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Assessing the Correlation between Acid-Base Parameters, BUN/Creatinine Ratio, and eGFR in Children Aged 2–18 Years Hospitalized with Diabetic Ketoacidosis: A Retrospective Study at Heshmatieh Hospital, Sabzevar (2016–2022)

Vahid Sheikhi [1], Mahboube Neamatshahi [2], Parisa Fouji [3], Aghil Miri [4], *Aghil Keykhosravi [5]

[1] Assistant Professor, Department of Pediatric Nephrology, Faculty of Medicine, Zahedan University of Medical Sciences, Zahedan, Iran.

[2] Assistant Professor, Department of Community Medicine, Faculty of Medicine, Sabzevar University of Medical Sciences, Khorasan Razavi, Iran.

[3] Student of Medical Science, Zahedan University of Medical Sciences, Zahedan, Iran.

[4] Assistant Professor, Department of Pediatric Medicine, Faculty of Medicine, Zahedan University of Medical Sciences, Zahedan, Iran.

[5] Assistant Professor, Department of Pediatric Nephrology, Faculty of Medicine, Sabzevar University of Medical Sciences, Sabzevar, Khorasan Razavi, Iran.

Abstract

Background: Diabetic Ketoacidosis (DKA) is a life-threatening complication of diabetes mellitus, particularly prevalent in pediatric populations. This study aims to explore the correlation between blood gas parameters, serum blood urea nitrogen (BUN)/creatinine (Cr) ratio, and estimated glomerular filtration rate (eGFR) in pediatric patients aged 2 to 18 years hospitalized with DKA at Heshmatieh Hospital in Sabzevar between 2016 and 2022.

Methods: In this retrospective study, 84 patients diagnosed with diabetic ketoacidosis (DKA) were included. Arterial blood gas analysis was performed to assess pH, bicarbonate (HCO_3^-), and anion gap levels, which are key parameters for evaluating DKA severity and guiding clinical management. Renal function was evaluated using the blood urea nitrogen-to-creatinine ratio (BUN/Cr) and estimated glomerular filtration rate (eGFR), as dehydration and metabolic disturbances during DKA may acutely impair kidney function. These laboratory markers were analyzed to explore their utility in monitoring both metabolic and renal status throughout the treatment course.

Results: This investigation evaluates the interplay between these parameters to identify potential biomarkers for assessing DKA severity and predicting clinical outcomes. Preliminary findings suggest that abnormal blood gas values, elevated BUN/Cr ratios, and reduced eGFR levels are associated with more severe DKA presentations and prolonged hospital stays. The integration of these biomarkers into clinical practice may enhance early risk stratification, optimize fluid and electrolyte management, and improve overall patient outcomes.

Conclusions: These findings underscore the importance of a multidisciplinary approach in managing pediatric DKA, emphasizing the role of laboratory parameters in guiding timely and effective interventions. Further research is warranted to validate these correlations and establish standardized protocols for their application in clinical settings.

Key Words: Acute kidney injury, BUN/Cr ratio, Diabetic ketoacidosis, Venous blood gases.

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Corresponding Author:

Aghil Keykhosravi, Assistant Professor, Department of Pediatric Nephrology, Faculty of Medicine, Sabzevar University of Medical Sciences, Sabzevar, Khorasan Razavi, Iran. Tel: 09155720721; Email: drakeykhosravi@yahoo.com .

1- INTRODUCTION

Diabetic Ketoacidosis (DKA) is a life-threatening acute complication of diabetes mellitus, particularly prevalent in children and adolescents with type 1 diabetes mellitus (T1DM) (1). It is characterized by the triad of hyperglycemia, metabolic acidosis, and ketonemia, resulting from a severe insulin deficiency and an excess of counter-regulatory hormones (2). DKA remains a leading cause of morbidity and mortality in pediatric patients, necessitating prompt diagnosis and aggressive management to prevent complications such as cerebral edema, acute kidney injury, and electrolyte imbalances (3).

The pathophysiology of DKA involves a cascade of metabolic disturbances, including dehydration, electrolyte imbalances, and renal dysfunction, which can significantly impact patient outcomes (4). Blood gas analysis is a cornerstone in the diagnosis and monitoring of DKA, providing critical information about acid-base status and the severity of metabolic acidosis. Additionally, renal function markers such as serum blood urea nitrogen (BUN), creatinine (Cr), and the estimated glomerular filtration rate (eGFR) are essential in assessing the extent of renal impairment, which is often exacerbated by dehydration and metabolic stress in DKA (5).

The BUN/Cr ratio, in particular, has been proposed as a useful indicator of dehydration and prerenal azotemia, while eGFR serves as a reliable measure of renal filtration capacity (6). Understanding the interplay between these parameters and blood gas findings in pediatric DKA patients can provide valuable insights into disease severity, guide therapeutic interventions, and improve prognostic accuracy (3). However, limited studies have explored the correlation between blood gas parameters and renal function markers in this specific population, particularly in resource-limited settings (7).

This study aims to investigate the relationship between blood gas analysis (including pH, bicarbonate, and anion gap) and renal function markers (BUN/Cr ratio and eGFR) in pediatric patients aged 2 to 18 years hospitalized with DKA at Heshmatieh Hospital in Sabzevar, Iran, between 2016 and 2022. By analyzing data from a six-year period, this study seeks to contribute to the growing body of evidence on the utility of these biomarkers in predicting DKA severity and renal outcomes, ultimately informing clinical practice and improving patient care in similar settings.

2- METHODS

A retrospective analysis was conducted on medical records of 84 pediatric patients aged 2 to 18 years hospitalized with DKA at Heshmatieh Hospital between 2016 and 2022. Data collected included venous blood gas (VBG) parameters (pH, bicarbonate [HCO3-], and partial pressure of carbon dioxide [pCO2]), serum BUN, Cr, and eGFR values. The BUN/Cr ratio was calculated, and eGFR was estimated using the Schwartz formula. Statistical analyses including descriptive statistics (mean and standard deviation) and inferential statistics (Chi-Squared test, correlation analysis, independent t-test, and non-parametric equivalents) were used to analyze the data. The code for the Ethics Committee is IR.ZAUMS.REC.1402.188.

2-1. Inclusion and Exclusion Criteria

The study included children aged 2 to 18 years who were hospitalized with diabetic ketoacidosis (DKA) at Heshmatieh Hospital between 2016 and 2022. Children whose medical records lacked the necessary information required for the study were excluded.

3- RESULTS

In this study, Severe metabolic acidosis (pH < 7.1) was observed in 45% of patients, while moderate acidosis (pH 7.1–7.2) was present in 35%.
A significant negative correlation was found between pH and serum BUN/Cr ratio, indicating that more severe acidosis was associated with higher BUN/Cr ratios (Table 1).
Elevated BUN/Cr ratios (>20:1) were observed in 60% of patients, suggesting prerenal azotemia due to dehydration.

A moderate negative correlation was noted between BUN/Cr ratio and eGFR, reflecting impaired renal perfusion in severe DKA (Table 2).
Reduced eGFR (<90 mL/min/1.73m²) was observed in 30% of patients, particularly those with severe acidosis.
A positive correlation was observed between eGFR and pH, suggesting improved renal function in patients with milder acidosis (Table 3).

4- DISCUSSION

The findings of this article provide valuable insights into the complex interplay between metabolic acidosis, renal function, and hydration status in pediatric patients with diabetic ketoacidosis (DKA). The strong correlation between blood gas parameters, such as pH, bicarbonate, and anion gap, and the BUN/Cr ratio underscores the utility of these biomarkers in assessing the severity of DKA and guiding clinical management. Elevated BUN/Cr ratios, often indicative of dehydration, were associated with more severe metabolic acidosis and reduced estimated glomerular filtration rate (eGFR). This highlights the critical role of fluid resuscitation in the management of DKA, as dehydration exacerbates acidosis and impairs renal function.

The observed reduction in eGFR in patients with severe acidosis may reflect acute kidney injury (AKI) secondary to hypovolemia and renal hypoperfusion. This is consistent with findings from other studies, which have demonstrated that AKI is a common complication in pediatric DKA patients, particularly in those with severe dehydration and metabolic derangements. For example, Jayashree et al. found that AKI occurred in approximately 30-40% of pediatric DKA

Table- 1: Demographic data of study population (n=84).

Demographic Characteristic Value	
Age range	2-18 years
Gender distribution	Male: 65% Female: 35%
Mean age	10.63
Age subgroups	2-5 years: %25 6-12 years: %46 13-18 years: %29
Weight distribution	36.44 kg
Height distribution	130.56 cm

Table-2: Blood Gas Parameters and Acidosis Severity.

Parameter	Value
Severe metabolic acidosis (pH < 7.1)	45% of patients
Moderate acidosis (pH 7.1–7.2)	35% of patients
Correlation: pH vs. BUN/Cr ratio	r = -0.62, p < 0.01

Table-3: BUN/Cr Ratio and Renal Function.

Parameter	Value
Elevated BUN/Cr ratio (>20:1)	60% of patients (suggesting prerenal azotemia due to dehydration)
Correlation: BUN/Cr ratio vs. eGFR	$r = -0.54$, $p < 0.01$ (moderate negative correlation)

Table-4: eGFR and Acidosis.

Parameter	Value
Reduced eGFR (<90 mL/min/1.73m²)	30% of patients (more common in severe acidosis)
Correlation: eGFR vs. pH	$r = 0.48$, $p < 0.01$

cases, with severity correlating with the degree of acidosis and dehydration(8). Similarly, our findings align with those of Rewers et al. (2018), who emphasized the importance of early fluid resuscitation in preventing AKI and improving outcomes in DKA patients.

Rewers et al. (2018) and the ISPAD guidelines (Wolfsdorf et al., 2018) both stress the importance of early fluid resuscitation to avert AKI (9, 10). However, our study uniquely integrates BUN/Cr ratios with eGFR and blood gas parameters, providing a multidimensional assessment of dehydration and renal function. This approach contrasts with studies focusing solely on creatinine-based eGFR, which may underestimate dehydration in early AKI (11).

The correlation between blood gas parameters and renal biomarkers (BUN/Cr ratio and eGFR) also highlights the potential for these markers to serve as prognostic indicators in pediatric DKA. For instance, Kuppermann et al. demonstrated that elevated BUN/Cr ratios at presentation were associated with longer hospital stays and higher rates of complications, such as cerebral edema (12). This suggests that early identification of elevated BUN/Cr ratios and reduced eGFR could help clinicians stratify patients based on disease severity and tailor treatment strategies accordingly.

In comparison to other studies, our findings are consistent with the broader literature on DKA management, which emphasizes the importance of addressing dehydration and metabolic acidosis to prevent complications. However, our study adds to the existing body of knowledge by specifically examining the relationship between blood gas parameters, BUN/Cr ratio, and eGFR in a pediatric population. This is particularly relevant given the unique physiological and metabolic characteristics of children, who may be more vulnerable to the effects of dehydration and acidosis compared to adults (13).

One notable difference between our findings and those of other studies is the emphasis on the BUN/Cr ratio as a marker of dehydration and renal function. While some studies have focused primarily on serum creatinine and eGFR as indicators of renal function, our review highlights the additional value of the BUN/Cr ratio in assessing hydration status and predicting DKA severity. This is supported by Ghetti et al. who found that the BUN/Cr ratio was a more sensitive marker of dehydration in pediatric DKA patients compared to serum creatinine alone (14).

Beyond hypovolemia, emerging evidence suggests that hyperglycemia and ketosis may directly impair renal tubular function (Myers et al.), a nuance not fully explored in our study (15). This mechanism could

explain why some patients exhibit persistent eGFR reductions despite adequate hydration, warranting investigation into tubular injury biomarkers (e.g., NGAL) for AKI prediction. Additionally, eGFR calculations in pediatrics often rely on the Schwartz formula, which may lack accuracy in acute settings due to fluctuating creatinine levels (Pottel et al.). Future studies could compare eGFR equations in DKA to optimize AKI detection (16).

The implications of these findings for clinical practice are significant. Early recognition of elevated BUN/Cr ratios and reduced eGFR in pediatric DKA patients can guide timely interventions, such as aggressive fluid therapy and electrolyte replacement, to prevent complications such as AKI and cerebral edema. Additionally, the use of these biomarkers in conjunction with blood gas parameters may improve risk stratification and help clinicians identify patients who are at higher risk for adverse outcomes.

4-1. Limitation

In patients with DKA type 1, the observed elevation in serum creatinine despite normal urea levels is often a false-positive artifact in the Jaffe Reaction Method.This is due to methodological interference in creatinine measurement (17).

5- CONCLUSION

This study highlights the importance of integrating blood gas analysis with renal biomarkers (BUN/Cr ratio and eGFR) in the assessment and management of pediatric DKA. The strong correlation between these parameters underscores the need for a comprehensive approach to DKA management that addresses both metabolic acidosis and dehydration. Future studies should explore the utility of these biomarkers in predicting long-term outcomes, such as the development of chronic kidney disease (CKD), in pediatric DKA patients. Additionally, further research is needed to determine the optimal fluid resuscitation strategies for preventing AKI and improving outcomes in this vulnerable population.

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7-CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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