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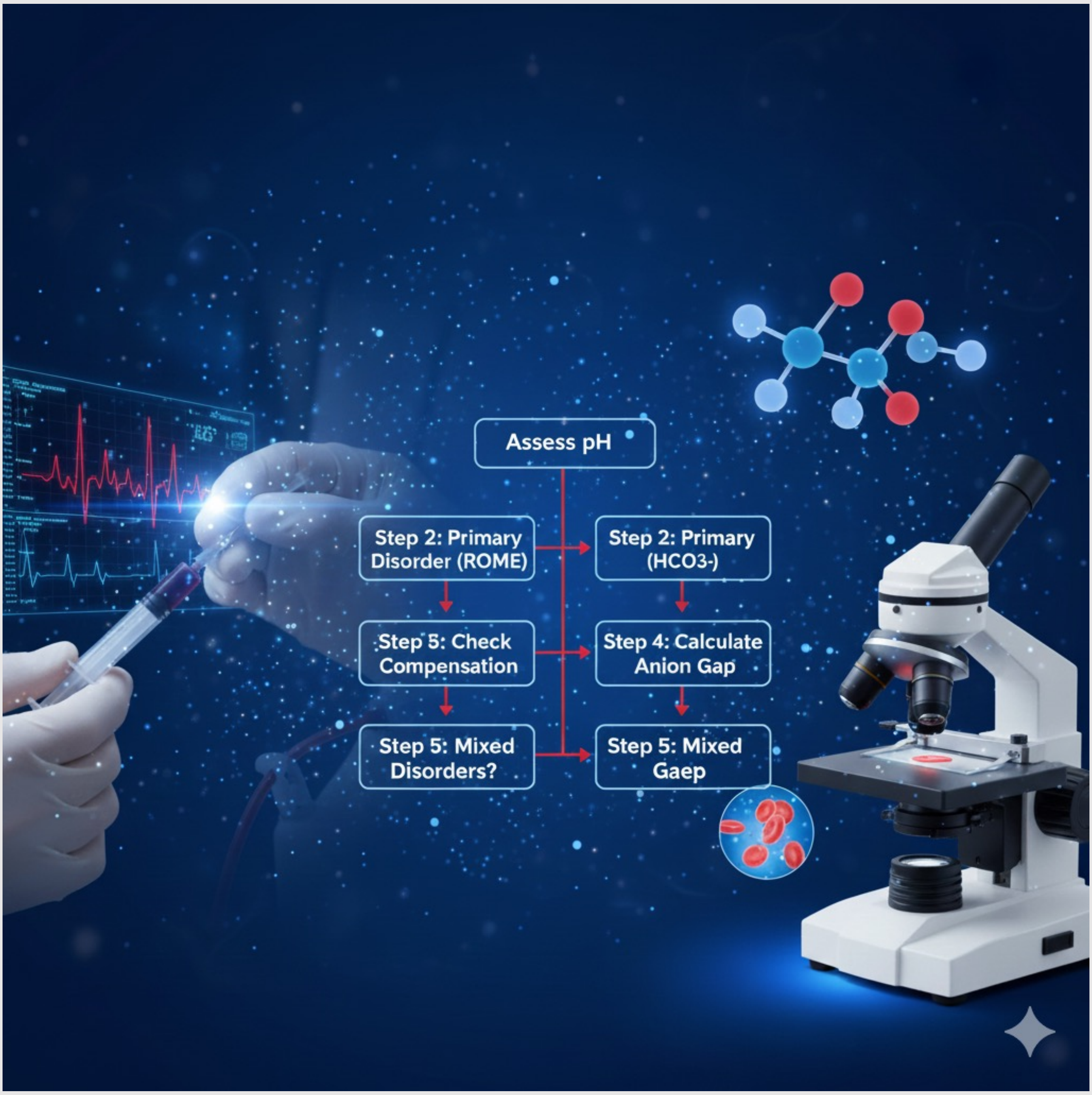


ARTERIAL BLOOD GAS (ABG) ANALYSIS: STEP-WISE APPROACH TO ARRIVE AT A DIAGNOSIS

Diagnostic procedure in which blood is obtained directly from an artery by an arterial puncture or accessed by an indwelling arterial catheter. ABG is considered an important POCT in day-to-day medical laboratory running in hospital setups.

The identification of variable degrees of acid-base disorders is urgently needed for the proper management of serious and acute diseases. Measurement of blood gas parameters is performed using blood gas analyzers, which are user-friendly.

These instruments, mostly based on potentiometry, measure pH, pCO_2, pO_2, etc., with the help of electrodes and also provide some calculated parameters. All information is needed to arrive at a diagnosis of the exact acid-base disorder, if any, for the necessary and urgent management of the patient.

Indications:

- To assess the ventilator status, oxygenation and acid base status.
- Assess the response to an intervention.
- Regular electrolyte therapy.
- Establish preoperative baseline parameters.
- Sudden dyspnoea, cyanosis, abnormal breath sounds. Sudden or unexplained tachypnea.
- Diffuse infiltrates in Chest X-ray.
- ABG may be most useful when a person's breathing rate is increased or decreased or when the person has very high blood sugar levels, a severe infection or heart failure.

Contraindications:

- Negative result of Allen's test (Allen's test: To determine that collateral circulation is present from the ulnar artery in case thrombosis occur in the radial.)
- Bleeding diathesis.
- AV fistula.
- Severe peripheral vascular disease.
- Absence of an arterial pulse.
- Infection over site.s

Complications

- Excessive bleeding or haematoma at the puncture site.
- Vasovagal attack.
- Nerve damage.
- Infection at the puncture site.
- Drop in blood pressure, sweating or pallor that may precede a loss of consciousness.

Preparatory Phase:

- Record patient inspired oxygen concentration.
- Check patient temperature.
- Explain the procedure to the patient.
- Provide privacy.
- If not using heparinized syringe, heparinize the needle.

Equipment:

- ABG kit:
  - 1 ml syringe.
  - 23-26 gauge needle.
  - Stopper or cap.
  - Alcohol swab.
  - Disposable gloves.
  - Plastic bag & crushed ice.
  - Lidocaine (optional)
  - Vial of heparin (1:1000)
  - Bar code or label.

Site

- Brachial or radial arteries (less commonly femoral) into a heparinized syringe
- Radial: most common
  - Smaller size and easily accessible, not a deep artery.
  - Can be compressed to control bleeding
  - Less risk for occlusion
  - Facilitates palpation, stabilization and puncturing.
  - The artery has a collateral blood circulation.

Performance phase

- Wash hands.
- Put on gloves.
- Palpate the artery for maximum pulsation.
- If radial, perform Allen's test.
- Place a small towel roll under the patient wrist.
- Instruct the patient to breath normally during the test and warm him that he may feel brief cramping or throbbing pain at the puncture site.
- Clean with alcohol swab in circular motion.
- Skin and subcutaneous tissue may be infiltrated with local anaesthetic agent if needed.
- Insert needle at 45 degree radial, 60 degree brachial, 90 degree femoral.
- Withdraw the needle and apply digital pressure.
- Check bubble in syringe.
- Place the capped syringe in the container of ice immediately.
- Maintain firm pressure on the puncture site for 5 minutes, if patient has coagulation abnormalities then apply pressure for 10-15 minutes.

Follow Up Phase

- Send labelled, iced specimen to the lab immediately.
- Palpate the pulse distal to the puncture site.
- Assess for cold hands, numbness, tingling or discoloration.
- Documentation include :
  - Results of Allen's test.
  - Time the sample was drawn.
  - Temperature.
  - Puncture site.
  - Time pressure was applied and if O_2 therapy is there.
  - Make sure it's noted on the slip whether the patient is breating room air or oxygen. If oxygen, document the number of liters. If the patient is receiving mechanical ventilation, FiO_2 should be documented.
- **Air-bubbles in sample should be expelled.**
- **Syringe should be capped and ideally placed in ice during transit.**

Components of ABG

- **pH**: hydrogen ion concentration. It shows blood's acidity or alkalinity.
- **pCO_2**: respiratory parameter. partial pressure of CO_2 that is carried by the blood for excretion by the lungs.
- **pO_2**: partial pressure of O_2 that is dissolved in the blood. Reflects body's ability to pick up oxygen from the lungs.

- **HCO_3**: metabolic parameter. Reflects the kidney's ability to retain and excrete bicarbonate.

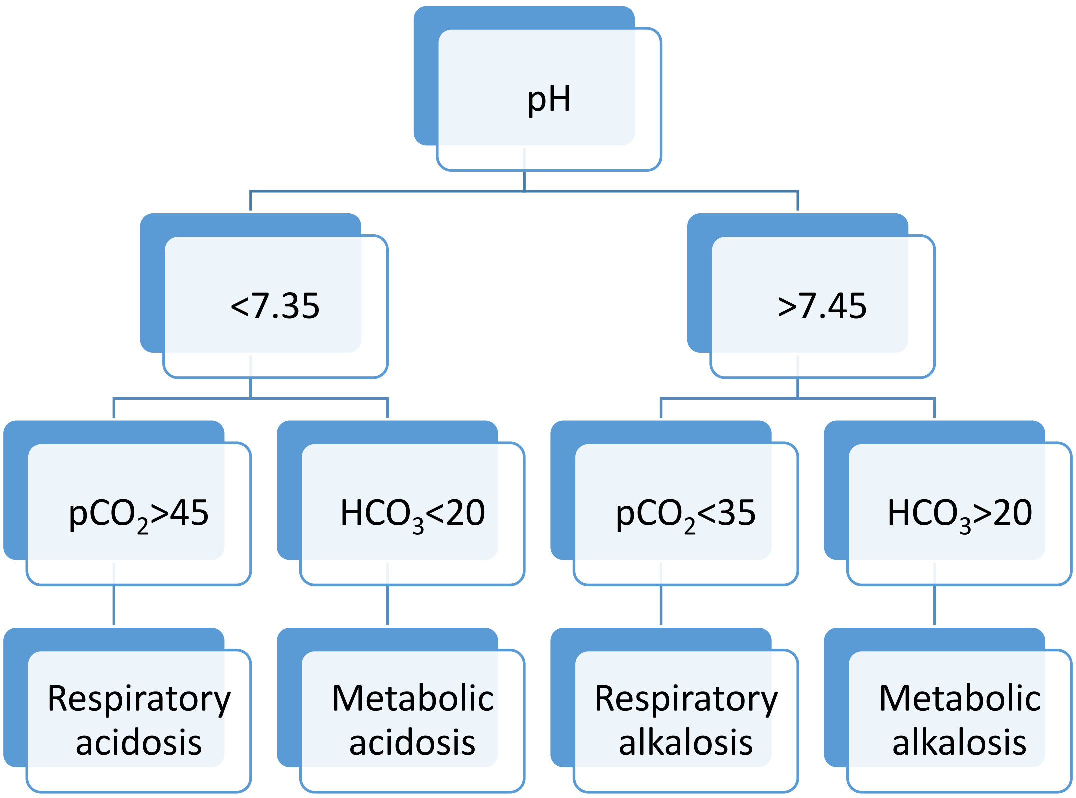
Acid-base problems : with reference to the three components of the bicarbonate buffer system

- ***pH and pCO_2 : directly measured.***
  - **No need to measure third variable.**
  - By the law of mass action: $H^+ \infty pCO_2/HCO_3^-$
  - Indeed, ABG analysers are programmed to provide as *Standard HCO_3^-*.
- ***pO_2***
- **Na+, K+, Ca++, Cl^-,** ions are measured to know the anion gap which is altered in acid- base disturbance.
- **Air pressure, Hb**

Some calculated parameters:

- **Standard HCO_3, Actual HCO_3** (<u>HCO_3-act should not differ from calculated arterial HCO_3--std by more than 3 mmol/L)</u>
- HCO_3 may be measured, usually on a venous blood.
- **Total CO_2** : dissolved CO_2, H_2CO_3, and other Carbamino compounds.
- **Base Excess (BE)**: Concentration of titrable base present in plasma. Amount of strong acid to titrate 1L of the given blood to normal pH 7.4 at pCO_2 40 mm Hg at 37^0 C.
- **Internal consistency of the sample:**
  - pO_2+pCO_2 <150 mm Hg in a person who is breathing room air

Interpretation of ABG



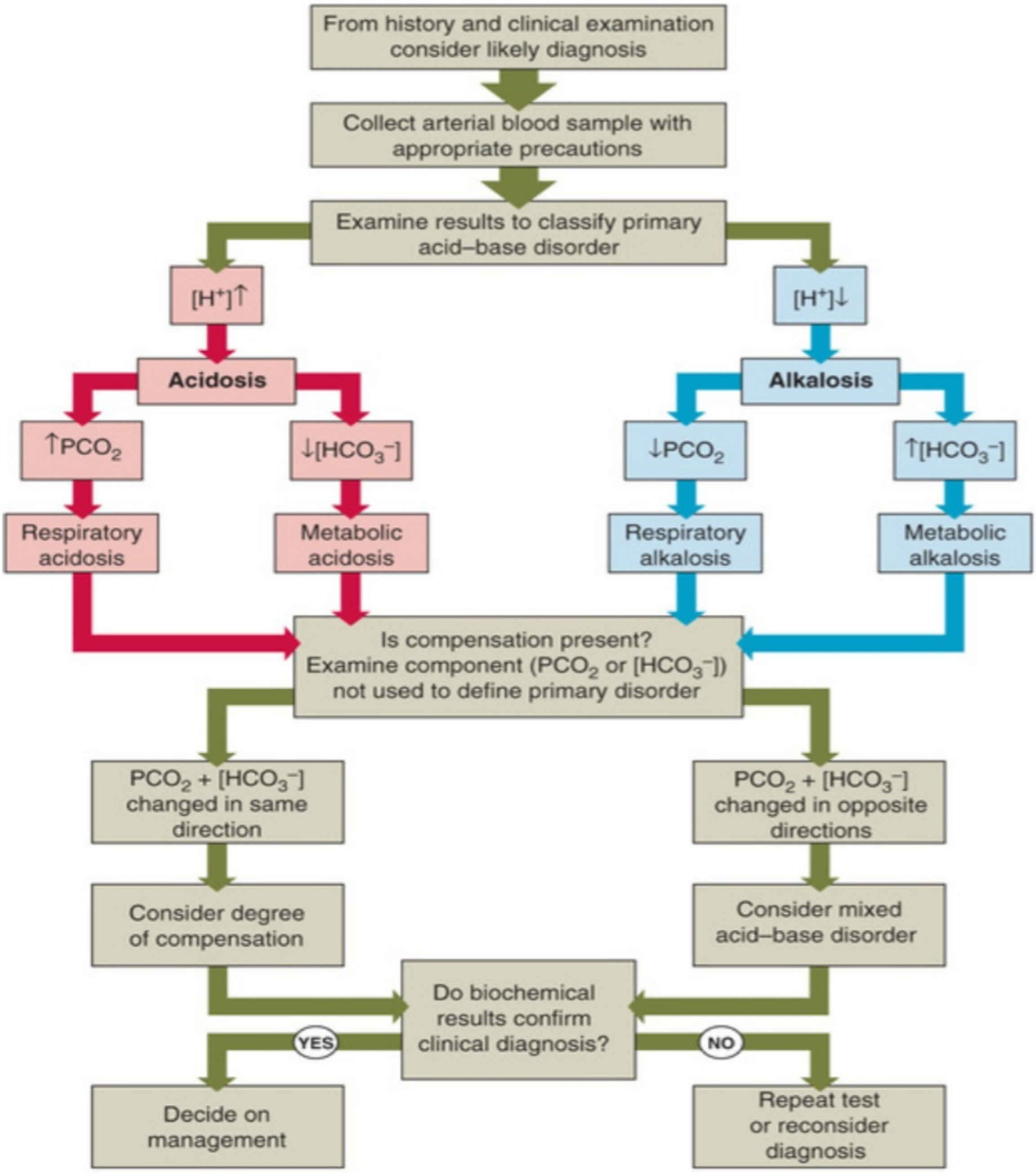
- **Step-by-step logical thinking for assessment of ABG:**
- ***Primary Acid Base Disorder***
- **pH: 7.35-7.45**
- **Acidosis**
  - High pCO_2 : Respiratory acidosis
  - LowHCO_3^-: Metabolic acidosis
- **Alkalosis**
  - Low pCO_2 : Respiratory alkalosis
  - HighHCO_3^- : Metabolic alkalosis
- **ROME Criteria**
- **Respiratory : Opposite. Metabolic: Same**

Condition	pH	pCO_2/HCO3
Respiratory acidosis	↓	pCO2↑
Respiratory alkalosis	↑	pCO2↓
Metabolic acidosis	↓	HCO3↓
Metabolic alkalosis	↑	HCO3↑

- Having decided on the primary acid-base disorder, look to see ***if there is compensation.***
- If there is, there will *be change in the other component* (the one which was not used to determine the primary disorder), *in the same direction as the primary abnormality.*
- *Acidosis*
- High pCO_2 : Respiratory acidosis : Compensation : Metabolic : High HCO_3^-
- Low HCO_3^-: Metabolic acidosis : Compensation : Respiratory : Low pCO_2
- *Alkalosis*
- Low pCO_2 : Respiratory alkalosis : Compensation : Metabolic : Low HCO_3^-
- High HCO_3^- : Metabolic alkalosis : Compensation : Respiratory : High pCO_2
  - *Compensation in parallel direction. Hydrogen ions in CSF can stimulate or depress CTZ.*
- If there is compensation, decide if *fully compensated (pH* : Within Normal Normal*) or partially compensated (pH not within reference limits)*

Primary acid-base disorder	**pCO_2/HCO^3**	**Compensatory response**
Acidosis		
Respiratory acidosis	High pCO_2	HighHCO_3^-
Metabolic acidosis	LowHCO_3^-	Low pCO_2
Alkalosis		
Respiratory alkalosis	Low pCO_2	LowHCO_3^-
Metabolic alkalosis	HighHCO_3^-	High pCO_2

- **If there is no returning to normal pH, it may be *uncompensated.***
- If the change is in the ***opposite direction, a second acid-base disorder may be present.***



Summary:

1. Even if the pH is within the normal range, it cannot be confirmed that the patient is normal. Normal pH does not exclude acid-base disorders, and HCO_3^- and pCO_2 levels should always be checked. If all three are normal, then only we could say normal acid-base homeostasis.
2. Even if compensation appears to have occurred, a second acid-base problem that mimics the compensatory response is possible. This case may be an example of a Mixed acid-base disorder. For example, patients with cardiopulmonary arrest have

severe respiratory acidosis, as they are not breathing, and metabolic acidosis due to lactate accumulation resulting from reduced perfusion. Another example may be a patient with respiratory acidosis due to COPD and diuretic-induced potassium depletion causing metabolic alkalosis. The **Patient's Clinical History** is the most important factor in determining the nature of the disorder. This interpretation may be confusing if one of the disorders mimics the expected compensation. Knowledge of the clinical picture is important if the correct interpretation is to be placed on the results.

For example:

Low HCO_3^- : Metabolic acidosis : Compensation : Respiratory hyperventilation : low pCO_2
Again Low pCO_2: Respiratory alkalosis : Compensation : Low HCO_3^-.
Now confusion

Look at Base Excess (one parameter in ABG)

Base Excess
BE ↑: More acids to be added to neutralize, so more bases in system: Alkalosis.
Interpretation:

- More than +2 : Alkalosis
- Less than -2 : Acidosis

Acknowledgements:

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