

Acid Base Derangements

$$\text{pH} = 6.1 + \log_{10} \left(\frac{\text{HCO}_3}{0.03 P_a\text{CO}_2} \right)$$

Respiratory

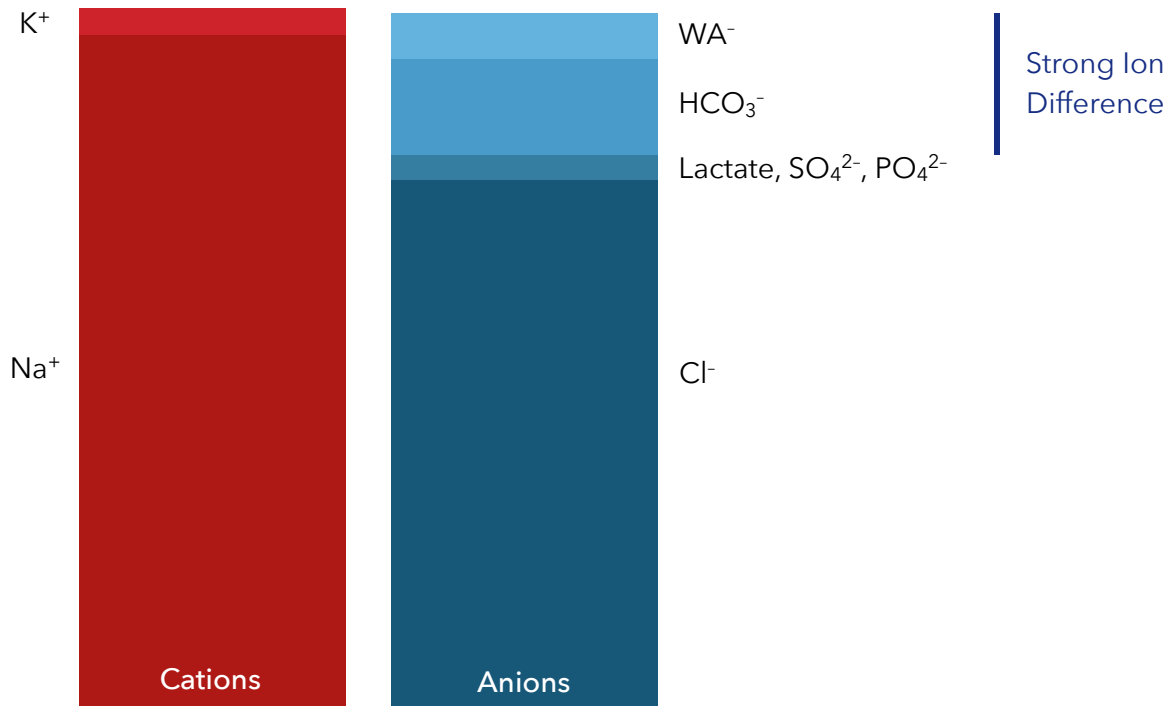
↑CO₂ = ↑H⁺ acidosis

↓CO₂ = ↓H⁺ alkalosis

Metabolic

↓SID = ↑H⁺ acidosis

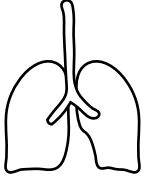

↑SID = ↓H⁺ alkalosis

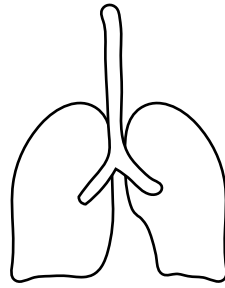


Compensation

Rules

- Respiratory compensation takes seconds
- Metabolic compensation takes hours
- The primary disorder is the one that is in the direction of the derangement
- You never actively over compensate

		Boston Rules	Copenhagen Rules
 Respiratory	acidosis ↑CO ₂	HCO ₃ up 4 for 10	SBE up 4 for 10
	alkalosis ↓CO ₂	HCO ₃ down 5 for 10	SBE down 4 for 10
 Metabolic	acidosis ↓SID ↓HCO ₃	PaCO ₂ = (1.5 HCO ₃) + 8	PaCO ₂ = 40 + SBE
	alkalosis ↑SID ↑HCO ₃	PaCO ₂ = (0.7 HCO ₃) + 21	PaCO ₂ = 40 + 0.6 SBE



Respiratory Problems

Alkalosis ↓CO₂

- CNS
 - Cerebral pathology
 - Chemical cerebral irritation
 - Endogenous
 - Liver failure
 - Pregnancy (progesterone)
 - SIRS (cytokines)
 - Exogenous
 - Aspirin
 - Sympathomemetics
 - Functional
 - pain
 - anxiety
- Lung pathology
- Mechanical ventilation

Acidosis ↑CO₂

- CNS
 - Cerebral pathology
 - Chemical cerebral depression
 - Opiates
 - Benzodiazepines
 - Anaesthetics
- Neuromuscular disorders
- Lung or chest wall defects
- Airway obstruction
- Catabolism
 - Malignant hyperthermia
 - Thyroid storm
 - Pheochromocytoma
 - Early sepsis
 - Liver failure
- Mechanical ventilation



Metabolic Acidosis ↓SID

Anion Gap

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

normal <16 mmol/L



Chloride

NAG

Any other
strong anion

↑AG

NAGMA

Urinary Anion Gap (UAG)

$$UAG = Na + K - Cl$$

normal = 0

NeGUTive UAG

- Saline infusion
- Lower GI losses

Positive UAG

- Renal tubular acidosis

↑AGMA

- Lactate
- Ketones
- SO_4^{2-} & PO_4^{2-}
- Pyroglutamate
- Exogenous strong anions



Metabolic Alkalosis ↑SID

- Upper GI losses
- Diuretics
- Conn's syndrome
- Cushings
- Barter's

Mixed Metabolic Derangements

Delta Ratio (ΔR)

$$\Delta R = \frac{\Delta AG}{\Delta HCO_3^-}$$

<0.4	NAGMA
0.4-0.8	RAGMA & NAGMA
0.8-2	RAGMA
>2	RAGMA & met-alkalosis

Gas Exchange

Determinants of PaO₂

- FiO₂ & P_{atm}
- Alveolar ventilation
- Shunt / VQ mismatch
- Diffusion limitation

↑ Aa
gradient

Determinants of PaCO₂

- FiCO₂
- Metabolic rate
- Alveolar ventilation

Alveolar Gas Equation

$$Aa \text{ gradient} = P_{AO_2} - PaO_2$$

$$P_{AO_2} = P_{iO_2} - (PaCO_2 / RQ)$$

$$P_{iO_2} = FiO_2 (P_{atm} - SVP)$$

Normal Aa gradient

10 - 20 mmHg depending on age with FiO₂ 0.21

60 - 100 mmHg depending on age with FiO₂ 1.0

P_aO₂ arterial partial pressure of O₂ (measured)

P_AO₂ alveolar partial pressure of O₂ (calculated)

Saturated Vapor Pressure (SVP) = 47 mmHg

Atmospheric pressure at sea level (P_{atm}) = 760 mmHg

Respiratory Quotient (RQ) almost always = 0.8