Management of metabolic acidosis: does correction with sodium bicarbonate do more harm than good?

Metabolic acidosis is a very common finding in critically ill patients and is associated with increased morbidity and mortality. Metabolic acidosis in critical care patients is commonly the result of either anaerobic metabolism or failure of excretion of endogenous acid. Other causes include renal or gastrointestinal loss of bicarbonate and the intake of exogenous acids.

Physiological effects of acidosis

Metabolic acidosis results in a variety of adverse physiological effects. It can be difficult to distinguish whether these are caused by the pathological process or the acidosis.

Acidosis depresses myocardial contractility, reduces systemic vascular resistance and increases mean pulmonary artery pressure, but pulmonary vascular resistance remains unchanged. The overall physiological effect of acidosis is an increase in cardiac output caused by concurrent stimulation of the sympathetic nervous system.

Acidosis decreases the responsiveness of adrenergic receptors to circulating catecholamines. Marsh et al (1988) investigated the effect of acidosis on cultured myocardial cells from chick embryo ventricles. An intracellular pH of 6.96 resulted in a greater than 50% reduction in contractile response to isoprenaline. The authors concluded that there was a reduction in the number of adrenergic receptors on the cell membranes. Other studies have postulated that the decreased responsiveness is a result of reduced cAMP production secondary to depressed adenylate cyclase activity.

Permissive hypercapnoea is commonly used in the management of patients with adult respiratory distress syndrome. Hypercapnoea and the resulting respiratory acidosis are very well tolerated. Hypercapnoea results in a reduced systemic vascular resistance and mean arterial pressure, and increased heart rate, cardiac output and mean pulmonary artery pressure. Correction of acidosis improves myocardial contractility by 10%, but does not return it to baseline levels (Weber et al, 2000).

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Beneficial effects of acidosis

Acidosis is generally assumed to be detrimental, but does it confer any benefits?

Animal studies have shown that the presence of a metabolic acidosis has protective effects on the heart, lung, brain and liver against physiological insults such as hypoxia. Respiratory acidosis is protective against acute lung injury secondary to ischaemia-reperfusion injury, baro- and volutrauma and endotoxin-induced acute lung injury.

Acidosis improves tissue oxygen delivery by causing a right shift of the oxygen dissociation curve. In-vitro studies have demonstrated an increase in tissue oxygen tension of 6% for each 1 mmol/litre increase in serum lactate (Boning et al, 1991). This can increase oxygen delivery by up to 60%.

Clinical outcomes after sodium bicarbonate administration

Administration of sodium bicarbonate used to be common practice during cardiac arrests for correction of metabolic acidosis. Extensive animal and human studies have shown that it results in reduced myocyte pH, reduced coronary perfusion, reduced oxygen delivery, hypernatraemia, hyperosmolarity and increased mortality.

A review article (Andrade et al, 2007) looked at the management of metabolic acidosis in children with cardiovascular collapse, diabetic ketoacidosis and lactic acidosis. The authors concluded that the administration of sodium bicarbonate did not improve the haemodynamic parameters, morbidity or mortality. These results are consistent with adult studies.

Prospective, randomized, blinded trials (Mathieu et al, 1991) have compared the effects of administration of sodium bicarbonate or sodium chloride to patients with sepsis and severe metabolic acidosis. The studies found that, although the administration of sodium bicarbonate increased plasma pH, it did not improve the haemodynamic parameters or the cardiovascular response to catecholamines.

Studies investigating exercising healthy volunteers found that an infusion of sodium bicarbonate resulted in an increase in arterial pH and partial pressure of carbon dioxide, but lead to a further reduction in intracellular pH.

Conclusions

A metabolic acidosis is common in critically ill patients in the intensive care unit and these patients have increased morbidity and mortality. The acidosis has some detrimental physiological effects, but paradoxically also has some benefits. Many animal and human studies have demonstrated that the administration of sodium bicarbonate does not reverse the adverse effects of the acidosis, but may even result in harm.

Treatment of a patient with a metabolic acidosis should be aimed at correcting the underlying disease process and only very rarely should the acidosis be corrected by administering sodium bicarbonate. BJHM

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