokalemia (&lt;2mEq/L)</td>
</tr>
<tr>
<td>• Diuretics</td>
<td>• Hyperaldosterone state</td>
</tr>
<tr>
<td>• Dehydration</td>
<td></td>
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<td>• Continuous NG suction</td>
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Effects of alkalemia

- WORSE THAN ACIDEemia!
- Decreased coronary blood flow
- Arrhythmias
- Hypoventilation
- Shifts O2-hgb curve to left
- Decreased cerebral blood flow
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<td>- HCO$_3$ $\uparrow$ by 1</td>
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2. If expected pH does not equal actual pH, superimposed metabolic process

1. Acute or chronic?

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<td>- HCO$_3$ $\downarrow$ by 5</td>
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1. Check for respiratory compensation

2. Measure urine chloride

1. Acute or chronic?

2. If expected pH does not equal actual pH, superimposed metabolic process
Respiratory Acidosis

• Lung disease
  – Asthma exacerbation
  – COPD

• Depression of respiratory center
  – Drug overdose
  – Obesity Hypoventilation

• Nerve or muscular disorders
  – Guillain-Barre
  – Myasthenia gravis
Respiratory Alkalosis

- Sepsis
- Hypoxia
- Anxiety
- Head injury
- Drugs
  - Salicylate overdose
  - Progesterone
- Pregnancy
- Liver disease
## 1. Acute or Chronic?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Acute</th>
<th>Chronic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory Acidosis</td>
<td>$\uparrow 10$</td>
<td>$\downarrow 0.08$</td>
</tr>
<tr>
<td></td>
<td>$\downarrow 10$</td>
<td>$\uparrow 0.03$</td>
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</table>
## 1. Acute or Chronic?

<table>
<thead>
<tr>
<th></th>
<th>Acute</th>
<th>Chronic</th>
<th>Δ pCO2</th>
<th>Δ HCO3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Respiratory Acidosis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute</td>
<td>↑ 10</td>
<td></td>
<td></td>
<td>↑ 1</td>
</tr>
<tr>
<td>Chronic</td>
<td>↑ 10</td>
<td></td>
<td></td>
<td>↑ 4</td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Acute</td>
<td>↓ 10</td>
<td></td>
<td></td>
<td>↓ 2</td>
</tr>
<tr>
<td>Chronic</td>
<td>↓ 10</td>
<td></td>
<td></td>
<td>↓ 5</td>
</tr>
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<tr>
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<tr>
<td></td>
<td>▼ 0.08</td>
<td>▼ 0.03</td>
</tr>
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<td></td>
<td>▲ 1</td>
<td>▲ 4</td>
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<tr>
<td></td>
<td>▲ 0.08</td>
<td>▲ 0.03</td>
</tr>
<tr>
<td></td>
<td>▼ 2</td>
<td>▼ 5</td>
</tr>
</tbody>
</table>
2. Superimposed metabolic process?

• If pH is lower than expected pH, metabolic acidosis
  – Don’t forget to measure the gap!

• If pH is higher than expected pH, metabolic alkalosis
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<tr>
<td><strong>High AG</strong></td>
<td><strong>Normal AG</strong></td>
</tr>
<tr>
<td>2a. Winters</td>
<td>2b. Winters</td>
</tr>
<tr>
<td>3a. Δ/Δ</td>
<td>3b. Urine anion gap</td>
</tr>
<tr>
<td>4a. Osmol. gap</td>
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Problem 1

7.35/30/100

142  118  13

3.4  16  0.9

• 49F with hx of spina bifida, colitis s/p end ileostomy and ileal conduit admitted with seizure

Albumin 3.0
Problem 1

7.35/30/100

142 118 13

3.4 16 0.9

Albumin 3.0

1. Acidosis or alkalosis?  
   acidosis

2. Metabolic or respiratory?  
   metabolic

3. Gap or non-gap?  
   142-118-16 = 8  
   Non-gap

4. Appropriate resp compensation?  
   Exp pCO2 =  
   (1.5 x 16) + 8 = 32 +/-2  
   Approp resp compensation
Problem 1

7.35/30/100

142 | 118 | 13
---|---|---
3.4 | 16 | 0.9

Albumin 3.0

- 49F with hx of spina bifida, colitis s/p end ileostomy and ileal conduit admitted with seizure

1. Non-gap metabolic acidosis with appropriate respiratory compensation
Problem 2

7.38/16/75

121  98  50
4.9  12  2.5

• 51M with recent diagnosis of HIV admitted with hyponatremia, diarrhea and concern for sepsis

Albumin 2.0
Problem 2

1. Acidosis or alkalosis?
   *Acidosis...kind of*

2. Metabolic or respiratory?
   *metabolic*

3. Gap or non-gap?
   
   \[
   121 - 98 - 12 = 11 \\
   11 + ((4 - 2) \times 2.5) = 11 + 5 = 16 \\
   \text{GAP}
   \]

4. Appropriate resp compensation?
   
   \[
   \text{Exp pCO2} = \\
   (1.5 \times 12) + 8 = 26 +/2
   \]
   *Co-existing resp alkalosis*

5. Delta-Delta
   
   \[
   \Delta \text{ Anion gap} = 16 - 12 = 4 \\
   \Delta \text{ bicarb} = 24 - 12 = 12 \\
   \text{Co-existing non-gap metabolic acidosis}
   \]
Problem 2

7.38/16/75

<table>
<thead>
<tr>
<th>121</th>
<th>98</th>
<th>50</th>
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<tr>
<td>4.9</td>
<td>12</td>
<td>2.5</td>
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</table>

Albumin 2.0

Lactate 6.6

• 51M with recent diagnosis of HIV admitted with hyponatremia, diarrhea and concern for sepsis

1. Gap metabolic acidosis
2. Respiratory alkalosis
3. Non-gap metabolic acidosis
Problem 3

7.53/50/85

146 | 91 | 45

3.1 | 39 | 1.6

• 65F with hx of CAD s/p CABG, CHF on diuretics, intubated. RT tells you that patient is apneic during spontaneous breathing trials.
Problem 3

1. Acidosis or alkalosis?  
   *Alkalosis*

2. Metabolic or respiratory?  
   *Metabolic*

3. Appropriate resp compensation?  
   
   Exp $\Delta pCO_2 = \frac{2}{3} \Delta HCO_3$

   $\Delta HCO_3 = 39 - 24 = 15$

   Exp $\Delta pCO_2 = 15 \times \frac{2}{3} = 10$

   *Appropriate resp compensation*  
   *(hypoventilation)*

4. Measure urine chloride  
   *Chloride responsive*

Urine Chloride = 10
Problem 3

7.53/50/85

146 | 91 | 45

3.1 | 39 | 1.6

• 65F with hx of CAD s/p CABG, CHF on diuretics, intubated. RT tells you that patient is apneic during spontaneous breathing trials.

1. Metabolic alkalosis with appropriate resp compensation

Urine Chloride = 10
Problem 4

6.92/100/60

142 100 34

3.2 30 1.7

• 24M found down at a party. Friends said he’d been drinking excessively and doing drugs then passed out.
Problem 4

6.92/100/60

142 100 34

3.2 30 1.7

1. Acidosis or alkalosis?
   Acidosis

2. Metabolic or respiratory?
   Respiratory

3. Acute or Chronic?
   pCO2 has increased by 60 (10 x 6)
   
   Expected pH if **ACUTE**
   
   \[
   0.08 \times 6 = 0.48 \\
   7.4 - 0.48 = 6.92 
   \]

   Expected pH if **CHRONIC**
   
   \[
   0.03 \times 6 = 0.18 \\
   7.4 - 0.18 = 7.22 
   \]

   **Acute resp acidosis**

4. Check for renal compensation
   For every 10 inc in pCO2, bicarb will go up by 1 for an acute process

   **Appropriate renal compensation**
Problem 4

6.92/100/60

142 100  34

3.2  30  1.7

1. Acute respiratory acidosis with appropriate renal compensation

- 24M found down at a party. Friends said he’d been drinking excessively and doing drugs then passed out.
Problem 5

7.32/18/173

147 | 115 | >300

7.3 | 7 | 23.55

• 71M with a history of HFrEF (15%) who presents with 5 days of lethargy, altered mental status. Hypothermic on arrival.
Problem 5

1. Acidosis or alkalosis?
   *Acidosis*

2. Metabolic or respiratory?
   *Metabolic*

3. Gap or non-gap?
   
   147 - 115 - 7 = 25
   *GAP*

4. Appropriate resp compensation?
   
   Exp pCO2 =
   
   \[(1.5 \times 7) + 8 = 18.5 +/\text{-}2\]
   *Appropriate respiratory compensation*

5. Delta-Delta
   
   $\Delta$ Anion gap = 25-12 = 13
   $\Delta$ bicarb = 24-7 = 17
   *Co-existing non-gap metabolic acidosis*
Problem 5

7.32/18/173

147 | 115 | >300
7.3 | 7 | 23.55

- 71M with a history of HFrEF (15%) who presents with 5 days of lethargy, altered mental status. Hypothermic on arrival.

1. Anion gap metabolic acidosis with appropriate respiratory compensation
2. Non-gap metabolic acidosis
Problem 6

7.53/12/92

- 35F with hx of bipolar disorder presents with tinnitus, vertigo, nausea, vomiting, and diarrhea

<table>
<thead>
<tr>
<th>135</th>
<th>100</th>
<th>35</th>
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<tbody>
<tr>
<td>5.0</td>
<td>10</td>
<td>2.1</td>
</tr>
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</table>
Problem 6

1. Acidosis or alkalosis?
   \( \text{alkalosis} \)

2. Metabolic or respiratory?
   \( \text{Respiratory} \)

3. Acute or chronic?
   pCO2 has decreased by 20
   \( \text{Expected pH if ACUTE} \)
   \[ 0.08 \times 2 = 0.16 \rightarrow 7.4 + 0.16 = 7.56 \]
   \( \text{Expected pH if CHRONIC} \)
   \[ 0.03 \times 2 = 0.06 \rightarrow 7.4 + 0.06 = 7.46 \]
   \( \text{Acute resp alkalosis} \)

4. Appropriate renal compensation?
   \( \text{For every 10 dec in pCO2, bicarb will go down by 1 for an acute process but bicarb has decreased by 14 instead of 2} \)
   \( \text{Co-existing metabolic acidosis} \)

5. Gap or non-gap?
   135-100-10 = 25
   \( \text{GAP} \)

6. Delta-Delta
   \( \Delta \text{Anion gap} = 25-12 = 13 \)
   \( \Delta \text{bicarb} = 24-10 = 14 \)
   \( \text{No co-existing metabolic process} \)
Problem 6

7.53/12/92

135 | 100 | 35
---|---|---
5.0 | 10 | 2.1

- 35F with hx of bipolar disorder presents with tinnitus, vertigo, nausea, vomiting, and diarrhea

1. Acute respiratory alkalosis
2. Gap metabolic acidosis
Problem 7

7.63/30/90

134 | 88
4.0 | 31

What is the most likely diagnosis??

A. COPD + sepsis
B. Pregnancy + hyperemesis
C. Liver disease + renal failure
D. COPD + diuretics
Problem 7

1. Acidosis or alkalosis?
   Alkalosis

2. Metabolic or respiratory?
   Respiratory AND Metabolic
Problem 7

What is the most likely diagnosis??

A. COPD + sepsis

B. Pregnancy + hyperemesis

C. Liver disease + renal failure

D. COPD + diuretics

Metabolic alkalosis and respiratory alkalosis
Questions?