

NEWBORN AND ACID BASE BALANCE

The rate of metabolism in infants is twice as great in relation to body mass as in adults, which means twice as much acid is formed which leads to a tendency toward acidosis. Functional development of kidneys is not complete until the end of the first month and hence renal regulation of acid base may not be optimal.

Table 1. Causes of acidosis and alkalosis

Causes of Acidosis

- Metabolic acidosis
 - renal failure
 - septicaemia
 - hypoxia
 - hypothermia
 - hypotension
 - cardiac failure
 - dehydration
 - hyperkalaemia
 - hyperglycaemia
 - anaemia
 - intraventricular haemorrhage
 - drugs (e.g. acetazolamide)
 - metabolic disorders (often associated with hypoglycaemia)
- Respiratory acidosis
 - asphyxia : damage to respiratory centre
 - obstruction to respiratory tract e.g. secretions, blocked endotracheal tube
 - respiratory conditions :
 - respiratory distress syndrome (RDS)
 - pneumonia
 - pulmonary oedema
 - apnoea

Causes of Alkalosis

- Metabolic alkalosis
 - administration of sodium bicarbonate
 - pyloric stenosis
 - hypokalaemia
 - use of diuretics like thiazides and frusemide
- Respiratory alkalosis
 - asphyxia – overstimulation of respiratory centre
 - over ventilation while on mechanical ventilation

Effects of acidosis and alkalosis in the body

- acidosis
 - depression of central nervous system (CNS)
 - disorientation and coma
 - increased depth and rate of respiration in metabolic acidosis and depressed respiration in respiratory acidosis
 - high PaCO₂ in respiratory acidosis increases cerebral blood flow and risk of intraventricular haemorrhage
- alkalosis
 - over excitability of the CNS
 - decreased cerebral blood flow - causing cerebral ischaemia , convulsions

Measurement of Acid Base Status

- done by analyzing following parameters in an arterial blood gas sample:

Table 2. Normal values for arterial blood gas parameters

| | |
|-------------------|--------------------------|
| pH | 7.34-7.45 |
| PaCO ₂ | 5.3-6.0 kPa (40-45 mmHg) |
| PaO ₂ | 8-10 kPa (60-75 mmHg) |
| HCO ₃ | 20-25 mmol/L |
| Base Excess (BE) | ± 5 mmol/L |

Interpretation of Blood Gases

- pH < 7.34 : *acidosis*
 - if PaCO₂ and HCO₃ are low and base deficit is high: *metabolic acidosis*
 - if PaCO₂ and HCO₃ are high and base excess is high: *respiratory acidosis*
 - if both PaCO₂ and base deficit are high: *mixed metabolic and respiratory acidosis*
- pH > 7.45 : *alkalosis*
 - if PaCO₂ is low : *respiratory alkalosis*
 - if HCO₃ and base excess are high : *metabolic alkalosis*

Acidosis and alkalosis may be partially or fully compensated by the opposite mechanism,

- low PaCO₂: *hypocarbica*; high PaCO₂: *hypercarbica*
Note: Permissive hypercapnia (PCO₂ 45-55mmHg) is one of ventilator techniques to reduce the risk of chronic lung disease of prematurity.
- low PaO₂ : *hypoxaemia*; high PaO₂ : *hyperoxaemia*

Management of Metabolic Acidosis and Alkalosis

- treat underlying cause when possible
- do not treat metabolic acidosis by hyperventilation (other than briefly while preparing to give NaHCO₃). This may correct pH but has deleterious effects on cardiac output and pulmonary blood flow.
- volume expansion (i.e., bolus 10 mL/kg of 0.9% NaCl) should not be used to treat acidosis unless there are signs indicative of hypovolemia. A volume load is poorly tolerated in severe acidosis because of the decrease in myocardial contractility.
- NaHCO₃ treatment should be used only if significant metabolic acidosis is present (e.g., pH < 7.3 with base deficit > 7)
- dose of NaHCO₃ for treatment of metabolic acidosis can be calculated by:

$$\text{Dose in mmol of NaHCO}_3 = \text{Base deficit (mmol/L)} \times \text{Body weight (kg)} \times 0.3$$

- administer NaHCO₃ IV at a rate not exceeding 1 mEq/kg/min.
- the usual NaHCO₃ used in newborns is NaHCO₃ and the concentration is 0.5 mEq/mL, so it is hyperosmolar (900 mOsm/L)
- do not give NaHCO₃ unless infant is receiving assisted ventilation that is adequate. With inadequate ventilation, NaHCO₃ will worsen acidosis from liberation of CO₂.

For chronic mild metabolic acidosis in small premature infants on hyperalimentation, maximize acetate and minimize chloride in the solution.

- metabolic alkalosis: usually iatrogenic in premature infants - diuretic use, gastrointestinal losses, and occurs in combination with contracted intravascular and ECF volumes

Treatment of respiratory acidosis and alkalosis

- a steadily rising PaCO₂ at any stage in the disease is an indication that ventilatory assistance is likely to be needed
- a sudden rise may be an indication of acute changes in the infant's condition e.g. pneumothorax, collapsed lobes, misplaced endotracheal tube
- a swift rise in PaCO₂ often accompanied by hypoxia following weaning is often an indication that the infant is not ready for weaning
- a gradual rise in PaCO₂ at the end of the first week in a LBW infant on ventilator may be an indicator of the presence of a patent ductus arteriosus
- low PaCO₂ in a infant on a ventilator means overventilation, hence treatment is to wean down the ventilation. However in conditions like pulmonary hypertension or cerebral oedema a slightly low PaCO₂ may be necessary in the treatment.

Interpretation of Blood Gases

- examples of Arterial Blood Gas (ABG) Interpretation

1. A 20 weeks' gestation and 1.1 kg BW infant has RDS. He is 20 hours old and is being nursed on nasal CPAP. His ABG shows:

| | |
|-------------------|-----------|
| pH | 7.21 |
| PaCO ₂ | 6.6 kPa |
| PaO ₂ | 7.5 kPa |
| HCO ₃ | 20 mmol/L |
| BE | -4 mmol/L |

Question (Q): What does the ABG show?

Answer (A): Mild respiratory acidosis due to worsening Respiratory Distress Syndrome

Q: What is the next appropriate mode of therapy?

A: Mechanical ventilation

2. Below is the ABG of a 10 hour old 28 weeks' gestation infant :

| | |
|-------------------|-----------|
| pH | 7.22 |
| PaCO ₂ | 7.0 Pa |
| PaO ₂ | 10.0 kPa |
| HCO ₃ | 17 mmol/L |
| BE | -8 mmol/L |

Q: What does the ABG show?

A: Mixed respiratory and metabolic acidosis

Q: Name a likely diagnosis

A: Respiratory distress syndrome

3. The following is the ABG of a 40 day old 26 weeks' gestation baby:

| | |
|-------------------|------------|
| pH | 7.38 |
| PaCO ₂ | 8.0 Pa |
| PaO ₂ | 8.0 kPa |
| HCO ₃ | 35 mmol/L |
| BE | +10 mmol/L |

Q: What does the ABG show?

A: Fully compensated respiratory acidosis by metabolic alkalosis

Q: What is a likely diagnosis?

A: Chronic lung disease

4. An infant of 30 weeks' gestation and BW 1.3 kg is being ventilated . ABG shows:

| | |
|-------------------|------------|
| pH | 7.35 |
| PaCO ₂ | 3.0 Pa |
| PaO ₂ | 15.0 kPa |
| HCO ₃ | 12 mmol/L |
| BE | -12 mmol/L |

Q: Interpret the ABG

A: Fully compensated metabolic acidosis by respiratory alkalosis and hyperoxaemia

Q: What is your next course of action?

A: Reduce FiO₂, give a small dose of NaHCO₃, treat any contributory cause of acidosis and wean down ventilation setting

5. A term infant is being ventilated for meconium aspiration. His ABG is as follows :

| | |
|-------------------|------------|
| pH | 7.16 |
| PaCO ₂ | 10.0 Pa |
| PaO ₂ | 6.0 kPa |
| HCO ₃ | 16 mmol/L |
| BE | -10 mmol/L |

Q: What is likely to have happened?

A: Pneumothorax

Q: What is your interpretation of the ABG

A: Mixed respiratory and metabolic acidosis with hypoxaemia

6. A 6 day old infant is being ventilated for a cyanotic heart disease. ABG shows :

| | |
|-------------------|------------|
| pH | 6.8 |
| PaCO ₂ | 4.5 Pa |
| PaO ₂ | 3.0 kPa |
| HCO ₃ | 8 mmol/L |
| BE | -24 mmol/L |

Q: What does the ABG show?

A: Severe metabolic acidosis with severe hypoxaemia

Q: What is your next course of action ?

A: Administer sodium bicarbonate, consider prostaglandin infusion, confirm heart defect and consider surgery

Pearls

Conversion of kPa to mmHg is a factor of 7.5 kPa