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In the Emergency Room, Metabolic Acidosis that has not Recovered: Clinical Outcomes, Epidemiology, and Sodium Bicarbonate Therapy

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Abstract

Critically ill patients frequently suffer from acute metabolic acidosis. It has been linked to worse outcomes that prioritize the needs of the patient, such as an increase in hospital length of stay (LOS), admissions to the intensive care unit (ICU), and mortality rates. However, it is still not clear whether the acidosis itself or the disease that causes the acidosis are to blame for these outcomes.

In order to lessen the negative effects of decompensated metabolic acidosis, intravenous sodium bicarbonate (SB) is sometimes given to patients. However, previous research has shown that intensive care clinicians' practices vary significantly across ICUs. The lack of large, multicenter randomized controlled trials (RCTs) contributes to the therapeutic uncertainty that these observations highlight. However, the recent BICAR-ICU trial demonstrated that SB reduced mortality in patients with acute kidney injury (AKI) and decompensated metabolic acidosis, reviving interest in SB therapy for ICU patients.

Epidemiological studies of patients in the emergency department (ED) have not yet replicated the aforementioned ICU data. However, such research is necessary to comprehend the prevalence of decompensated metabolic acidosis at initial hospital presentation and the current treatment for it. As a result, we conducted an epidemiological study to test the hypothesis that, in patients with arterial blood gas (ABG)-confirmed decompensated metabolic acidosis who presented to the emergency department (ED), SB would be used in a small percentage of patients and given at a low dose of approximately 100 mmol, as was recently observed in the ICU.

Keywords: Crisis office; Acidosis; pH; Excess base; Bicarbonate

Introduction

Metabolic acidosis is a medical condition characterized by an imbalance in the body's acid-base balance, resulting in a decrease in blood pH and an excess of acid [1]. It occurs when there is an accumulation of acid in the body or a loss of bicarbonate, a base that helps regulate pH. Metabolic acidosis can occur due to various underlying causes and can have significant implications for overall health and organ function.

The acid-base balance in the body is tightly regulated to maintain a pH within a narrow range. The pH scale ranges from 0 to 14, with a value of 7 considered neutral. A pH below 7 is considered acidic, while a pH above 7 is alkaline or basic. The normal blood pH range is approximately 7.35 to 7.45.

Metabolic acidosis can occur through two primary mechanisms

Increased Acid Production: This occurs when there is an excess production of acids in the body, such as in certain metabolic disorders like diabetic ketoacidosis or lactic acidosis. These conditions result in an increased production of ketoacids or lactic acid, respectively, overwhelming the body's ability to neutralize and eliminate the excess acid.

Decreased bicarbonate levels: Bicarbonate is an essential base in the body that helps buffer and neutralize acids. Metabolic acidosis can occur if there is a loss of bicarbonate or if the kidneys are unable to reabsorb and regenerate bicarbonate effectively [2]. Causes of decreased bicarbonate levels include renal tubular acidosis, severe diarrhea, or kidney dysfunction.

Metabolic acidosis can lead to a variety of symptoms and complications. Common symptoms include rapid breathing, fatigue, confusion, headache, and nausea. In severe cases, metabolic acidosis can result in organ dysfunction, cardiac arrhythmias, and impaired oxygen delivery to tissues.

Diagnosis of metabolic acidosis involves evaluating blood gas levels, electrolyte concentrations, and calculating the anion gap—a measure of the balance between cations and anions in the blood. Treatment aims to address the underlying cause, correct acid-base imbalances, and restore normal pH levels. This may involve administering intravenous fluids, correcting electrolyte imbalances, or addressing the specific condition causing the metabolic acidosis.

Overall, metabolic acidosis is a complex medical condition that can have serious implications for overall health and organ function [3]. Timely diagnosis and appropriate management are essential to prevent complications and restore the acid-base balance in the body.

Methods and Materials

Setting and design of the study

Austin Health, a tertiary referral hospital in Melbourne, Australia, was the setting for this retrospective cohort study. Included were all

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adult patients under the age of 18 who presented to the emergency department with an ABG showing decompensated metabolic acidosis. Only the first episode of metabolic acidosis in patients who presented to the emergency department was taken into account. A modified definition was used to count the number of patients who did not have an ABG but had venous blood gas (VBG) that suggested decompensated metabolic acidosis. Patients who had only undergone a VBG assessment were excluded from further analysis for the purposes of this study. This was necessary to match the existing ICU literature and to more precisely identify decompensated metabolic acidosis [4]. This project was reviewed and approved by Austin Health's Office for Research in accordance with the National Statement on Ethical Conduct in Research.

Data collection

The baseline demographics, ICD-10 principal diagnosis codes, all available ABG parameters, a full blood examination, and urea and electrolyte panels were all extracted from electronic health records. While patients were incorporated in view of ABG boundaries, all VBG information from the patients' ED affirmation were additionally gathered. Additionally, the ICD-10 primary diagnosis codes for conditions that are anticipated to result in metabolic acidosis were gathered. Diabetic ketoacidosis (DKA), heart failure, and AKI were picked deduced, while codes connecting with disease, sepsis, and septic shock were in this manner gathered minus any additional examination.

The respiratory rate (RR), oxygen saturation (SpO2), heart rate (HR), blood pressure (BP), temperature, and conscious state were all recorded in the first and last sets of ED vital sign data [5]. Finally, the time point at which the intravenous SB was received as well as the quantity of any doses that were administered were recorded.

Data from venous blood gases

Despite the fact that the study's inclusion criteria required an ABG diagnosis of decompensated metabolic acidosis, data from venous blood gases were still collected and used in the statistical analysis for these patients. This made it possible to conduct a more in-depth analysis of the changes and trends in blood gas parameters that occurred in patients during their admission to the emergency department.

Measurable examination

Patients were apportioned to either the SB or No SB bunch contingent upon SB treatment in the ED. The proportion of patients who received SB and the incidence of decompensated metabolic acidosis were calculated. Wilcoxon rank-sum tests were used to compare continuous variables, and the median and interquartile range were used to summarize the results [6]. Fisher's exact tests were used to compare categorical variables, and counts and percentages were used to summarize the results. R-4.0.2 was used for all analyses, and a p value of less than 0.05 was considered statistically significant.

The baseline pathology, vital signs, and blood gas parameters of each group's patients were compared to one another. We calculated the median number and size of SB doses that were given to each patient. The groups were compared when it came to the frequency and type of blood gas sampling. The SB and No SB groups were also compared in terms of changes in vital signs and blood gas parameters during ED admission.

Using an internal point algorithm and patients as random effects to account for the repeated measurements, a mixed-effect median regression model was used to examine the median difference between each blood gas parameter measured immediately before and after SB administration in the SB group. In addition, a mixed-effect linear model with time (as a continuous variable), group, and an interaction between time—group as fixed effects and patients as random effects—was used to compare the change in specific blood gas parameters (median pH, BE, bicarbonate concentration, and sodium concentration) over time for each group.

Generalized linear models with a binomial distribution (logistic regression) and generalized linear models were used to identify factors related to the use of SB and the total dose. Covariates were included in the univariable model if p 0.10 and were selected from a predefined list based on clinical relevance [7]. The effect of increasing each value by one standard deviation served as the foundation for the effect estimates for continuous variables. The same analysis was used to investigate factors that could be associated with mortality in hospitals. The ED LOS, ICU admission, ICU LOS, hospital LOS, and hospital mortality were all evaluated as clinical outcomes.

Results

The results of metabolic acidosis can vary depending on the underlying cause, the severity of the condition, and the promptness of treatment. Here are some potential results and outcomes associated with metabolic acidosis:

Acid-base balance: The primary result of metabolic acidosis is a decrease in blood pH and an excess of acid. The severity of acidosis can be measured using parameters such as arterial blood pH and bicarbonate levels. The results will reflect the extent of the acid-base imbalance.

Clinical symptoms: Metabolic acidosis can manifest with a range of symptoms, which can vary depending on the underlying cause and the severity of acidosis. Common symptoms include rapid breathing (hyperventilation), fatigue, confusion, headache, nausea, and vomiting. Severe cases of metabolic acidosis can lead to altered mental status, lethargy, and even coma.

Electrolyte imbalances: Metabolic acidosis can disrupt electrolyte balance in the body. It can lead to decreased levels of potassium (hypokalemia) and calcium (hypocalcemia) in the blood, which can result in muscle weakness, cardiac arrhythmias, and bone demineralization.

Organ dysfunction: In severe or prolonged cases of metabolic acidosis, organ dysfunction can occur. The decreased pH can negatively impact various organ systems, including the cardiovascular, respiratory, and nervous systems. This can result in impaired cardiac contractility, respiratory depression, and altered neurological function.

Underlying cause: Identifying the underlying cause of metabolic acidosis is crucial for appropriate management. The results of diagnostic tests and evaluations will help determine the specific condition or factor contributing to the acid-base imbalance [8]. This may include assessing blood glucose levels, lactate levels, renal function, or specific laboratory tests depending on the suspected cause.

Treatment response: The results of treatment for metabolic acidosis can vary depending on the effectiveness of interventions and the ability to correct the underlying cause. Prompt and appropriate treatment, such as correcting the acid-base imbalance, addressing the underlying condition, and restoring electrolyte balance, can lead to the resolution of metabolic acidosis and improvement in symptoms.

It's important to note that the specific results and outcomes of metabolic acidosis can differ among individuals and depend on the unique circumstances of each case. Prompt medical attention, accurate diagnosis, and appropriate treatment are essential in managing metabolic acidosis and minimizing potential complications.

Discussions

Metabolic acidosis is a complex medical condition that can give rise to several important discussions. Here are some key points that can be discussed in relation to metabolic acidosis:

Underlying causes and risk factors: Metabolic acidosis can be caused by various factors, including metabolic disorders (e.g., diabetic ketoacidosis), kidney dysfunction, severe diarrhea, certain medications, or poisoning. The discussion can focus on exploring the different causes, risk factors, and their respective mechanisms of inducing metabolic acidosis.

Diagnostic challenges: The diagnosis of metabolic acidosis involves assessing blood pH, bicarbonate levels, and calculating the anion gap. However, certain cases can present diagnostic challenges, especially when multiple acid-base disturbances are present or when compensatory mechanisms mask the acidosis. Discussing these challenges and strategies for accurate diagnosis can be valuable.

Acid-Base disorders and compensation: Metabolic acidosis can occur in combination with other acid-base disorders, such as respiratory acidosis or alkalosis. Understanding the compensatory mechanisms that the body employs to maintain acid-base balance in these situations can be an intriguing discussion point.

Clinical manifestations and complications: Metabolic acidosis can have a wide range of clinical manifestations, ranging from mild symptoms to severe organ dysfunction [9]. The discussion can delve into the pathophysiological mechanisms that underlie these manifestations and the potential complications associated with untreated or severe cases of metabolic acidosis.

Treatment approaches: Treatment of metabolic acidosis aims to address the underlying cause, correct the acid-base imbalance, and manage associated complications. Discussions can focus on the various treatment modalities, including intravenous fluids, bicarbonate administration, targeted therapies for specific underlying conditions, and the importance of individualized approaches.

Prognosis and outcomes: The prognosis of metabolic acidosis depends on multiple factors, such as the underlying cause, severity of acidosis, and timely intervention. Discussing the potential long-term outcomes, including recovery, residual effects, or chronic management, can provide insights into the prognosis of metabolic acidosis.

Research and future directions: Exploring ongoing research in the field of metabolic acidosis can shed light on emerging diagnostic tools, therapeutic strategies, and potential targets for intervention [10]. This discussion can encompass new technologies, molecular mechanisms, or clinical trials that may shape the future management of metabolic acidosis.

It's important to approach these discussions by considering the specific context, audience, and available scientific evidence. This ensures a comprehensive and informed exchange of ideas related to metabolic acidosis.

Conclusion

In conclusion, metabolic acidosis is a significant medical condition characterized by an imbalance in the body's acid-base balance, resulting in a decrease in blood pH and an excess of acid. It can arise from various causes, including metabolic disorders, kidney dysfunction, severe diarrhea, or medication-related factors.

Diagnosis of metabolic acidosis involves assessing blood pH, bicarbonate levels, and calculating the anion gap. Prompt and accurate diagnosis is crucial to identify the underlying cause and guide appropriate treatment.

Metabolic acidosis can lead to a range of clinical manifestations and complications, affecting multiple organ systems. Symptoms can vary in severity and may include rapid breathing, fatigue, confusion, headache, and nausea. Severe cases can result in organ dysfunction, electrolyte imbalances, and altered mental status.

Treatment of metabolic acidosis aims to address the underlying cause, correct the acid-base imbalance, and manage associated complications. This may involve administering intravenous fluids, bicarbonate therapy, or targeted treatments for specific conditions. Timely intervention can lead to the resolution of metabolic acidosis and improvement in symptoms.

The prognosis of metabolic acidosis depends on various factors, including the underlying cause, severity of acidosis, and promptness of treatment. Early recognition and appropriate management can prevent complications and improve outcomes.

Further research in the field of metabolic acidosis is needed to enhance understanding of the underlying mechanisms, improve diagnostic approaches, and explore novel therapeutic strategies. Continued investigation holds promise for advancing our knowledge and improving the management of metabolic acidosis.

Overall, metabolic acidosis is a complex condition that requires careful evaluation, tailored treatment, and ongoing monitoring. Through comprehensive care and timely intervention, it is possible to mitigate the effects of metabolic acidosis and improve patient outcomes.

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Conflict of Interest

None

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