

ABG Collection and Interpretation

Respiratory Associates | ABG Clinical Reference | 2026

Use this reference to check specimen quality, recognize acid-base patterns, and work through oxygen content, anion gap, and delta-ratio calculations. Interpret every result with the patient's condition and respiratory support.

Normal values and reporting order

Parameter	Usual adult reference	Meaning
pH	7.35-7.45	Overall acid-base status
PaCO ₂	35-45 mmHg	Ventilation relative to CO ₂ production
PaO ₂	80-100 mmHg	Dissolved oxygen pressure
HCO ₃	22-26 mmol/L	Metabolic component
Base excess	-2 to +2 mmol/L	Calculated metabolic contribution

Report in order: pH / PaCO₂ / PaO₂ / HCO₃ / base excess. Label all values. PaO₂ reference values vary with age, altitude, and clinical circumstances; always consider FiO₂. [1, 3]

Before accepting the result

Confirm: patient and specimen identity, arterial source, collection time, oxygen device/FiO₂, SpO₂, and relevant ventilator settings. Document temperature when required. Ask whether support changed around the time of collection. [1, 2]

Collect safely: use the required heparinized syringe and fill volume. Follow facility policy for collateral-circulation assessment and site selection. Activate the needle safety device; do not recap a used needle. Apply firm pressure until hemostasis, with longer observation when bleeding risk is increased. [1, 2]

Problem	Possible effect or response
Air contamination	PaO ₂ moves toward ambient-air oxygen tension: low values may rise; very high values may fall. PaCO ₂ generally falls and pH may rise.
Delayed analysis	Cell metabolism may lower PaO ₂ , raise PaCO ₂ , and lower pH. Marked leukocytosis increases concern.
Clots or inadequate mixing	May compromise analysis. Mix according to instructions; follow rejection and recollection procedures.

Remove air bubbles promptly, cap, mix, label, and transport promptly. Follow the syringe/analyzer instructions and facility policy for timing and storage; do not assume every plastic ABG syringe should be iced. [1, 2]

Calibration and quality control

Calibration establishes or adjusts analyzer response using known materials. QC checks performance. On a Levey-Jennings chart, a trend is gradual movement; a shift is a sustained change to a different level. Resolve failed QC under laboratory rules before reporting affected results. [1]

Acid Base Interpretation

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A consistent bedside sequence

1. PaCO₂: assess ventilation relative to CO₂ production. High PaCO₂ favors respiratory acidosis; low PaCO₂ favors respiratory alkalosis or compensation for metabolic acidosis.
2. pH: below 7.35 is acidemia; above 7.45 is alkalemia. A normal pH does not exclude an important disorder.
3. HCO₃ and base excess: determine the metabolic contribution and whether it represents a primary disorder or compensation.
4. Compensation: compare the observed response with the expected response. A mismatch suggests a mixed disorder.
5. Oxygenation: interpret PaO₂ with FiO₂, saturation, hemoglobin, and respiratory support.
6. Metabolic acidosis: calculate the anion gap, consider albumin, and use the delta ratio when appropriate. [3]

Primary process	Typical primary change	Examples of causes
Respiratory acidosis	PaCO ₂ rises; pH tends to fall	Reduced drive, neuromuscular weakness, severe airflow obstruction
Respiratory alkalosis	PaCO ₂ falls; pH tends to rise	Hypoxemia, pain, sepsis, excessive ventilation
Metabolic acidosis	HCO ₃ falls; pH tends to fall	Lactate, ketoacids, renal dysfunction, diarrhea
Metabolic alkalosis	HCO ₃ rises; pH tends to rise	Vomiting, gastric suction, diuretics

Expected compensation quick reference

Primary process	Approximate expected response
Metabolic acidosis	Winter's formula: expected PaCO ₂ = 1.5 x HCO ₃ + 8, with a range of ±2 mmHg.
Metabolic alkalosis	PaCO ₂ increases about 0.6-0.75 mmHg for each 1 mmol/L rise in HCO ₃ above 24.
Respiratory acidosis	For each 10 mmHg rise in PaCO ₂ above 40: HCO ₃ rises about 1-2 mmol/L acutely or 3-4 chronically.
Respiratory alkalosis	For each 10 mmHg fall in PaCO ₂ below 40: HCO ₃ falls about 1-2 mmol/L acutely or 4-5 chronically.

These are approximate rules for simple disorders; timing and baseline values matter. A normal-range pH alone does not prove appropriate compensation. [3]

Base excess: a positive value indicates an alkalinizing metabolic contribution; a negative value indicates an acidifying contribution. Either can reflect compensation for a respiratory disorder, so interpret it with the full ABG. [3]

Oxygenation and Worked ABGs

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Oxygen pressure is different from oxygen content

PaO₂ measures dissolved oxygen pressure. SaO₂ describes arterial hemoglobin oxygen saturation. CaO₂ estimates oxygen carried per deciliter of blood. A patient with severe anemia may have an acceptable PaO₂ and saturation but low oxygen content. [4]

$$\text{CaO}_2 = (1.34 \times \text{Hb} \times \text{SaO}_2) + (0.003 \times \text{PaO}_2)$$

Use Hb in g/dL, SaO₂ as a decimal, and PaO₂ in mmHg. The result is mL O₂/dL.

Example: Hb 10, SaO₂ 0.98, PaO₂ 100:

$$(1.34 \times 10 \times 0.98) + (0.003 \times 100) = 13.432 \approx 13.4 \text{ mL O}_2/\text{dL}$$

Dissociation curve and venous saturation

A right shift reduces hemoglobin oxygen affinity and favors unloading: increased CO₂, acidosis, increased temperature, and increased 2,3-DPG. A left shift increases affinity and reduces unloading at a given PaO₂. [4]

SvO₂ is mixed venous saturation, typically about 65-75% at rest. It reflects the balance of oxygen delivery and consumption. A high value does not guarantee adequate tissue oxygen use. [4]

Apply the interpretation sequence

ABG and context	Interpretation and reasoning
Longstanding CO ₂ retention pH 7.36 PaCO ₂ 60 mmHg HCO ₃ 33 mmol/L	Chronic respiratory acidosis with renal compensation fits the history. PaCO ₂ is elevated, bicarbonate has increased, and pH is near normal.
DKA pH 7.25 PaCO ₂ 26 mmHg HCO ₃ 11 mmol/L	Metabolic acidosis. Winter's expected PaCO ₂ = $1.5 \times 11 + 8 = 24.5 \pm 2$. The observed 26 fits expected respiratory compensation.
After cardiac arrest pH 7.10 PaCO ₂ 60 mmHg HCO ₃ 18 mmol/L	Mixed respiratory and metabolic acidosis. High CO ₂ and low bicarbonate both acidify the blood. Expected PaCO ₂ for the metabolic acidosis is 35 ± 2 ; the observed 60 indicates an additional respiratory acidosis.

Worked ABGs are rounded educational examples. Use trends, timing, laboratory data, and the patient's condition to determine the clinical cause. [3]

Results that deserve a second look

Investigate a result that conflicts with the bedside picture. Check identification, sample source, air exposure, transport delay, support changes, and analyzer QC. Extreme pH values indicate high risk, but no single pH defines an absolute survival limit. [1, 3]

Anion Gap and Delta Ratio

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Calculate the anion gap

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

Use contemporaneous chemistry-panel values when available, including total CO₂ as the usual bicarbonate surrogate. This formula excludes potassium. Use the laboratory's reference range. [3]

Example: Na 138, Cl 102, HCO₃ 14:

$138 - (102 + 14) = 22$ mEq/L. Using the course reference AG of 12, this is elevated.

Pattern	Common considerations
High-gap metabolic acidosis	Lactic acidosis, ketoacidosis, renal failure, selected toxins
Normal-gap metabolic acidosis	Diarrhea, renal tubular acidosis, chloride-rich fluid exposure
Low gap or unexpectedly normal gap	Hypoalbuminemia may lower the gap and hide an elevated-gap process; verify unexpected results.

Albumin correction: corrected AG $\approx$ measured AG + $2.5 \times (4 - \text{albumin in g/dL})$. Example: measured AG 12 and albumin 2 gives corrected AG $\approx$ 17 mEq/L. This is an approximation. [3]

After identifying high-gap metabolic acidosis

$$\text{Delta ratio} = (AG - 12) / (24 - HCO_3)$$

The course uses reference values of 12 and 24. Consider the local AG range, albumin, and baseline bicarbonate. Do not apply mechanically when HCO₃ is 24 or higher. [3]

Ratio	Suggested pattern
Below 0.4	Predominantly normal-gap acidosis; reconsider the context.
0.4 to below 0.8	Combined high-gap and normal-gap metabolic acidosis.
Approximately 0.8-2.0	High-gap acidosis without clear additional metabolic process.
Above 2.0	Additional metabolic alkalosis or elevated baseline HCO ₃ .

Examples: AG 22 / HCO₃ 14: $10/10 = 1.0$.

AG 19 / HCO₃ 10: $7/14 = 0.5$, suggesting added normal-gap acidosis.

AG 30 / HCO₃ 16: $18/8 = 2.25$, suggesting added alkalosis or high baseline HCO₃. Cutoffs vary; use these as clues. [3]

Selected references and course source

Course source: Analyzing ABGs 2026 Update - Slide Rework(1), slides 1-64.

[1] Davis MD et al. AARC clinical practice guideline: Blood gas analysis and hemoximetry. Respir Care. 2013;58:1694-1703. doi:10.4187/respcare.02786.

[2] Seccombe LM et al. ANZSRS position statement for arterial blood gas sampling. Intern Med J. 2024;54:1208-1213. doi:10.1111/imj.16439.

[3] Merck Manual Professional Edition. Acid-base disorders; Primary changes and compensations in simple acid-base disorders. merckmanuals.com. Accessed October 19, 2026.

[4] StatPearls. Oxygen Saturation; Physiology, Oxygen Transport. NCBI Bookshelf. ncbi.nlm.nih.gov/books/.