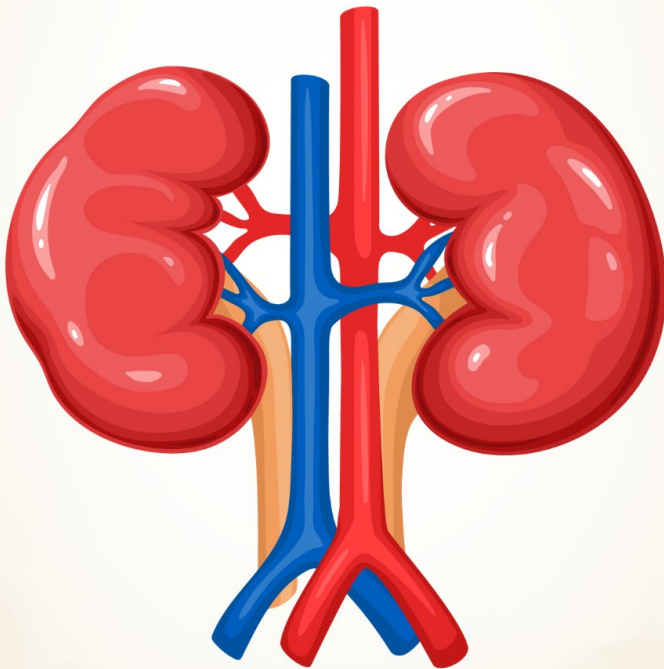




Internal Medicine



Topic : ABG approach and cases

Done by : Johainah Taha

The 6-Step Approach to ABGs

Step 1: Assess Validity

Before analyzing the ABG, ask yourself:

1. Does this ABG make sense?
2. Are the numbers physiologically possible?

◆ Methods to check validity:

- Clinical Judgment → Does this ABG fit the patient's symptoms?
- Henderson-Hasselbalch Equation (for advanced validation)

$$pH = 6.1 + \log \left(\frac{HCO}{0.03 \times PaCO_2} \right)$$

- If the calculated pH is far from the given pH, the sample may have errors (e.g., air contamination, venous blood instead of arterial).

◆ Example:

A patient with COPD and severe respiratory distress has an ABG:

- pH = 7.65
- $PaCO_2 = 80$ mmHg
- $HCO_3^- = 39$ mEq/L
- The pH is alkalotic, but high $PaCO_2$ should cause acidosis. There's a mismatch! This suggests a lab error or mixed disorder —recheck the sample.

Step 2: Acidemia or Alkalemia

Look at the pH to determine the primary disturbance:

- pH < 7.35 → Acidemia
- pH > 7.45 → Alkalemia
- pH normal (7.35–7.45)? → Could be compensated

◆ Example:

ABG results:

- pH = 7.28
- $PaCO_2 = 60$ mmHg
- $HCO_3^- = 30$ mEq/L
- Since pH < 7.35, we have acidemia

Step 3: Metabolic or Respiratory?

Now, determine which system is causing the pH disturbance:

1. Metabolic Disorder → HCO_3^- is abnormal

- Low HCO_3^- = Metabolic Acidosis
- High HCO_3^- = Metabolic Alkalosis
- 2. Respiratory Disorder → $PaCO_2$ is abnormal

- High $PaCO_2$ = Respiratory Acidosis (hypoventilation)
- Low $PaCO_2$ = Respiratory Alkalosis (hyperventilation)

Handwritten notes on ABG analysis:

ABG 6 Steps

- ① Validity = $6.1 + \log \left(\frac{HCO_3^-}{0.03 \times PaCO_2} \right) = pH$
- ② pH = acidosis / alkalosis / compensation
→ Mixed
- ③ Metabolic or Respiratory: $\rightarrow$ direction
- ④ Compensation:
 - pH normal, values abnormal → Mixed
 - Values same direction → Compensation
 - opposite → Uncompensated
- ⑤ Chronic vs acute
 - $CO_2 : HCO_3^-$
 - 10 : 11-12 → Acute
 - 10 : 13-15 → Chronic
- ⑥ Anion Gap → $MA_{AG} = Na^+ - (Cl^- + HCO_3^-)$
- ⑦ $\Delta/D \rightarrow$ Mixed → to check having 2nd disorder
 - $\Delta AG = \frac{O - 12}{24 - O} = \frac{O - 12}{24 - O}$
 - $\Delta HCO_3^- = \frac{O - 12}{24 - O}$
 - 1: Pure MA
 - 1: MAK hidden @ Alk Acidosis
 - 1: normal AG @ Respiratory

AG = 24, $HCO_3^- = 18$, $\Delta AG = \frac{24 - 12}{24 - 12} = \frac{12}{12} = 1$

✓ metabolic alkalosis → vomiting

✓ AG acidosis → DKA

Goals

- ☒ CVS
- ☒ GI
- ☐ Kidney
- ☐ Kidney
- ☐ Respiratory
- ☐ Rheumatoid
- ☐ Endocrine
- ☐ Hematology
- ☐ Respiratory

Cholesterol → HPS
Calcium → HPS
Sodium → HPS
Kidney → HPS

◆ Example:

ABG:

- pH = 7.28 (Acidemia)
- PaCO₂ = 60 mmHg (↑) → Retaining CO₂
- HCO₃⁻ = 30 mEq/L (↑) → Compensation

Since PaCO₂ is driving the pH change, this is Respiratory Acidosis.

🟢 **Step 4: Check Compensation**

The body tries to balance the pH using compensation:

- Metabolic disorders → Lungs compensate by changing PaCO₂
- Respiratory disorders → Kidneys compensate by changing HCO₃⁻

📌 **Key Rule:**

- Compensation NEVER fully normalizes pH
- If pH is normal but values are abnormal, there's a mixed disorder

◆ Expected Compensation Rules:

1. Metabolic Acidosis:

- Winter's Formula (expected PaCO₂): $PaCO_2 = (1.5 \times HCO_3^-) + 8 \pm 2$

2. Metabolic Alkalosis:

- Expected PaCO₂ = (0.7 × HCO₃⁻) + 20

3. Acute Respiratory Acidosis:

- HCO₃⁻ increases by 1 for every 10 mmHg ↑ in PaCO₂

4. Chronic Respiratory Acidosis:

- HCO₃⁻ increases by 3-4 for every 10 mmHg ↑ in PaCO₂

5. Acute Respiratory Alkalosis:

- HCO₃⁻ decreases by 2 for every 10 mmHg ↓ in PaCO₂

6. Chronic Respiratory Alkalosis:

- HCO₃⁻ decreases by 4-5 for every 10 mmHg ↓ in PaCO₂

◆ Example:

A patient has:

- pH = 7.30 (Acidemia)
- HCO₃⁻ = 12 mEq/L (↓) → Metabolic Acidosis
- PaCO₂ = 30 mmHg

Using Winter's Formula:

$$(1.5 \times 12) + 8 = 26 \pm 2$$

→ Expected PaCO₂ = 24 - 28 mmHg

→ Since actual PaCO₂ is 30, the compensation is appropriate.

🟢 Step 5: Calculate the Anion Gap (AG).

This helps identify the cause of metabolic acidosis:

$$AG = Na^+ - (Cl^- + HCO_3^-)$$

📌 Normal AG: 8 - 12 mEq/L

📌 High AG Metabolic Acidosis (HAGMA) → MUDPILES

- Methanol
- Uremia
- Diabetic Ketoacidosis
- Propylene glycol
- Isoniazid, Iron
- Lactic Acidosis
- Ethylene Glycol
- Salicylates

📌 Normal AG Metabolic Acidosis (NAGMA) → HARDASS

- Hyposalinemia
- Acetazolamide
- Renal Tubular Acidosis
- Diarrhea
- Adrenal Insufficiency
- Spironolactone
- Saline Infusion

💡 Example:

ABG:

- $Na^+ = 140$
- $Cl^- = 104$
- $HCO_3^- = 12$

$$AG = 140 - (104 + 12) = 24$$

→ High AG Metabolic Acidosis (likely DKA or lactic acidosis).

🟢 Step 6: Delta/Delta (Δ/Δ) - Detecting Mixed Disorders

If there's AG metabolic acidosis, check if there's a second metabolic disorder: E

$$\left(\frac{\Delta AG}{\Delta HCO} = \frac{(AG - 12)}{(24 - HCO)} \right)$$

📌 Rules:

- $\Delta/\Delta = 1 \rightarrow$ Pure AG Metabolic Acidosis
- $\Delta/\Delta > 1 \rightarrow$ Metabolic Alkalosis + AG Acidosis
- $\Delta/\Delta < 1 \rightarrow$ Normal AG Acidosis + AG Acidosis

💡 Example:

• AG = 24 (High) → AG Acidosis

• $HCO_3^- = 18$ (Mildly Low)

$$\Delta/ = \frac{(24 - 12)}{(24 - 18)} = 12/6 = 2$$

Conclusion: This suggests a metabolic alkalosis on top of AG acidosis (e.g., DKA with vomiting).

ABG cases

6-steps approach

6-steps approach

- **Step 1: Assess Validity** (using the Henderson-Hasselbalch equation or clinical judgment).
- **Step 2: Acidemia or Alkalemia**

Determine pH: $\text{pH} < 7.35$: Acidemia. $\text{pH} > 7.45$: Alkalemia.

- **Step 3: Metabolic or Respiratory**

Determine the primary disorder: Metabolic: HCO_3^- is abnormal (low for acidosis, high for alkalosis). Respiratory: PaCO_2 is abnormal (high for acidosis, low for alkalosis).

- **Step 4: Check Compensation**
- **Step 5: Calculate the Anion Gap**

Anion Gap (AG) = $\text{Na}^+ - (\text{Cl}^- + \text{HCO}_3^-)$: Normal AG: 8-12 mEq/L. Elevated AG suggests a primary metabolic acidosis

- **Step 6: Delta/Delta**

Evaluate Delta Gap (Delta/Delta): $\Delta\text{AG}/\Delta\text{HCO}_3^-$: Assess if there is an additional metabolic disorder (metabolic alkalosis with an AG metabolic acidosis).

Case 1

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.31
- PaCO₂: 55 mmHg
- HCO₃⁻: 28 mEq/L
- Na⁺: 138 mEq/L
- Cl⁻: 105 mEq/L

Step	Analysis	Finding
Step 1	Check validity	 Valid ABG
Step 2	Acidemia/Alkalemia	Acidemia (pH 7.31)
Step 3	Metabolic vs Respiratory	Respiratory Acidosis ($\text{PaCO}_2 = 55$, $\text{HCO}_3^- = 28$)
Step 4	Compensation	Chronic compensation (HCO_3^- appropriately elevated)
Step 5	Anion Gap	Normal (AG = 5), no AG metabolic acidosis
Step 6	Delta/Delta	Not needed (no AG acidosis)
Final Diagnosis	Chronic Respiratory Acidosis (likely COPD or hypoventilation syndrome)	

Case 2

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.50
- PaCO₂: 29 mmHg
- HCO₃⁻: 24 mEq/L
- Na⁺: 140 mEq/L
- Cl⁻: 100 mEq/L

Step	Analysis	Finding
Step 1	Check validity	✅ Valid ABG
Step 2	Acidemia/Alkalemia	Alkalemia (pH 7.50)
Step 3	Metabolic vs Respiratory	Respiratory Alkalosis (PaCO₂ = 29, HCO₃⁻ = 24)
Step 4	Compensation	No significant compensation → Acute Respiratory Alkalosis
Step 5	Anion Gap	Elevated (AG = 16) → Suggests High AG Metabolic Acidosis
Step 6	Delta/Delta	Suggests concurrent metabolic alkalosis
Final Diagnosis	Acute Respiratory Alkalosis + High AG Metabolic Acidosis + Metabolic Alkalosis	✅

Case 3

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.28
- PaCO₂: 27 mmHg
- HCO₃⁻: 15 mEq/L
- Na⁺: 135 mEq/L
- Cl⁻: 100 mEq/L

Step	Value/Calculation	Interpretation
1. Check Validity	pH 7.28, PaCO ₂ 27, HCO ₃ ⁻ 15	Valid results (pH and components are internally consistent).
2. Acidemia/Alkalemia	pH = 7.28 (< 7.35)	Acidemia (blood is acidic).
3. Determine Primary Disorder	- pH ↓, PaCO ₂ ↓, HCO ₃ ⁻ ↓	Primary Metabolic Acidosis (low HCO ₃ ⁻ drives pH down; PaCO ₂ compensates by ↓).
4. Compensation	Expected PaCO₂ = (1.5 × HCO ₃ ⁻) + 8 ± 2 = 30.5 ± 2	Actual PaCO ₂ = 27 (within range). Appropriate respiratory compensation.
5. Anion Gap (AG)	AG = Na ⁺ – (Cl ⁻ + HCO ₃ ⁻) = 135 – (100 + 15) = 20	Elevated AG (≥12) → Indicates high-AG metabolic acidosis.
6. Delta-Delta (Δ/Δ)	ΔAG = AG – 12 = 8 ; ΔHCO ₃ ⁻ = 24 – 15 = 9	ΔAG/ΔHCO ₃ ⁻ ≈ 0.9 (0.8–1.0 suggests pure high-AG metabolic acidosis) ✓

Case 4

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.46
- PaCO₂: 50 mmHg
- HCO₃⁻: 34 mEq/L
- Na⁺: 139 mEq/L
- Cl⁻: 96 mEq/L

Step	Value/Calculation	Interpretation
1. Check Validity	pH 7.46, PaCO ₂ 50, HCO ₃ ⁻ 34	Valid results (pH and components are internally consistent).
2. Acidemia/Alkalemia	pH = 7.46 (> 7.45)	Alkalemia (blood is alkaline).
3. Determine Primary Disorder	- pH ↑, PaCO ₂ ↑, HCO ₃ ⁻ ↑	Primary Metabolic Alkalosis (high HCO ₃ ⁻ drives pH up; PaCO ₂ compensates by ↑).
4. Compensation	Expected PaCO₂ = (0.7 × HCO ₃ ⁻) + 20 ± 1.5 = 44 ± 1.5	Actual PaCO ₂ = 50 (slightly high). Partial respiratory compensation (may have concurrent respiratory acidosis).
5. Anion Gap (AG)	AG = Na ⁺ – (Cl ⁻ + HCO ₃ ⁻) = 139 – (96 + 34) = 9	Normal AG (3–11) → Suggests non-gap metabolic alkalosis .
6. Delta-Delta (Δ/Δ)	Not applicable (normal AG).	N/A (Delta-delta used only for high-AG metabolic acidosis).

Case 5

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.60
- PaCO₂: 22 mmHg
- HCO₃⁻: 24 mEq/L
- Na⁺: 141 mEq/L
- Cl⁻: 104 mEq/L

Step	Analysis	Finding
Step 1	Check validity	✅ Valid ABG
Step 2	Acidemia/Alkalemia	Alkalemia (pH 7.60)
Step 3	Metabolic vs Respiratory	Respiratory Alkalosis ($\text{PaCO}_2 = 22$, $\text{HCO}_3^- = 24$)
Step 4	Compensation	No significant compensation → Acute Respiratory Alkalosis
Step 5	Anion Gap	Slightly elevated (AG = 13), but not clinically significant
Step 6	Delta/Delta	Not needed (no AG metabolic acidosis)
Final Diagnosis	Acute Respiratory Alkalosis (likely hyperventilation, pulmonary embolism, or anxiety attack)	✅

Case 6

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.30
- PaCO₂: 35 mmHg
- HCO₃⁻: 18 mEq/L
- Na⁺: 137 mEq/L
- Cl⁻: 99 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.30, PaCO ₂ 35, HCO ₃ ⁻ 18	Valid
2. Acidemia	pH = 7.30	Acidemia
3. Primary Disorder	pH ↓, HCO ₃ ⁻ ↓, PaCO ₂ NI	Metabolic Acidosis
4. Compensation	Expected PaCO ₂ = 1.5×18 + 8 = 35	Appropriate respiratory compensation (matches actual PaCO ₂)
5. Anion Gap	AG = 137 - (99 + 18) = 20	High AG Metabolic Acidosis (≥12)
6. Delta-Delta	ΔAG=8, ΔHCO ₃ ⁻ =6, Ratio=1.33	Concurrent Non-Gap Acidosis (ratio >1 suggests mixed high-AG + normal-AG acidosis)

Case 7

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.22
- PaCO₂: 60 mmHg
- HCO₃⁻: 25 mEq/L
- Na⁺: 136 mEq/L
- Cl⁻: 98 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.22, PaCO ₂ 60, HCO ₃ ⁻ 25	Valid
2. Acidemia	pH = 7.22	Severe Acidemia
3. Primary Disorder	pH ↓, PaCO ₂ ↑, HCO ₃ ⁻ NI	Respiratory Acidosis (acute)
4. Compensation	Acute: $\Delta\text{HCO}_3^- = 0.1 \times \Delta\text{PaCO}_2 = +2$	Expected HCO ₃ ⁻ = 26 (actual 25) - Appropriate
5. Anion Gap	AG = 136 - (98 + 25) = 13	Mildly elevated AG (normal 3-11)
6. Delta-Delta	Not primary metabolic	N/A (respiratory primary)

Final Diagnosis:

Acute Respiratory Acidosis

- Likely causes: Acute hypoventilation (e.g., opioid overdose, asthma exacerbation, neuromuscular weakness)
- Mild AG elevation suggests concurrent lactic acidosis from hypoxia

Case 8

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.55
- PaCO₂: 40 mmHg
- HCO₃⁻: 33 mEq/L
- Na⁺: 140 mEq/L
- Cl⁻: 98 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.55, PaCO ₂ 40, HCO ₃ ⁻ 33	Valid
2. Alkalemia	pH = 7.55	Alkalemia
3. Primary Disorder	pH ↑, HCO ₃ ⁻ ↑, PaCO ₂ NI	Metabolic Alkalosis
4. Compensation	Expected PaCO ₂ = 0.7×33 + 20 = 43	Appropriate respiratory compensation (mild hypoventilation)
5. Anion Gap	AG = 140 - (98 + 33) = 9	Normal AG (3-11)
6. Delta-Delta	N/A	Not applicable (non-gap disorder)

Final Diagnosis:

Primary Metabolic Alkalosis

- Likely causes: Volume depletion (vomiting, diuretics), hypokalemia, or alkali ingestion
- Normal AG suggests chloride-responsive alkalosis

Case 9

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.18
- PaCO₂: 32 mmHg
- HCO₃⁻: 14 mEq/L
- Na⁺: 135 mEq/L
- Cl⁻: 100 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.18, PaCO ₂ 32, HCO ₃ ⁻ 14	Valid
2. Acidemia	pH = 7.18	Severe Acidemia
3. Primary Disorder	pH ↓, HCO ₃ ⁻ ↓, PaCO ₂ ↓	Metabolic Acidosis (primary)
4. Compensation	Expected PaCO ₂ = 1.5×14 + 8 = 29	Appropriate respiratory compensation (mild hyperventilation)
5. Anion Gap	AG = 135 - (100 + 14) = 21	High AG Metabolic Acidosis (≥12)
6. Delta-Delta	ΔAG=9, ΔHCO ₃ ⁻ =10, Ratio=0.9	Pure High-AG Acidosis (ratio 0.8–1.0)

Final Diagnosis:

High Anion Gap Metabolic Acidosis

- Likely causes: Lactic acidosis, ketoacidosis (DKA), toxins (methanol, ethylene glycol)
- Normal respiratory compensation

Case 10

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.35
- PaCO₂: 52 mmHg
- HCO₃⁻: 32 mEq/L
- Na⁺: 137 mEq/L
- Cl⁻: 103 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.35, PaCO ₂ 52, HCO ₃ ⁻ 32	Valid
2. Acid-Base Status	pH = 7.35 (normal)	Compensated Disorder (normal pH with abnormal components)
3. Primary Disorder	PaCO ₂ ↑, HCO ₃ ⁻ ↑	Chronic Respiratory Acidosis (compensated by metabolic alkalosis)
4. Compensation	Expected HCO ₃ ⁻ = 24 + 0.4×(52-40) = 28.8	Actual HCO ₃ ⁻ = 32 (elevated) - Partial metabolic compensation
5. Anion Gap	AG = 137 - (103 + 32) = 2	Low AG (possible hypoalbuminemia, hypercalcemia, or lab error)
6. Delta-Delta	N/A	Not applicable (primary

Final Diagnosis:

Compensated Chronic Respiratory Acidosis

- Likely causes: COPD, obesity hypoventilation syndrome, neuromuscular disorders
- Elevated HCO₃⁻ reflects renal compensation (3-5 days)
- Low AG suggests hypoalbuminemia (common in chronic illness)

Case 11

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.47
- PaCO₂: 48 mmHg
- HCO₃⁻: 30 mEq/L
- Na⁺: 138 mEq/L
- Cl⁻: 97 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.47, PaCO ₂ 48, HCO ₃ ⁻ 30	Valid
2. Alkalemia	pH = 7.47	Mild Alkalemia
3. Primary Disorder	pH ↑, HCO ₃ ⁻ ↑, PaCO ₂ ↑	Metabolic Alkalosis (primary)
4. Compensation	Expected PaCO ₂ = 0.7×30 + 20 = 41	Actual PaCO ₂ = 48 → Inadequate compensation (suggests *concurrent respiratory acidosis*)
5. Anion Gap	AG = 138 - (97 + 30) = 11	Normal AG (3-11)
6. Delta-Delta	N/A	Not applicable (non-gap disorder)

Final Diagnosis:

Mixed Metabolic Alkalosis + Respiratory Acidosis

- **Metabolic Alkalosis** (↑HCO₃⁻): Vomiting, diuretics, or volume depletion.
- **Respiratory Acidosis** (↑PaCO₂): Hypoventilation (e.g., COPD, sedation).

Case 12

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.41
- PaCO₂: 40 mmHg
- HCO₃⁻: 24 mEq/L
- Na⁺: 140 mEq/L
- Cl⁻: 103 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.41, PaCO ₂ 40, HCO ₃ ⁻ 24	Valid (all values internally consistent)
2. Acid-Base Status	pH = 7.41 (normal)	Normal pH (no acidemia/alkalemia)
3. Primary Disorder	All values normal	No primary disorder
4. Compensation	N/A	Not applicable (normal acid-base status)
5. Anion Gap	AG = 140 - (103 + 24) = 13	Mildly elevated AG (normal 3-11; consider hypoalbuminemia if AG <15)
6. Delta-Delta	N/A	Not applicable (normal pH, no metabolic acidosis)

Final Interpretation:

- **Normal acid-base status** with **mildly elevated anion gap (13)**.
- Possible **hypoalbuminemia** (lowers expected AG) or lab variability.



Case 13

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.15
- PaCO₂: 35 mmHg
- HCO₃⁻: 12 mEq/L
- Na⁺: 136 mEq/L
- Cl⁻: 98 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.15, PaCO ₂ 35, HCO ₃ ⁻ 12	Valid
2. Acidemia	pH = 7.15	Severe Acidemia
3. Primary Disorder	pH ↓, HCO ₃ ⁻ ↓, PaCO ₂ ↓	Primary Metabolic Acidosis
4. Compensation	Expected PaCO ₂ = 1.5×12 + 8 = 26	Actual PaCO ₂ = 35 → Inadequate compensation (suggests *concurrent respiratory acidosis*)
5. Anion Gap	AG = 136 - (98 + 12) = 26	Severe High-AG Metabolic Acidosis (≥12)
6. Delta-Delta	ΔAG=14, ΔHCO ₃ ⁻ =12, Ratio=1.16	Mixed High-AG + Normal-AG Acidosis (ratio >1)

Final Diagnosis:

Mixed High Anion Gap + Non-Gap Metabolic Acidosis with Concurrent Respiratory Acidosis

- **High-AG Causes:** Lactic acidosis, ketoacidosis, toxins (methanol, ethylene glycol).
- **Non-Gap Component:** Renal tubular acidosis or diarrhea.
- **Respiratory Acidosis:** Hypoventilation (e.g., fatigue, opioid effect).

Case 14

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.29
- PaCO₂: 25 mmHg
- HCO₃⁻: 14 mEq/L
- Na⁺: 135 mEq/L
- Cl⁻: 100 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.29, PaCO ₂ 25, HCO ₃ ⁻ 14	Valid
2. Acidemia	pH = 7.29	Moderate Acidemia
3. Primary Disorder	pH ↓, HCO ₃ ⁻ ↓, PaCO ₂ ↓	Primary Metabolic Acidosis
4. Compensation	Expected PaCO ₂ = 1.5×14 + 8 = 29	Actual PaCO ₂ = 25 → Overcompensation (suggests *concurrent respiratory alkalosis*)
5. Anion Gap	AG = 135 - (100 + 14) = 21	High-AG Metabolic Acidosis (≥12)
6. Delta-Delta	ΔAG=9, ΔHCO ₃ ⁻ =10, Ratio=0.9	Pure High-AG Acidosis (ratio 0.8–1.0)

Final Diagnosis:

High Anion Gap Metabolic Acidosis with Concurrent Respiratory Alkalosis

- **High-AG Causes:** Lactic acidosis, ketoacidosis, toxins.
- **Respiratory Alkalosis:** Hyperventilation (e.g., sepsis, pain, CNS disorder).

Case 15

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.56
- PaCO₂: 30 mmHg
- HCO₃⁻: 24 mEq/L
- Na⁺: 138 mEq/L
- Cl⁻: 99 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.56, PaCO ₂ 30, HCO ₃ ⁻ 24	Valid
2. Alkalemia	pH = 7.56	Significant Alkalemia
3. Primary Disorder	pH ↑, PaCO ₂ ↓, HCO ₃ ⁻ NI	Primary Respiratory Alkalosis (hyperventilation)
4. Compensation	Acute: $\Delta\text{HCO}_3^- = 0.2 \times \Delta\text{PaCO}_2 = -2$ (Expected HCO ₃ ⁻ = 22)	Actual HCO ₃ ⁻ = 24 → No metabolic compensation yet (acute process)
5. Anion Gap	AG = 138 - (99 + 24) = 15	Mildly elevated AG (normal 3-11; may reflect hypoalbuminemia)
6. Delta-Delta	N/A	Not applicable (primary respiratory disorder)

Final Diagnosis:
Acute Respiratory Alkalosis

- **Cause:** Hyperventilation (pain, anxiety, PE, sepsis, salicylate toxicity).
- **Uncompensated** (renal compensation takes 2-3 days).



Case 16

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.32
- PaCO₂: 52 mmHg
- HCO₃⁻: 30 mEq/L
- Na⁺: 139 mEq/L
- Cl⁻: 95 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.32, PaCO ₂ 52, HCO ₃ ⁻ 30	Valid
2. Acidemia	pH = 7.32 (<7.35)	Mild Acidemia
3. Primary Disorder	pH ↓, PaCO ₂ ↑, HCO ₃ ⁻ ↑	Respiratory Acidosis (primary) with Metabolic Compensation
4. Compensation	Chronic: Expected HCO ₃ ⁻ = 24 + 0.4×(52-40) = 28.8	Actual HCO ₃ ⁻ = 30 → Adequate renal compensation (chronic process)
5. Anion Gap	AG = 139 - (95 + 30) = 14	Mildly elevated AG (normal 3-11; consider hypoalbuminemia if AG <15)
6. Delta-Delta	N/A	Not applicable (primary respiratory disorder)

Final Diagnosis:

Chronic Compensated Respiratory Acidosis

- **Cause:** Chronic hypoventilation (COPD, obesity hypoventilation, neuromuscular disease).
- **Compensation:** Elevated HCO₃⁻ reflects renal adaptation (>3-5 days).

Case 17

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.40
- PaCO₂: 40 mmHg
- HCO₃⁻: 24 mEq/L
- Na⁺: 142 mEq/L
- Cl⁻: 102 mEq/L

1. Validity	pH 7.40, PaCO ₂ 40, HCO ₃ ⁻ 24	Valid (all values internally consistent)
2. Acid-Base Status	pH = 7.40 (normal)	Normal pH (no acidemia/alkalemia)
3. Primary Disorder	All values normal	No primary disorder
4. Compensation	N/A	Not applicable (normal acid-base status)
5. Anion Gap	AG = 142 - (102 + 24) = 16	Elevated AG (normal 3-11; consider hypoalbuminemia or occult acidosis)
6. Delta-Delta	N/A	Not applicable (normal pH, no metabolic acidosis)

Final Interpretation:

- **Normal acid-base status** with **elevated anion gap (16)**.
- Possible causes:
 - **Hypoalbuminemia** (lowers expected AG; correct by adding 2.5×(4 - albumin)).
 - **Occult high-AG metabolic acidosis** (e.g., lactate, ketones).

Case 18

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.24
- PaCO₂: 50 mmHg
- HCO₃⁻: 20 mEq/L
- Na⁺: 137 mEq/L
- Cl⁻: 100 mEq/L

1. Validity	pH 7.24, PaCO ₂ 50, HCO ₃ ⁻ 20	Valid
2. Acidemia	pH = 7.24	Moderate Acidemia
3. Primary Disorder	pH ↓, PaCO ₂ ↑, HCO ₃ ⁻ ↓	Mixed Respiratory Acidosis + Metabolic Acidosis
4. Compensation	Expected HCO ₃ ⁻ (acute): 24 + 0.1×(50-40) = 25	Actual HCO ₃ ⁻ = 20 → No compensation (HCO ₃ ⁻ ↓ suggests metabolic acidosis)
5. Anion Gap	AG = 137 - (100 + 20) = 17	High-AG Metabolic Acidosis (≥12)
6. Delta-Delta	ΔAG=5, ΔHCO ₃ ⁻ =4, Ratio=1.25	Mixed High-AG + Normal-AG Acidosis (ratio >1)

Final Diagnosis:

Mixed Respiratory Acidosis + High Anion Gap Metabolic Acidosis

- **Respiratory Acidosis:** Hypoventilation (e.g., COPD, sedation).
- **Metabolic Acidosis:** Lactic acidosis, ketoacidosis, or toxins.



Case 19

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.48
- PaCO₂: 29 mmHg
- HCO₃⁻: 22 mEq/L
- Na⁺: 139 mEq/L
- Cl⁻: 100 mEq/L

1. Validity	pH 7.48, PaCO ₂ 29, HCO ₃ ⁻ 22	Valid
2. Alkalemia	pH = 7.48	Alkalemia
3. Primary Disorder	pH ↑, PaCO ₂ ↓, HCO ₃ ⁻ NI	Primary Respiratory Alkalosis (hyperventilation)
4. Compensation	Acute: $\Delta\text{HCO}_3^- = 0.2 \times \Delta\text{PaCO}_2 = -2.2$ (Expected HCO ₃ ⁻ = 21.8)	Actual HCO ₃ ⁻ = 22 → No metabolic compensation yet (acute process)
5. Anion Gap	AG = 139 - (100 + 22) = 17	Elevated AG (normal 3-11; consider hypoalbuminemia or occult acidosis)
6. Delta-Delta	N/A	Not applicable (primary respiratory disorder)

Final Diagnosis:
Acute Respiratory Alkalosis

- **Cause:** Hyperventilation (pain, anxiety, PE, sepsis, salicylate toxicity).
- **Uncompensated** (renal compensation takes 2-3 days).



Case 20

- 1- Check Validity.
- 2- Determine Acidemia/Alkalemia.
- 3- Determine Primary
- 4- Check for Compensation.
- 5- Calculate Anion Gap
- 6- Use Delta/Delta

- pH: 7.19
- PaCO₂: 33 mmHg
- HCO₃⁻: 13 mEq/L
- Na⁺: 135 mEq/L
- Cl⁻: 98 mEq/L

Step	Value/Calculation	Interpretation
1. Validity	pH 7.19, PaCO ₂ 33, HCO ₃ ⁻ 13	Valid
2. Acidemia	pH = 7.19	Severe Acidemia
3. Primary Disorder	pH ↓, HCO ₃ ⁻ ↓, PaCO ₂ ↓	Primary Metabolic Acidosis
4. Compensation	Expected PaCO ₂ = 1.5×13 + 8 = 27.5	Actual PaCO ₂ = 33 → Inadequate compensation (suggests *concurrent respiratory acidosis*)
5. Anion Gap	AG = 135 - (98 + 13) = 24	Severe High-AG Metabolic Acidosis (≥12)
6. Delta-Delta	ΔAG=12, ΔHCO ₃ ⁻ =11, Ratio=1.1	Mixed High-AG + Normal-AG Acidosis (ratio >1 suggests dual acidosis)

Final Diagnosis:
Mixed High Anion Gap + Non-Gap Metabolic Acidosis with Concurrent Respiratory Acidosis

- **High-AG Causes:** Lactic acidosis, ketoacidosis (DKA), toxins (methanol, ethylene glycol).
- **Non-Gap Component:** Renal tubular acidosis or diarrhea.
- **Respiratory Acidosis:** Hypoventilation (e.g., fatigue, opioid effect, CNS depression).