Metabolic Alkalosis

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*The Fluid, Electrolyte and Acid-Base Companion,* S. Faubel and J. Topf, [http://www.pbfluids.com](http://www.pbfluids.com)
A 76 year old nursing home resident with h/o COPD is admitted to the hospital with severe gastroenteritis, and is noted to have a high serum $\text{HCO}_3^-$. An ABG is ordered:

**ABG:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.47</td>
</tr>
<tr>
<td>$\text{pCO}_2$</td>
<td>46</td>
</tr>
<tr>
<td>$\text{HCO}_3^-$</td>
<td>32</td>
</tr>
<tr>
<td>$\text{pO}_2$</td>
<td>96</td>
</tr>
</tbody>
</table>

**BMP:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Na}^+$</td>
<td>130</td>
</tr>
<tr>
<td>$\text{K}^+$</td>
<td>3.2</td>
</tr>
<tr>
<td>$\text{Cl}^-$</td>
<td>86</td>
</tr>
<tr>
<td>$\text{HCO}_3^-$</td>
<td>33</td>
</tr>
</tbody>
</table>

Urine pH 5.5

**What is causing elevated serum $\text{HCO}_3^-$:**

A. Compensated metabolic alkalosis

B. Metabolic alkalosis w respiratory acidosis

C. Metabolic alkalosis w anion gap metabolic acidosis
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- pH 7.47
- pCO$_2$ 46
- HCO$_3^-$ 32
- pO$_2$ 96

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- Na$^+$ 130
- K$^+$ 3.2
- Cl$^-$ 86
- HCO$_3^-$ 33

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Metabolic Alkalosis: mechanism

Generation

- Addition of bicarbonate
- Contraction alkalosis
- Loss of hydrogen
Metabolic Alkalosis: maintenance

- Excess mineralocorticoid activity
- Hypovolemia
- Inability to excrete excess bicarbonate
- Hypokalemia
- Hypochloremia
Metabolic Alkalosis: classification

Chloride (saline) responsive

Chloride (saline) resistant
Metabolic Alkalosis: diagnosis

**Diagnosis** The urine chloride concentration distinguishes saline-responsive from saline-resistant metabolic alkalosis.

**Saline-responsive**
- Urine Cl⁻ < 20 mEq/L
- Urine Na⁺ > 20 mEq/L

**Saline-resistant**
- Urine Cl⁻ > 20 mEq/L
- Urine Na⁺ > 20 mEq/L
Metabolic Alkalosis: chloride (saline) responsive

- Associated with volume depletion
Metabolic Alkalosis: chloride (saline) resistant

- Not associated with volume depletion
Unexplained metabolic alkalosis

- Surreptitious vomiting
- Diuretics abuse
- Laxatives abuse
- Licorice abuse
- Hyperaldosteronism states
A 56 year old man with a 25-pack-year smoking history, h/o CVA and a 10-year h/o HTN treated with chlorthalidone, presents with generalized fatigue. BP is 110/70
Na 128, K 3.3, Cl 79, bicarb 38
pH 7.50, PCO₂ 50, PO₂ 74

Which condition best explains the acid-base disturbance?

A. Metabolic alkalosis induced by diuretic use
B. Respiratory acidosis induced by COPD
C. Neurogenic-induced respiratory alkalosis
D. Primary hyperaldosteronism
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Which hormone caused this disorder:

A. Aldosterone
B. Cortisol
C. Dihydrotestosterone
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Serum: Na 135, K 3.0, Cl 80, bicarb 40,
Plasma aldosterone 32.8 ng/dl, plasma renin activity 89 ng/ml/hr
Urine: Na 50, K 20, Cl 5, pH 7.0

Which of the following is the most likely cause of these laboratory abnormalities?
A. Recent ingestion of furosemide
B. Recent episode of vomiting
C. Laxative abuse
D. Bartter syndrome
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Metabolic Alkalosis: Why use urine Cl\(^-\), not urine Na\(^+\)?

- Typically, both \( U_{Na} \) and \( U_{Cl} \) will be low in volume depletion.
- However, in metabolic alkalosis, there might be dissociation between \( U_{Na} \) and \( U_{Cl} \).
- During bicarbonate urine dump (think vomiting), \( Na^+ \) will be wasted with \( HCO_3^- \), and \( U_{Na} \) will be elevated.
A 50 year old man is seen in your office after vomiting x 5 days due to viral gastroenteritis. He last vomited 24 hrs ago. Physical exam reveals BP 110/70 supine and 95/60 standing, reduced skin turgor, and weight is 3 kg below his baseline. Which set of labs fits best with this clinical scenario?

Case:

Set A

<table>
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<tr>
<td>Cr</td>
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<tr>
<td>Na</td>
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</tr>
<tr>
<td>K</td>
<td>3.2</td>
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<tr>
<td>Cl</td>
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<td>HCO3</td>
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Set B

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</tr>
<tr>
<td>Cr  1.2</td>
<td>Cr  1.2</td>
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<tr>
<td>Na  141</td>
<td>Na  141</td>
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<tr>
<td>K  3.2</td>
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<tr>
<td>Cl  90</td>
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<td>PCO2 48</td>
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<td>UNa 10</td>
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<td>UK 35</td>
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</tr>
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<td>UCl 10</td>
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</tr>
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<td>UpH 5.0</td>
<td>UpH 7.0</td>
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Case

- You admit the patient to the hospital and start IV 0.9% NaCl and KCl. You repeat labs in 6 hrs

- Labs reveal:

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<thead>
<tr>
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<tbody>
<tr>
<td>BUN</td>
<td>20 mg/dl</td>
</tr>
<tr>
<td>Cr</td>
<td>1.0 mg/dl</td>
</tr>
<tr>
<td>Na</td>
<td>141 meq/L</td>
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<tr>
<td>K</td>
<td>3.5 meq/L</td>
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<tr>
<td>Cl</td>
<td>95 meq/L</td>
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<td>HCO₃⁻</td>
<td>30 meq/L</td>
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<td>pH</td>
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<td>PCO₂</td>
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<td>U_Na</td>
<td>35 meq/L</td>
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<tr>
<td>U_K</td>
<td>40 meq/L</td>
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<tr>
<td>U_Cl</td>
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A 35 yo man who has been healthy presents with severe flank pain and hematuria after a softball outing. The pain is sharp and radiates to the groin. He vomited 8 times *en route*. He is found to have a Lt UPJ stone. On presentation, BP is 130/90 and HR 110.

BUN 24, cr 0.9, Na 141, K 4, Cl 100, bicarb 34 U Na 20, U Cl 3, U K 20

ABG 7.61, PCO2 36

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B. Respiratory alkalosis  
C. Both metabolic and respiratory alkalosis  
D. Metabolic and respiratory alkalosis, with hidden metabolic acidosis
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A 46-yo man w a 20-year history of HTN. H/o hypokalemia and IBS. He takes amlodipine 5 mg/d.
WD/WN, BP 150/88, HR 74. Hypertensive retinopathic changes.
Laboratory studies:
Na 142, K 2.7, Cl 105, bicarb 30
UA: pH 5.0; SG1020; dipstick negative for protein and blood
24-hour urine: Cr 1200 mg, Na 100 meq, K 82 meq, Ca 200 mg

What is the most likely cause of this patient’s hypokalemia?
A. Distal renal tubular acidosis
B. Primary hyperaldosteronism
C. Gitelman’s syndrome
D. Diarrhea
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pH 7.29, PCO₂ 25

What is acid-base disturbance?

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C. Anion gap metabolic acidosis and metabolic alkalosis
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