血液氣體分析

Ming-Chih Lin M.D.
Pediatric Intensive Care Unit & Pediatric Cardiology
Taichung Veterans General Hospital
Taichung city, Taiwan

基本原理

- Henderson-Hasselbach equation
  - $H_2O + CO_2 \rightleftharpoons H^+ + HCO3^-$
  - $pH = 6.1 + \log ([HCO_3^-] / P_{CO2} \times 0.03)$
- 思考：
  - 與$HCl \rightleftharpoons H^+ + Cl^-$ 有何異同？

系統性解讀

- 酸血或是鹼血？
  - pH
- 看二氧化碳，是否解釋pH值？
  - $PaCO_2$
- 看碳酸氫根，是否解釋pH值？
  - $HCO3^-$
- 看代償機轉？
  - 原則：不會過度代償

代償機制

不平衡處	主要改變	期望的代償 （$PaCO_2$ mmHg; HCO_3^- mEq/L）
Metabolic Acidosis	HCO_3^- ↓	↓ $PaCO_2$ 1-1.5 for each 1↓ in HCO_3^-
Metabolic Alkalosis	HCO_3^- ↑	↑$PaCO_2$ 0.25-1 for each 1↑ in HCO_3^-
Respiratory Acidosis (acute)	$PaCO_2$ ↑	↑HCO_3^- 0.1 for each 1↑ in $PaCO_2$
Respiratory Acidosis (compensated)	$PaCO_2$ ↑	↑HCO_3^- 0.4 for each 1↑ in $PaCO_2$
Respiratory Alkalosis (acute)	$PaCO_2$ ↓	↓ HCO_3^- 0.2 for each 1↓ in $PaCO_2$
Respiratory Alkalosis (compensated)	$PaCO_2$ ↓	↓ HCO_3^- 0.4 for each 1↓ in $PaCO_2$

正常值

	pH	PaO_2	$PaCO_2$	HCO_3^-
NB (birth)	7.26-7.29		55	
NB (24h/o)	7.37	70	33	20
Infant	7.40	90	34	20
Child-Adult	7.35-7.45	90-110	35-45	22-26

代謝性酸血症

- Anion gap（陰離子間隙）
  - Anion gap = $[Na^+] - ([Cl^-] + [HCO_3^-])$
  - Normal range 12 +/- 4
- 陰離子間隙上昇（外來酸根，non-titratable）
  - Diabetic ketoacidosis, uremia, salicylate intoxication, starvation ketosis, methanol, alcohol ketoacidosis, unmeasured osmoles, lactic acidosis
- 陰離子間隙正常（鹼流失，或外來鹽酸）
  - Renal loss (Renal tubule acidosis)
  - GI loss (diarrhea, uretero- sigmoidostomy).
  - Ingestion (ammonium chloride, hyperalimentation intravenous nutrition)
- Urine anion gap
  - Negative means normal renal NH_4 excretion, non-renal cause

代謝性鹼血症

- 酸流失
  - GI:
    - Vomiting, Nasogastric drainage
  - Renal:
    - Diuretics (loss of Cl^-, K^+ fluid volume),
    - Hypochloremia (increased H^+ secrection and HCO_3^- reabsorption),
    - Hypokalemia (increased H^+ secrection and HCO_3^- reabsorption),
    - Hypovolemia (increased H^+ secrection)
- 外來鹼
  - Retention of biocarbonate ion:
    - $NaHCO_3^-$ infusion or ingestion

呼吸性酸血症

- 呼吸衰竭
  - 中樞神經系統:
    - drugs, brain injury, obesity
- 神經肌肉系統 :
  - Guillain-Barre syndrome, myasthenic crisis, poliomyelitis
- 肺部疾病 :
  - COPD, sleep apnea, kyphoscoliosis, acute airway obstruction (late phases)

呼吸性鹼中毒

- 正常肺:
  - Anxiety, fever, stimulant drugs, CNS lesion, pain, sepsis, high altitude, iatrogenic hyperventilation
- 異常肺:
  - Hypoxemic-causing conditions, acute asthma, pneumonia, stimulation of vagal lung receptors, pulmonary edema, pulmonary vascular disease
- 症狀
  - Light-headness, paresthesia, cramps, tetany, arrhythmias.

名詞解釋

Alveolar-arterial Oxygen Gradient ($AaDO_2$)

$$AaDO_2 = PAO_2 - PaO_2$$

$$PA = (PB - PH_2O) \times FiO_2 - PaCO_2/R$$

$$= (760 - 47) \times FiO_2 - PaCO_2/0.8$$

A：Alveolar

a: artery

BASE EXCESS

- **base excess**
  - the amount of acid required to return the blood pH of an individual to the normal value (pH 7.4). in units of (mEq/L). The normal value is somewhere between -3 to +3.
- Actual base excess
  - the base excess in the blood.
- Standard base excess
  - the value of base excess when the hemoglobin-value of 5g/l. This gives a better view of the base excess of the entire extracellular fluid.

Therapy

- Bicarb = (0.1-0.3) x BW x BE (mEq)