



## The Use of Bicarbonate Therapy in Critical Care for Metabolic Acidosis

Authors

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### Abstract

*Metabolic acidosis is a condition when there is a relative accumulation of plasma anions than the cations, which reduces the plasma pH. Replacement by sodium bicarbonate therapy is useful for the patients with diarrhea or renal tubular acidosis, but there is no definite evidence that sodium bicarbonate administration to the patients with acute metabolic acidosis.*

*Acute metabolic acidosis occurs in conditions like diabetic ketoacidosis, lactic acidosis, septic shock, intraoperative metabolic acidosis. Patients with advanced chronic kidney disease also shows metabolic acidosis due to increased unmeasured anions and hyperchloremia.*

*It's also a predominant buffer used in dialysis fluids and a load of sodium bicarbonate subjected to patients on maintenance dialysis during the sessions, suffering a transient metabolic alkalosis of variable severity. Side effects associated with sodium bicarbonate therapy include hypokalemia, ionized hypocalcemia, hypercapnia, and QTc interval prolongation. Administration of sodium bicarbonate in sepsis that is subject to ongoing debate.*

### Introduction

In critically ill patients the severe metabolic acidemia (blood pH  $\leq 7.20$ ) is associated with impaired hemodynamics and increased mortality. It is mainly caused by acid accumulation due to increased acid production or loss of bicarbonate from the body, which overwhelms the mechanisms of acid–base homeostasis or when renal acidification mechanisms are compromised. Administration of sodium bicarbonate can increase blood pH, but its ability to improve

hemodynamics and reducing mortality remains unproven<sup>(2)</sup>

Metabolic acidosis results from a loss of bicarbonate from the body (e.g., diarrhea) or from its titration to an anionic base that often can be converted back to bicarbonate, such as seen in diabetic ketoacidosis or lactic acidosis<sup>(3) (6)</sup>

Metabolic acidosis frequently occurs as a part of mixed acid–base disorders, especially among in critically ill patients and they can be acute (lasting minutes to several days) or chronic (lasting weeks to years) in duration.

The serum anion gap, is used as a diagnostic tool for metabolic acidosis. There are some conditions with no change in the anion gap, whereas in some conditions there is increased anion gap. Mixed normal and high anion gap patterns are also common in some conditions. The normal range for the serum anion gap is 8-16 mEq/L<sup>(4)</sup>.

Both acute kidney injury and CKD can cause metabolic acidosis, Diabetic ketoacidosis and lactic acidosis are the most common causes of acute metabolic acidosis. The frequency of this condition might increase with the anticipated rise in chronic kidney disease (CKD) in our aging population<sup>(9)</sup>. Either it is acute or chronic metabolic acidosis can cause adverse effects on cellular function and can contribute to increased morbidity and mortality rate. As in all critically ill patients, the primary aim of therapy should be to reverse the cause of metabolic acidosis<sup>(5)</sup>

Bicarbonate therapy to a patient with a true bicarbonate deficit is not controversial. Controversial occurs when the conversion of bicarbonate to another base, can be converted back to bicarbonate by giving time. If one knew that the timely and efficient conversion of acetoacetate and -hydroxybutyrate or lactate back to bicarbonate would occur without morbidity or mortality, then there would be no reason even to contemplate giving bicarbonate.<sup>(3)</sup>

Severe acidemia can cause decrease in myocardial contractility, a fall in cardiac output, and a fall in BP. Acidemia also decreases the binding capacity of norepinephrine to its receptors. Here the Bohr Effect has been seen as it shifts the oxyhemoglobin curve to the right, allowing more O<sub>2</sub> to be released. These protons bind to intracellular and extracellular proteins, especially albumin and hemoglobin. Thus, acidemia may adversely affect cell functions such as enzymatic reactions, ATP generation, fatty acid biosynthesis, and bone formation/resorption<sup>(3)</sup>

The acidemia can cause fall in BP and cardiac output, pulmonary vasoconstriction and decreased myocardial contractility<sup>(6)</sup>. This has been noted in humans and experimental animals under a variety

of acidemic conditions. In this condition, there is a shift in ionized calcium, and in strong acidosis potassium also shifts out of the cell, sensitizing the heart to abnormal electrical activity and subsequent arrhythmias are formed. Mostly bicarbonate is given when the arterial pH is <7.1. Moreover an intracellular acidosis may occur when giving bicarbonate therapy because CO<sub>2</sub> generated from its titration freely diffuses across the cell membrane. In addition, both volume expansion and hypernatremia can occur; in patients with compromised cardiac output, fulminate congestive heart failure with flash pulmonary edema may result.<sup>(3)</sup>

### Discussion

Administration of sodium bicarbonate of lactic acidosis in sepsis is subject to ongoing debate. Published evidence indicates that bicarbonate therapy is not useful in cases of metabolic acidosis in sepsis and can also cause harm by worsening intracellular acidosis.<sup>(7)</sup>

Sodium bicarbonate on the basis of evidence that reductions in pHe and pHi can cause cellular dysfunction, it seems self evident that base therapy would be beneficial. Sodium bicarbonate is the most common form of base recommended by physicians. However, the value of bicarbonate administration remains controversial,<sup>(4)(8)</sup>

Bicarbonate buffers hydrogen ions by reacting to form carbonic acid (H<sub>2</sub>CO<sub>3</sub>), which is converted to carbon dioxide and water ( $\text{HCO}_3^- + \text{H}^+ \rightarrow \text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ ). In order for this reaction to continue, the carbon dioxide and water must be removed from the tissue bed and the body by circulation and respiration. Bicarbonate therapy can only result in an increase in pH if ventilation is adequate to remove carbon dioxide. Even when ventilation is adequate, the PCO<sub>2</sub> is likely to increase at the cellular level because carbon dioxide diffuses across cell membranes readily, resulting in worsening intracellular acidosis and bicarbonate therapy does not improve cellular or hemodynamic functions.<sup>(5)</sup>

Side effects: Other side effects of bicarbonate therapy are potassium shifts resulting in hypokalemia, ionized calcium shifts resulting in hypocalcemia, volume expansion and hypernatremia (with sodium bicarbonate), acidosis of cerebrospinal fluid, hypoxia due to left shift of the oxyhemoglobin curve (which increases the affinity of hemoglobin for oxygen), rebound alkalosis, and prolongation of the QTc interval.<sup>(5)(8)</sup> The treatment of severe metabolic acidemia in critically ill patients remains a challenging problem.<sup>(2)</sup>

### Conclusion

On the basis of evidence that reduction in pHe and can cause cellular dysfunction. Increased mortality has been documented in patients with lower or acidic pH level (pH level below 7 and bicarbonate level below 10).

Published evidence and recommendation by physicians and intensivists indicates that sodium bicarbonate therapy is beneficial in severe metabolic acidosis. However, the value of bicarbonate administration remains controversial. Administration of sodium bicarbonate in sepsis condition that is subject to ongoing debate. Published evidence indicate that bicarbonate therapy is not useful in case of metabolic acidosis in sepsis and can cause harm by worsening intracellular acidosis.

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