Acid Base Derangements

$$pH = 6.1 + \log_{10}\left(\frac{HCO_3}{0.03\ P_aCO_2}\right)$$

Respiratory

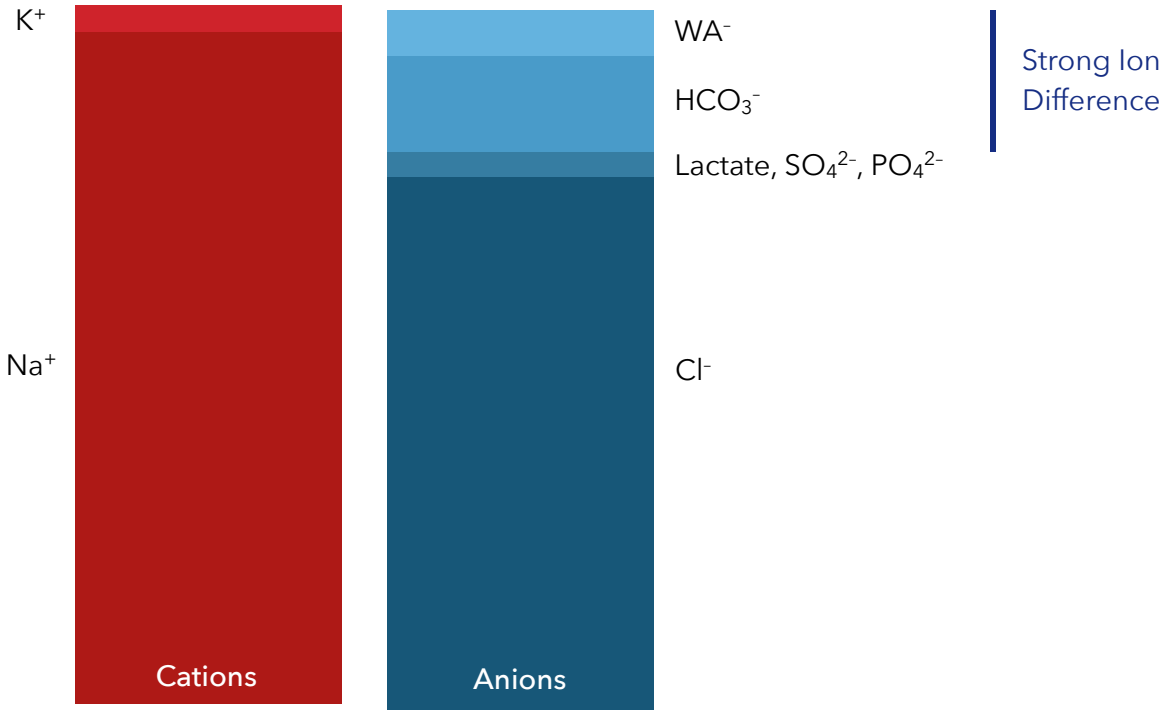
⬆CO_2 = ⬆H^+ acidosis

⬇CO_2 = ⬇H^+ alkalosis

Metabolic

⬇SID = ⬆H^+ acidosis

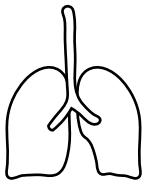
⬆SID = ⬇H^+ alkalosis

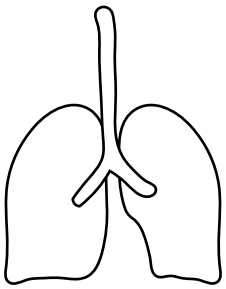


Compensation

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 ⬇CO_2

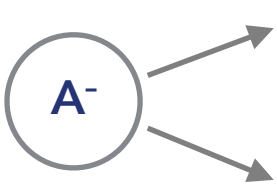
- CNS
  - Cerebral pathology
  - Chemical cerebral irritation
    - Endogonous
      - Liver failure
      - Pregnancy (progesterone)
      - SIRS (cytokines)
    - Exogonous
      - Aspirin
      - Sympathomemetics
  - Functional
    - pain
    - anxiety
- Lung pathology
- Mechanical ventilation

Acidosis ⬆CO_2

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

Metabolic Acidosis ⬇SID

Anion Gap
AG = (Na + K) – (HCO3 + Cl)
normal <16 mmol/L



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 PaO_2

- FiO_2 & P_{atm}
- Alveolar ventilation
- Shunt / VQ mismatch
- Difusion limitation

↑Aa gradient

Determinants of $PaCO_2$

- $FiCO_2$
- Metabolic rate
- Alveolar ventilation

Alveolar Gas Equation

Aa gradient = $P_AO_2 - PaO_2$

$P_AO_2 = P_IO_2 - (PaCO2 / RQ)$

$P_IO_2 = FiO2\ (P_{atm} - SVP)$

Normal Aa gradient
10 – 20 mmHg depending on age with FiO2 0.21
60 – 100 mmHg depending on age with FiO2 1.0

P_aO_2 arterial partial pressure of O_2 (measured)
P_AO_2 alveolar partial pressure of O_2 (calculated)
Saturated Vapor Pressure (SVP) = 47 mmHg
Atmospheric pressure at sea level (P_{atm}) = 760 mmHg
Respiratory Quotient (RQ) almost always = 0.8