



Last Minute Revision

LMR NOTES

Acid Base

PRESENTED BY
Stem-S

ACID–BASE DISORDERS

- **LAST-MINUTE HIGH-YIELD REVISION (ICU + NEET SS)**
- **CORE CONCEPT**

pH is determined by the ratio of HCO_3^- (kidney) to pCO_2 (lungs)
 Henderson–Hasselbalch → *metabolic vs respiratory control*

- **STEPWISE APPROACH**

STEP 1 → Identify primary disorder (acidosis or alkalosis)
 STEP 2 → Calculate anion gap
 STEP 3 → Check respiratory compensation
 STEP 4 → Look for mixed disorders (delta gap)
 STEP 5 → Identify cause & urgency

1. RESPIRATORY COMPENSATION

Disorder	Expected Compensation
Metabolic acidosis	↓ pCO_2 by 1.2 mmHg per ↓ 1 mEq/L HCO_3^-
Metabolic alkalosis	↑ pCO_2 by 0.7 mmHg per ↑ 1 mEq/L HCO_3^-
Max pCO_2 in alkalosis	< 60 mmHg

✦ Inadequate compensation = mixed disorder

2. METABOLIC ACIDOSIS

- **MAJOR MECHANISMS**
 - Buffering (HCO_3^- , bone, intracellular)
 - \uparrow Ventilation (\downarrow pCO_2)
 - Renal H^+ excretion (slow)

3. ANION GAP METABOLIC ACIDOSIS (AGMA)

- **FORMULA (AUTO-MCQ)**
 $\text{AG} = \text{Na}^+ - (\text{Cl}^- + \text{HCO}_3^-)$
 Normal: 8–12 mEq/L
- **ALBUMIN CORRECTION**
 $\text{AG} \downarrow$ by $\sim 2.5\text{--}3$ mEq/L for every 1 g/dL \downarrow albumin
- **HIGH-YIELD CAUSES (MEMORIZE)**

Category	Causes
Lactic acidosis	Shock, sepsis, hypoxia, seizures
Ketoacidosis	DKA, starvation, alcoholism
Renal failure	Uremia
Toxins	Methanol, ethylene glycol, salicylates
Others	Rhabdomyolysis, D-lactate, 5-oxoproline

4. OSMOLAL GAP

- Calculated Osm = $2\text{Na} + \text{Glucose}/18 + \text{BUN}/2.8$
- Osmolal gap = Measured – Calculated
- Normal ≈ 10 mOsm/kg
- \uparrow Gap \rightarrow **Methanol / Ethylene glycol / Ethanol**

5. KEY AGMA SYNDROMES

- **Lactic Acidosis**
 - **Treat cause FIRST**
 - Bicarbonate \rightarrow **only if pH < 7.1**
 - Risks: \uparrow CO₂, \downarrow ionized Ca²⁺, volume overload
- **Salicylate Toxicity**

Feature	Key
Acid-base	Metabolic acidosis + respiratory alkalosis
Treatment	Urine & plasma alkalinization
Dialysis	Level >80 mg/dL or severe toxicity

- **Methanol / Ethylene Glycol**

Step	Action
Block metabolism	Fomepizole / Ethanol
Remove toxin	Hemodialysis
Adjuncts	Thiamine, pyridoxine, folate

6. NON-ANION GAP METABOLIC ACIDOSIS (NAGMA)

- CORE IDEA**

HCO_3^- loss replaced by Cl^- → hyperchloremic acidosis

- URINE ANION GAP (VERY HIGH YIELD)**

$\text{UAG} = (\text{Urine Na}^+ + \text{K}^+) - \text{Urine Cl}^-$

UAG	Interpretation
Negative (-20 to -50)	GI loss (diarrhea)
Positive / zero	Renal cause (RTA, CKD)

- UAG useless in AGMA, oliguria, hypovolemia

7. RENAL TUBULAR ACIDOSIS (RTA)

Type	Defect	K^+	Urine pH	Key Associations
Type 1 (Distal)	↓ H^+ secretion	↓	>5.3	Sjögren, amphotericin
Type 2 (Proximal)	↓ HCO_3^- reabsorption	↓	Variable	Myeloma
Type 4	↓ Aldosterone	↑	<5.3	Diabetes, ACEI

8. BICARBONATE THERAPY — WHEN & HOW

- **WHEN TO GIVE**
 - pH < 7.1
 - Refractory acidosis
 - Loss of buffering capacity
- **BICARBONATE DEFICIT (EXAM FORMULA)**

Deficit = $V_d \times \Delta HCO_3^-$
 $V_d = \text{Weight} \times [0.4 + (2.4 / HCO_3^-)]$

✦ Give slowly over 4–8 hrs, frequent ABGs

9. METABOLIC ALKALOSIS

- **COMMON ICU CAUSES**
 - Vomiting / NG suction
 - Diuretics
 - Post-hypercapnia
 - Hypokalemia
 - Citrate (transfusion)
- **CHLORIDE-RESPONSIVE vs RESISTANT (FAVORITE)**

Type	Urine Cl ⁻	Causes	Treatment
Responsive	≤25	Vomiting, diuretics	NS + KCl
Resistant	>25	Hyperaldosteronism	Treat cause

11. SPECIAL ALKALOSIS SYNDROMES

- **Post-hypercapnic Alkalosis**
Do NOT rapidly normalize pCO₂ in chronic CO₂ retainers
- **Severe Hypokalemia**
 - Maintains alkalosis
 - Cannot correct alkalosis until K⁺ corrected

12. TREATMENT OF METABOLIC ALKALOSIS

Scenario	Treatment
Volume depleted	NS + KCl
Volume overloaded	Acetazolamide
Refractory severe	HCl infusion / dialysis

13. MIXED ACID–BASE DISORDERS

- **DELTA GAP (EXAM ESSENTIAL)**

$$\Delta AG / \Delta HCO_3^-$$

Ratio	Interpretation
<1	AGMA + NAGMA
1–2	Pure AGMA
>2	AGMA + metabolic alkalosis

- **NORMAL pH BUT ABNORMAL VALUES = MIXED DISORDER**

Pattern	Diagnosis
$\downarrow p\text{CO}_2 + \downarrow \text{HCO}_3^-$	Resp alkalosis + metabolic acidosis
$\uparrow p\text{CO}_2 + \uparrow \text{HCO}_3^-$	Resp acidosis + metabolic alkalosis
Normal pH + \uparrow AG	Hidden mixed disorder

- **LAST-DAY EXAM PEARLS (SAVE THIS)**
 - Always calculate AG
 - Correct AG for albumin
 - UAG differentiates diarrhea vs RTA
 - pH <7.1 → consider bicarbonate
 - Salicylates = mixed disorder
 - Normal pH ≠ normal acid–base
 - Never rapidly correct chronic CO₂ retainers
- **CORE CONCEPT**
 - **Respiratory disorders = PaCO₂ problem** Lungs change CO₂, kidneys compensate by changing HCO₃⁻ (slow)

- NORMAL BASELINES (USE FOR CALCULATIONS)**

Parameter	Normal
pH	7.35–7.45 (use 7.40)
PaCO ₂	35–45 mmHg (use 40)
HCO ₃ ⁻	22–26 mEq/L (use 24)

- STEPWISE APPROACH (EXAM SAFE)**

- STEP 1 → Look at pH (acidemia or alkalemia)
- STEP 2 → Look at PaCO₂ (primary respiratory disorder?)
- STEP 3 → Check expected HCO₃⁻ compensation
- STEP 4 → Decide acute vs chronic
- STEP 5 → If compensation inappropriate → mixed disorder

1. RESPIRATORY ACIDOSIS

- DEFINITION**

- ↑ PaCO₂
- ↓ pH
- Cause = alveolar hypoventilation

- PATHOPHYSIOLOGY FLOW**

Hypoventilation → CO₂ retention → ↑ H₂CO₃ → ↑ H⁺ → ↓ pH

- CAUSES**

Level	Examples
CNS	Sedatives, opioids, stroke
NMJ	Myasthenia gravis, ALS
Chest wall	Obesity hypoventilation
Airways	COPD, asthma
Lung	Pulmonary edema
Iatrogenic	Underventilation

2. ACUTE vs CHRONIC RESPIRATORY ACIDOSIS

- COMPENSATION RULES (MUST MEMORIZE)

Type	ΔHCO_3^-	ΔpH
Acute	$\uparrow 1 \text{ mEq/L}$ per $\uparrow 10 \text{ PaCO}_2$	$\downarrow 0.08$ per 10
Chronic ($\geq 3-5 \text{ d}$)	$\uparrow 3-4 \text{ mEq/L}$ per $\uparrow 10$	$\downarrow 0.03$ per 10

✦ If HCO_3^- higher than expected \rightarrow concomitant metabolic alkalosis

- EXAM TRAP

Normal pH + high PaCO_2 = chronic respiratory acidosis + metabolic alkalosis

3. TREATMENT OF RESPIRATORY ACIDOSIS

- GOLDEN RULE

Treat hypoventilation, NOT pH

Do	Don't
Bronchodilators (COPD/asthma)	Routine bicarbonate ✗
Reverse sedatives/opioids	Rapidly normalize PaCO_2 in chronic CO_2 retainers ✗
NIV / Mechanical ventilation	-

✦ Bicarbonate only if pH < 7.1 with intractable hypercapnia

- ICU PEARL
- Rapid ventilation of chronic CO₂ retainers → severe metabolic alkalosis → seizures, arrhythmias

4. RESPIRATORY ALKALOSIS

- DEFINITION
 - ↓ PaCO₂
 - ↑ pH
 - Cause = alveolar hyperventilation

- PATHOPHYSIOLOGY

Hyperventilation → ↓ CO₂ → ↓ H₂CO₃ → ↓ H⁺ → ↑ pH

5. ACUTE vs CHRONIC RESPIRATORY ALKALOSIS

- COMPENSATION RULES

Type	Δ HCO ₃ ⁻	Δ pH
Acute	↓ 2 mEq/L per ↓10 PaCO ₂	↑ 0.08
Chronic	↓ 5-7 mEq/L per ↓10	↑ 0.03

✦ Excess fall in HCO₃⁻ → concomitant metabolic acidosis

6. CAUSES OF RESPIRATORY ALKALOSIS

- CLASSIFY BY A-a GRADIENT
- NORMAL A-a GRADIENT

Cause	Examples
CNS	Anxiety, pain, fever
Drugs	Salicylates (early), catecholamines
Endocrine	Pregnancy (progesterone), hyperthyroid
Hypoxia (non-lung)	High altitude, severe anemia
Iatrogenic	Overventilation

- ELEVATED A-a GRADIENT

(Same as hypoxia causes)

Cause
Pulmonary embolism
Pneumonia
Pulmonary edema
CHF
Pneumothorax

7. TREATMENT OF RESPIRATORY ALKALOSIS

Situation	Management
Hypoxia	Treat cause (O ₂ , PE, pneumonia)
Ventilated patient	↓ RR or ↓ TV
Anxiety	Reassurance, anxiolytics
High altitude	Acetazolamide

✦ Acetazolamide induces metabolic acidosis → compensates alkalosis

8. MIXED RESPIRATORY–METABOLIC DISORDERS

- **KEY RULE**

Normal pH + abnormal PaCO₂ = MIXED DISORDER

- **COMMON PATTERNS**

ABG Pattern	Diagnosis
↓ pH + ↑ PaCO ₂ + ↓ HCO ₃ ⁻	Resp acidosis + metabolic acidosis
↑ pH + ↓ PaCO ₂ + ↑ HCO ₃ ⁻	Resp alkalosis + metabolic alkalosis
Normal pH + ↑ PaCO ₂ + ↑ HCO ₃ ⁻	Chronic resp acidosis + metabolic alkalosis
Normal pH + ↓ PaCO ₂ + ↓ HCO ₃ ⁻	Resp alkalosis + metabolic acidosis

9. QUICK H⁺ vs pH TABLE (EXAM TRICK)

pH	[H ⁺] (nmol/L)
7	100
7.1	79
7.2	63
7.3	50
7.4	40
7.5	32
7.6	25

✦ Small pH change = big H⁺ change

• LAST-DAY EXAM PEARLS

- PaCO₂ defines respiratory disorder
- Renal compensation takes 24–72 hrs
- Normal pH does NOT mean normal ABG
- Never rapidly correct chronic CO₂ retention
- Salicylates = respiratory alkalosis early
- Use expected HCO₃⁻ change to detect mixed disorders
- Bicarbonate rarely indicated in respiratory acidosis

Study Smart for NEET SS

Medical Group

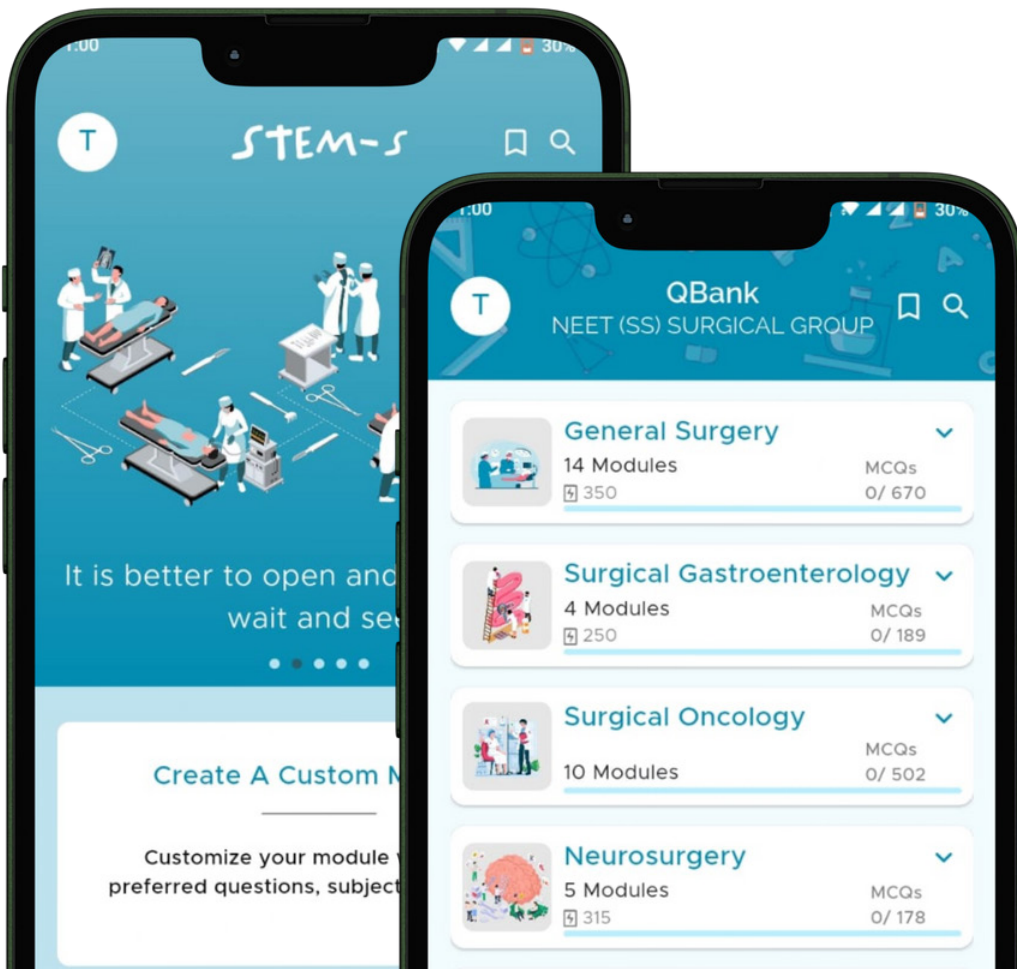
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