The Year in Review Series: Case 4. Acid-Base Disturbance
Case-based NBME review

$$[H+] = 24 \times \frac{pCO2}{[HCO3]}$$

Howard J. Sachs, MD
www.12DaysinMarch.com
E-mail: Howard@12daysinmarch.com

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Case-based NBME review

$$[H+] = 24 \times \frac{pCO2}{[HCO3]}$$

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Tutorial Services
(see website for details)

	Ref Range & Units	10:44 AM
NA	135 - 145 mmol/L	137
K	3.5 - 5.3 mmol/L	4.5
Cl	97 - 110 mmol/L	95 (L)
CO2	24 - 32 mmol/L	38 (H)
BUN	7 - 23 mg/dL	9
Creatinine	0.60 - 1.30 mg/dL	1.02
Glucose	70 - 99 mg/dL	69 (L)
Calcium	8.7 - 10.7 mg/dL	9.3
Anion Gap	5 - 15	4 (L)

Choose the least likely scenario to explain these laboratory findings.

1. Diuretic use
2. Vomiting
3. Diarrhea
4. Refractory Hypertension
5. SLE on glucocorticoids

Note: on chemistry panels, serum HCO_3^- is expressed as CO2.
The laboratory measures total serum CO2, 95% of which is HCO_3^-

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To confirm you clinical suspicions, further diagnostics are obtained. The patient is noted with a low urinary chloride level. Which of the following is most likely?

1. Spironolactone use
2. Vomiting
3. Refractory Hypertension
4. SLE on glucocorticoids

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Anion Gap	5 - 15	4 (L)

An arterial blood gas analysis is obtained.

7.35 – 50 (pCO_2) – 38 (HCO_3^-)

Choose the correct acid-base disturbance:

1. Respiratory Acidosis, Compensated
2. Respiratory Acidosis, Metabolic Alkalosis
3. Metabolic Acidosis, Compensated
4. Metabolic Acidosis, Respiratory Alkalosis
5. Respiratory Acidosis, Metabolic Acidosis
6. Metabolic Alkalosis, Compensated

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Anion Gap	5 - 15	4 (L)

An arterial blood gas analysis is obtained.

7.35 – 50 – 38

Choose the least likely clinical scenario:

1. COPDer with hydrochlorothiazide
2. COPDer on steroids
3. COPDer with vomiting
4. COPDer on acetazolamide
5. COPDer on furosemide

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Anion Gap	5 - 15	4 (L)

Choose the least likely scenario to explain these laboratory findings.

Step One: Determine the Primary Acid-Base Disturbance

1. Diuretic use
2. Vomiting
3. Diarrhea
4. Refractory Hypertension
5. SLE on glucocorticoids

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Anion Gap	5 - 15	4 (L)

Choose the least likely scenario to explain these laboratory findings.

Step One: Determine the Primary Acid-Base Disturbance

High $HCO3^-$: Metabolic Alkalosis

$$\downarrow [H+] = 24 \times \frac{pCO2}{[HCO3]} \uparrow$$

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Anion Gap	5 - 15	4 (L)

Choose the least likely scenario to explain these laboratory findings.

Step One: Determine the Primary Acid-Base Disturbance

High HCO3-: Metabolic Alkalosis OR Compensation for Respiratory Acidosis

$$\uparrow [H+] = 24 \times \frac{pCO2}{[HCO3]} \uparrow$$

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Choose the least likely scenario to explain these laboratory findings.

Step One: Determine the Primary Acid-Base Disturbance

High HCO3-: Metabolic Alkalosis OR Compensation for Respiratory Acidosis

$$\uparrow [H+] = 24 \times \frac{pCO2 \uparrow}{[HCO3]}$$

Bicarbonate will rise to compensate. That is, normalize the [H+]

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Choose the least likely scenario to explain these laboratory findings.

1. Diuretic use
2. Vomiting
3. Diarrhea
4. Refractory Hypertension
5. SLE on glucocorticoids

<u>Metabolic Alkalosis</u>
Volume Contraction
Vomiting
Mineralocorticoid excess (aldosterone, cortisol)

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Anion Gap	5 - 15	4 (L)

Choose the least likely scenario to explain these laboratory findings.

1. Diuretic use
2. Vomiting
3. Diarrhea → Loss of HCO_3^- in stool

4. Refractory Hypertension
5. SLE on glucocorticoids

<u>Metabolic Alkalosis</u>
Volume Contraction
Vomiting
Mineralocorticoid excess (aldosterone, cortisol)

	Ref Range & Units	10:44 AM
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Anion Gap	5 - 15	4 (L)

Choose the least likely scenario to explain these laboratory findings.

1. Diuretic use
2. Vomiting
3. Diarrhea → Loss of HCO_3^- in stool → non-anion gap metabolic acidosis
4. Refractory Hypertension
5. SLE on glucocorticoids

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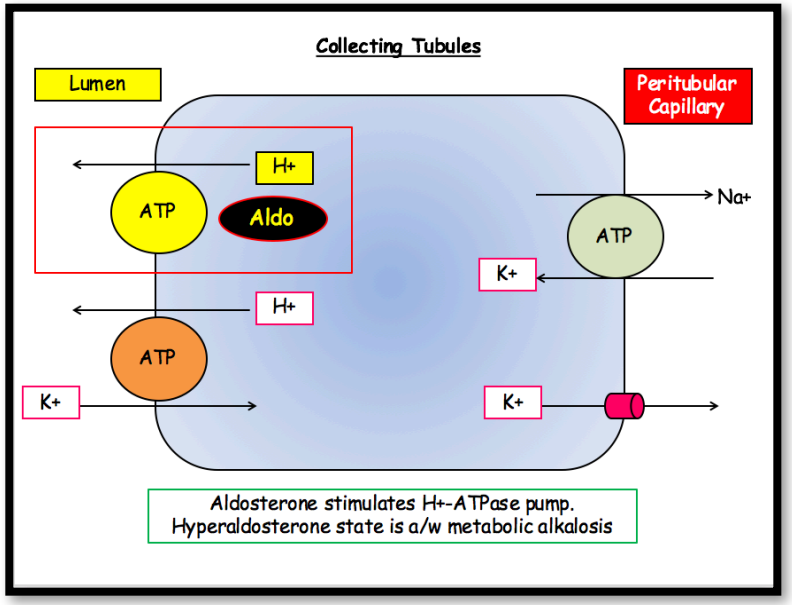

1. Diuretic use ☆
2. Vomiting
3. Diarrhea
4. Refractory Hypertension ☆
5. SLE on glucocorticoids ☆

☆ Mineralocorticoids stimulate H^+-ATPase pump (collecting tubule)

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Choose the least likely scenario to explain these laboratory findings.

1. Diuretic use
2. Vomiting ☆

4. Refractory Hypertension
5. SLE on glucocorticoids

Vomit HCL^- → Loss of H^+ ions

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Choose the least likely scenario to explain these laboratory findings.

1. Diuretic use
2. Vomiting ☆

4. Refractory Hypertension
5. SLE on glucocorticoids

Vomit HCL^- → Loss of H^+ ions
Volume Contraction

→

Mineralocorticoids stimulate
H^+-ATPase pump (collecting tubule)

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Anion Gap	5 - 15	4 (L)

To confirm you clinical suspicions, further diagnostics are obtained. The patient is noted with a low urinary chloride level. Which of the following is most likely?

1. Spironolactone use
2. Vomiting: volume deplete; maximum reabsorption of Na^+ and Cl^-
3. Refractory Hypertension
4. SLE on glucocorticoids

	Ref Range & Units	10:44 AM
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Anion Gap	5 - 15	4 (L)

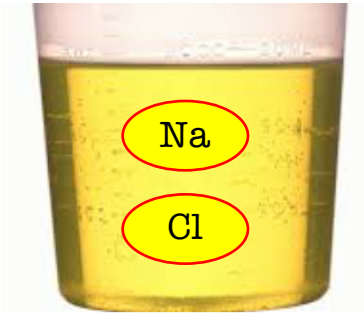
To confirm you clinical suspicions, further diagnostics are obtained. The patient is noted with a low urinary chloride level. Which of the following is most likely?

2. Vomiting
3. Refractory Hypertension
4. SLE on glucocorticoids

} Volume replete → escape (↑ Ur Cl^-)

Aldosterone Escape

Hyperaldosteronism → Volume Expansion



Choose One:
1. Waste Na and Cl
2. Explode

2. Vomiting
3. Refractory Hypertension
4. SLE on glucocorticoids

} Volume replete → escape (↑ Ur Cl^-)

Aldosterone Escape

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2. Vomiting
3. Refractory Hypertension
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} Volume replete → escape (↑ Ur Cl^-)

Take Home:

Volume Depletion: suck up Na and Cl; result – low urine chloride

Volume Replete: dump the excess Na and Cl – elevated urine chloride

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Anion Gap	5 - 15	4 (L)

To confirm you clinical suspicions, further diagnostics are obtained. The patient is noted with a low urinary chloride level. Which of the following is most likely?

1. Spironolactone use: Non-anion gap, metabolic acidosis (blocks aldosterone receptor)
2. Vomiting
3. Refractory Hypertension
4. SLE on glucocorticoids

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An arterial blood gas analysis is obtained.

7.35 – 50 (pCO_2) – 38 (HCO_3^-)

Choose the correct acid-base disturbance:

Step One: is pH acidotic or alkalotic?

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7.35 – 50 – 38

Choose the correct acid-base disturbance:

Step One: is pH acidosis

Step Two. What is the primary disturbance: metabolic or respiratory?

pCO2 = 50 torr

HCO_3^- = 38 mmol/L

$$\uparrow [H+] = 24 \times \frac{pCO2}{[HCO3]}$$

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Anion Gap	5 - 15	4 (L)

An arterial blood gas analysis is obtained.

7.35 – 50 – 38

Choose the correct acid-base disturbance:

Step One: is pH acidosis

Step Two. What is the primary disturbance: metabolic or respiratory?

Respiratory Acidosis
pCO2 = 50 torr

Is this a simple or mixed acid-base disturbance?

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An arterial blood gas analysis is obtained.

7.35 – 50 – 38

Choose the correct acid-base disturbance:

Step One: pH acidosis	
Step Two: Respiratory Acidosis	pCO2 = 50 torr (nl 40 torr)
Step Three: Expected Compensation?	pCO2 ↑ 10 torr

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An arterial blood gas analysis is obtained.

7.35 – 50 – 38

Choose the correct acid-base disturbance:

Step One: is pH acidosis

Step Two: Respiratory Acidosis

pCO2 = 50 torr

Step Three: Expected Compensation?

pCO2 ↑ 10 torr

HCO_3^- will increase 1 (acute) or 3 (chronic) for every 10 torr increase

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7.35 – 50 – 38

Choose the correct acid-base disturbance:

Respiratory Acidosis is Bad Luck

Step One: is pH acidosis

Step Two: Respiratory Acidosis

pCO2 = 50 torr

Step Three: Expected Compensation?

pCO2 ↑ 10 torr

HCO3- will increase 1 (acute) or 3 (chronic) for every 10 torr increase

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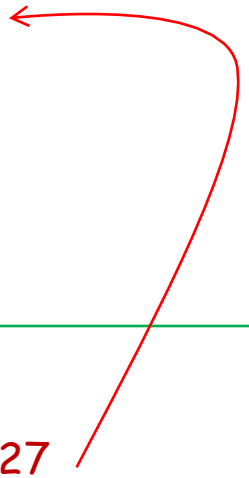

An arterial blood gas analysis is obtained.

7.35 – 50 – 38 Expected HCO3 = 27

Choose the correct acid-base disturbance:

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Anion Gap	5 - 15	4 (L)

An arterial blood gas analysis is obtained.

Respiratory Acidosis: 7.35 – 50 – 38 Metabolic Alkalosis:

Choose the correct acid-base disturbance:

1. Respiratory Acidosis, Compensated
2. Respiratory Acidosis, Metabolic Alkalosis
3. Metabolic Acidosis, Compensated
4. Metabolic Acidosis, Respiratory Alkalosis
5. Respiratory Acidosis, Metabolic Acidosis
6. Metabolic Alkalosis, Compensated

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An arterial blood gas analysis is obtained.

Respiratory Acidosis:
COPD
Hypoventilation

7.35 – 50 – 38

Metabolic Alkalosis:
Volume Contraction/Loss of H+
Mineralocorticoid excess

Choose the least likely clinical scenario:

1. COPDer with hydrochlorothiazide
2. COPDer on steroids
3. COPDer with vomiting
4. COPDer on acetazolamide: NAG MA (Proximal RTA; Type II)
5. COPDer on furosemide

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Anion Gap	5 - 15	4 (L)

An arterial blood gas analysis is obtained.

Respiratory Acidosis:
COPD
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Metabolic Alkalosis:
Volume Contraction/Loss of H+
Mineralocorticoid excess

Choose the least likely clinical scenario:

1. COPDer with hydrochlorothiazide
2. COPDer on steroids
3. COPDer with vomiting

5. COPDer on furosemide

Choose the least likely scenario to explain these laboratory findings.

An arterial blood gas analysis is obtained.

7.35 – 50 – 38

Choose the correct acid-base disturbance:

Metabolic Alkalosis:
Recognizing the causes
Practicing compensation for mixed disturbances

Step One: pH is acidosis or alkalosis

Step Two: determine the primary disturbance

Step Three: Calculate the expected compensation?

To confirm you clinical suspicions, further diagnostics are obtained. The patient is noted with a low urinary chloride level. Which of the following is most likely?

An arterial blood gas analysis is obtained.

7.35 – 50 – 38

Choose the least likely clinical scenario:

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Case-based NBME review

$$[H+] = 24 \times \frac{pCO2}{[HCO3]}$$

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