Acidosis

Introduction

Acidaemia is common in neonates especially in association with prematurity and perinatal asphyxia. It is essential to establish whether the acidaemia is respiratory with a raised PaCO\textsubscript{2}, or metabolic with a normal PaCO\textsubscript{2} but a negative base excess, or a combination of both. Metabolic acidosis in preterm infants may be associated with hypoxaemia, hypotension or poor tissue perfusion, anaemia, infection or sepsis, or strenuous activity (respiratory distress).

A late metabolic acidosis may develop in premature infants that receive high protein or amino acid intakes. This may be exacerbated by reduced reabsorption of bicarbonate from the proximal tubules and reduced new base formation by the kidneys of premature infants.

This guideline deals with postnatal acidosis. See resuscitation for acidosis at birth.

Incidence and risk factors

Goldaber\textsuperscript{1} studied 30,000 consecutive deliveries and found a cord pH < 7.2 occurred in 3506 infants (11.7%), pH < 7.1 in 472 (1.6%), and pH < 7.0 in 87 (0.3%). The incidence of postnatal acidosis has not been documented in the overall population of neonates born at KGV Hospital. In a cohort of preterm infants born at KGV the incidence of postnatal acidosis in the first 48hr of life by gestation were:

<table>
<thead>
<tr>
<th>Gestation (weeks)</th>
<th>pH &lt; 7.20</th>
<th>Base excess &lt; -10</th>
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<tbody>
<tr>
<td>23 to 25</td>
<td>18%</td>
<td>26%</td>
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<td>26 to 27</td>
<td>28%</td>
<td>19%</td>
</tr>
<tr>
<td>28 to 29</td>
<td>11%</td>
<td>14%</td>
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Important causes of acidosis in neonates:
Consequences

There is an association between acidosis, acute physiological dysfunction in the neonate and longer term neurodevelopmental abnormalities. Whether the acidosis is causative or only associated with acute organ dysfunction and abnormal neurodevelopment is less certain. The following associations with acidosis have been documented:

Short term:

Acidaemia associated with asphyxia inhibits surfactant production\(^2,3\) and increases pulmonary vascular resistance\(^4\). A pH < 7.15 is associated with reduced myocardial contractility\(^5\) and diaphragmatic activity (in dogs\(^6\)). EEG documented abnormal cerebral function has been shown in preterm infants < 32 weeks gestation in relation to episodes of acidosis\(^7\).

Hydrogen ions cause the precipitation of bilirubin acid. Acidosis may exacerbate kernicterus. This should be taken into account in the treatment of hyperbilirubinaemia.

Longer term:

There is an association between neonatal acidosis and evidence of end-organ damage from perinatal asphyxia including hypoxic ischaemic encephalopathy. In the series of 30 000 infants of Goldeber\(^1\), the incidence of neonatal death and neonatal seizures did not increase until a pH < 7.05 was reached. The absolute incidence of otherwise unexplained neonatal seizures was 1.1% for pH < 7.05 and 9.2% for pH < 7.00. The mortality increased to 1.1% for pH < 7.05 and 8% at a pH < 7.00.

In preterm infants there is an association between a low umbilical arterial pH and subsequent abnormal neurodevelopmental outcome in extremely low birth weight infants\(^8\).

Diagnosis

Determination of acid-base status may be made by:

- Arterial blood gas - cord umbilical artery at delivery, umbilical arterial line, or peripheral arterial line or arterial puncture post delivery.
- Capillary blood gas - more accurate at determining pH, less accurate for PCO\(_2\) and
inaccurate at predicting arterial PO₂. Results should be used with caution.⁹

It is essential to establish whether the acidaemia is respiratory with an elevated PaCO₂ or metabolic with a normal PaCO₂ but a negative base excess, or a combination of both.

**Acidosis may be:**

- Respiratory: low pH, high PaCO₂, and high HCO₃⁻
- Metabolic: low pH, negative base excess
- Mixed metabolic and respiratory: low pH, high PaCO₂ and negative base excess most frequent in premature infants
- Compensated respiratory: near normal pH, high PaCO₂, high base excess and near normal HCO₃⁻
- Compensated metabolic: near normal pH, low PaCO₂, negative base excess and low HCO₃⁻

**Establishing the underlying cause of the acidosis may be assisted by:**

- History - evidence of fetal distress, risk factors for sepsis, prematurity
- Examination - respiratory distress, cardiac disease, poor peripheral perfusion, pallor (anaemia), hypotension, unusual odours (metabolic disease),
- Serum Na, K, Cl, and bicarbonate (on ABG) to determine anion gap = ([Na + K] -[Cl + HCO₃⁻])
- Blood lactate to confirm lactic acidosis
- Metabolic screen: urine and serum for amino acids and organic acids
- Blood count - sepsis, anaemia
- Blood cultures - sepsis
- ECHO - low cardiac output

**Interventions**

Respiratory acidosis should be corrected by manipulation of the ventilation. Normocarbia (PaCO₂ 35-45 mmHg) should be the aim of ventilatory management. Bicarbonate therapy given to a hypercarbic baby may worsen the hypercarbia as well as increase cerebral acidosis (animal and adult data reviewed by Howell).¹⁰

Metabolic acidosis is most often corrected by attention to its cause. **Hypocarbia should not be produced when treating a metabolic acidosis.**

- **Bicarbonate therapy:**

  Consider treatment with alkali in infants if pH < 7.20 and a metabolic acidosis is present (low pH and high base deficit). The evidence for use of alkali therapy in premature infants with respiratory distress is equivocal. Several studies have attempted to demonstrate the effect of treatment of early acidosis in infants (usually pH < 7.25) with RDS and shown differing results¹¹,¹²,¹³.

  Whether correction of severe acidosis improves outcomes has not been studied in a randomized trial.
Give bicarbonate therapy over 30-60 minutes. Sinclair\(^{11}\) studied rapid (<5 minutes) versus slow bicarbonate therapy (over 24 hours) and found a trend to increased mortality in the rapid group and no benefit in terms of time to correction of pH. In view of experiences with rapid infusions of bicarbonate resulting in an increased incidence of intraventricular haemorrhage\(^{14,15,16}\) (non-randomised studies) and animal data suggesting harmful effects (reviewed by Howell\(^{10}\)) rapid infusions of bicarbonate should be avoided where possible.

- **Alkalinisation of total parenteral nutrition:**

  Acetate should be added to total parenteral nutrition of infants with a base deficit ≥5. Premature infants with late metabolic acidosis have better weight gain and higher nitrogen assimilation if given NaHCO\(_3\) compared to saline\(^{17}\), and the use of acetate in total parenteral nutrition for premature infants reduces the severity of the acidosis and incidence of hyperchloraemia\(^{18}\).

- **Bicarbonate therapy for resuscitation:**

  See resuscitation.

- **THAM (tris-hydroxymethylaminomethane):**

  THAM is not available in Australia. This alkali has the potential advantages of not causing hypernatraemia and hypercarbia. However, it provides a higher osmolar load in equimolar doses to sodium bicarbonate and caused depression of ventilation and hypoglycaemia. It has not been subjected to randomised trials.

If a decision is made to correct the metabolic acidosis using base, sodium bicarbonate is used in the following amount. Remember that repeated infusion of sodium bicarbonate may cause hypernatraemia. Half correction should be aimed at and repeated if necessary. Use sodium bicarbonate 8.4% and dilute 50:50 with water (= 4.2%).

For half correction:

\[
4.2\% \text{ NaHCO}_3 (\text{ml}) = \text{weight (kg)} \times \text{base deficit} \times 0.3
\]

Administer over 30-60 minutes.

### Key Points

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<thead>
<tr>
<th>Key points</th>
<th>Level of evidence</th>
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<tr>
<td>Treat acidosis to keep pH ≥7.20</td>
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<tr>
<td>Avoid giving rapid infusions of bicarbonate (&lt;5 minutes)</td>
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</table>
Use bicarbonate 4.2% (1:1 dilution of 8.4% NaHCO₃ and water)

References
