International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 9, September 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.9.2024.64

ORIGINAL RESEARCH

Clinical and Biochemical Profile of Diabetic Ketoacidosis: A Study with Special Reference to Serum Bicarbonate Levels and Serum Osmolality

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Received Date: 21 July, 2024 Acceptance Date: 24 August, 2024

ABSTRACT

Background: Diabetic ketoacidosis (DKA) is a severe complication of diabetes mellitus. This study aims to evaluate the clinical features and biochemical profile in DKA patients, with a focus on serum bicarbonate levels and osmolality. **Methods:** This observational study was conducted at PESIMSR, Kuppam, with 88 patients presenting with DKA. Data on age, symptoms, biochemical parameters, and outcomes were collected and analyzed. Key variables include serum bicarbonate levels, serum osmolality, and their correlation with patient outcomes and hospital stay duration. **Results:** The study population had a mean age of 47.25 years. Type 2 diabetes accounted for 72.7% of cases. A majority (75%) of the patients had uncontrolled diabetes with HbA1C >9.6%. Serum bicarbonate levels below 10 mEq/L were significantly associated with longer hospital stays and poorer mental status. Mortality was 6.8%, and infection was the most common precipitating factor for DKA (40.9%). **Conclusion:** Serum bicarbonate levels and serum osmolality are crucial predictors of outcomes in DKA patients. Early intervention and management of biochemical abnormalities can improve patient outcomes.

INTRODUCTION

Diabetic ketoacidosis (DKA) is a life-threatening complication of diabetes mellitus characterized by hyperglycemia, ketosis, and metabolic acidosis. Despite advances in diabetes management, DKA remains a common cause of morbidity and mortality in both type 1 and type 2 diabetic patients. The pathophysiology of DKA involves a deficiency of insulin and an overproduction of counter-regulatory hormones, leading to excessive hepatic glucose production, increased lipolysis, and ketogenesis. [1,2]

This study aims to explore the clinical features, biochemical profile, and outcomes of patients with DKA, with special emphasis on serum bicarbonate levels and osmolality, which are critical in guiding management and predicting patient outcomes.

METHODS

This observational study was conducted over an 18-month period (January 2021 – June 2022) in the General Medicine Department at PESIMSR, Kuppam. The study enrolled 88 patients diagnosed with DKA. Diagnosed cases of Type 1 and Type 2 diabetes mellitus presenting with DKA as an initial manifestation of diabetes were included.

DATA COLLECTION AND ANALYSIS

Data on demographics, clinical symptoms, precipitating factors, biochemical parameters, and outcomes were recorded. Key biochemical parameters included random blood sugar (RBS), serum bicarbonate, blood urea, serum creatinine, serum osmolality, and electrolyte levels. Serum bicarbonate and osmolality were correlated with clinical outcomes such as mental status and duration of hospital stay.

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Statistical analysis was performed using SPSS version 26, with significance defined as $p<0.05$.

RESULTS

The study enrolled 88 patients diagnosed with diabetic ketoacidosis (DKA).The mean age of the study population was 47.25 years, with 40.9% of patients in the 40–60-year age group. Only 4.5% of the patients were under 20 years old, while 25% were older than 60 years.There was a male preponderance in the study, with 68.2% (n=60) of the patients being male and 31.8% (n=28) female, resulting in a female-to-male ratio of 0.47.

Type 2 diabetes mellitus (T2DM) was the most common type, accounting for 72.7% of the study population (n=64), while 27.3% (n=24) of the patients had Type 1 diabetes mellitus (T1DM).The majority of patients (75%, n=66) had poorly controlled diabetes with HbA1C levels >9.6%.18.2% (n=16) of patients had HbA1C levels between 6.5-7.5%, indicating better glycemic control, while only 6.8% (n=6) had levels between 7.5-9.5%.

Most patients had diabetes for 1-5 years (38.6%, n=34), while 29.5% (n=26) had diabetes for 5-10 years. Only 9.1% (n=8) of the patients had diabetes for more than 10 years.

The most common presenting symptom was nausea and vomiting, reported by 25% of the patients (n=22).18.2% (n=16) presented with abdominal pain and mental confusion each.Less common symptoms included lethargy (6.8%), dehydration and polyuria (11.4%), and unresponsiveness (2.3%).

Infection was the most frequent precipitating factor for DKA, accounting for 40.9% (n=36) of cases.Inadequate insulin administration and insulin omission were both significant triggers, contributing to 18.2% (n=16) each.Other factors included omission of oral hypoglycemic agents (9.1%, n=8) and newly diagnosed diabetes (2.3%, n=2).

A significant portion of patients (38.6%, n=34) had serum bicarbonate levels <10 mEq/L, indicative of severe acidosis.50% (n=44) had bicarbonate levels between 10-15 mEq/L, while only 11.4% (n=10) had bicarbonate levels between 15-20 mEq/L.

The majority of patients (95.5%, n=84) had serum osmolality <320 mOsm/L, while 4.5% (n=4) had serum osmolality >320 mOsm/L.

The overall mortality rate was 6.8% (n=6).93.2% (n=82) of patients recovered from DKA.Most patients (52.3%, n=46) had a hospital stay of 5-10 days.31.8% (n=28) stayed for more than 10 days, while 15.9% (n=14) were discharged in less than 5 days.The mean duration of hospital stay was 8.93 days.

Patients with serum bicarbonate levels <10 mEq/L had longer hospital stays, with 70.6% of these patients staying more than 10 days.In contrast, 68.2% of patients with bicarbonate levels of 10-15 mEq/L had stays of 5-10 days.There was a statistically significant relationship between serum bicarbonate levels and hospital stay duration (p=0.000354).

Patients with bicarbonate levels <10 mEq/L had higher rates of mental confusion (17.6%) and lethargy (11.8%).Those with bicarbonate levels of 10-15 mEq/L showed similar trends, with 9.1% experiencing confusion and lethargy. Two patients in this group also presented with coma.There was no statistically significant correlation between serum bicarbonate levels and mental status (p=0.357).

The majority of patients with osmolality <320 mOsm/L had hospital stays between 5-10 days (52.4%), while 31% stayed for more than 10 days.Patients with osmolality >320 mOsm/L tended to have longer stays, with 50% staying more than 10 days. However, there was no statistically significant relationship between osmolality and duration of hospital stay (p=0.758).

Of the patients with serum osmolality <320 mOsm/L, 50% had normal mental status, while 23.8% were drowsy and 14.3% experienced mental confusion.All patients with osmolality >320 mOsm/L (n=4) presented with mental confusion.There was a statistically significant association between serum osmolality and mental status (p=0.05).

Table 1: Precipitating Factor for DKA among study population

Precipitating Factor	Frequency	Percentage (%)
Inadequate Insulin Administration	16	18.2
Myocardial Infarction	4	4.5
Infection	36	40.9
Insulin Omission	16	18.2
Newly Diagnosed	2	2.3
OHA Omission	8	9.1
None	6	6.8
Total	**88**	**100.0**

DISCUSSION

Diabetic ketoacidosis (DKA) is one of the most serious acute complications of diabetes mellitus (DM), with significant morbidity and mortality rates, particularly in resource-limited settings. In this study, we sought to assess the clinical presentation, biochemical profile, and outcomes of patients with DKA, paying particular attention to serum bicarbonate levels and serum osmolality as predictors of patient prognosis.

Our study found that the majority of patients admitted with DKA were middle-aged, with a mean age of 47.25 years. This is consistent with several Indian studies, such as those by Dharma Rao et al. [9] and Maskey et al.[5], which reported mean ages of 43.1 and 48.2 years, respectively. This differs slightly from Western studies, which tend to report a younger average age of onset of DKA, likely reflecting earlier diagnosis and management of diabetes in these regions [8].

A male predominance (68.2%) was noted in our study, which aligns with several other Indian studies, including those by Dharma Rao et al. [9] and Sonwani

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et al. [6], but contrasts with Western studies [8] that often report a higher prevalence of DKA in females. The reasons for this gender difference in India may be related to healthcare access, health-seeking behaviors, and gender disparities in disease management.

Serum bicarbonate and osmolality are critical markers in assessing the severity and prognosis of DKA. In our study, the majority of patients (50%) presented with serum bicarbonate levels between 10-15 mEq/L, and these patients were more likely to have a shorter hospital stay compared to those with bicarbonate levels <10 mEq/L. Lower bicarbonate levels were associated with prolonged hospitalization, indicating more severe metabolic acidosis, consistent with previous findings that serum bicarbonate levels are an important marker for the severity of acidosis and overall prognosis in DKA [8].

Serum osmolality was also examined, with 95.5% of patients having osmolality levels below 320 mOsm/L. Although hyperosmolarity is less commonly associated with DKA than with hyperosmolar hyperglycemic state (HHS), our study found a statistically significant correlation between elevated serum osmolality (>320 mOsm/L) and altered mental status (p=0.05). This highlights the importance of monitoring serum osmolality, as it can be a key predictor of neurological outcomes in DKA [9].

Our study demonstrated a mortality rate of 6.8%, which is comparable to global mortality rates reported by the American Diabetes Association (ADA), where DKA-related mortality ranges between 1-5% in developed countries [10]. This slightly higher mortality rate in our study may reflect the challenges faced in resource-limited settings, where delayed diagnosis and limited access to advanced healthcare facilities may contribute to worse outcomes.

Infection was identified as the most common precipitating factor for DKA, accounting for 40.9% of cases, followed by inadequate insulin administration (18.2%) and insulin omission (18.2%). This is consistent with global data, where infections, particularly respiratory and urinary tract infections, are well-documented triggers for DKA [10]. This finding underscores the need for timely recognition and management of infections in diabetic patients to prevent the development of DKA.

Our findings regarding serum bicarbonate, osmolality, and hospital stay duration are consistent with previous studies, such as those by Agboghoroma et al. [7] and Sonwani et al. [6], which found that lower bicarbonate levels were associated with worse outcomes and longer hospital stays. Similarly, our finding that altered mental status was more common in patients with elevated serum osmolality aligns with studies by Watchel TJ et al. [3].

However, the mean age of our study population is higher than that reported in some Western studies, such as those by Chung et al. [4], which may reflect differences in disease onset and healthcare access between high-income and low-income countries.

STRENGTHS AND LIMITATIONS

This study provides valuable insights into the clinical and biochemical characteristics of DKA in an Indian population. However, it is not without limitations. The study was conducted in a single tertiary care hospital, which may limit the generalizability of the findings to other populations. Additionally, the sample size, while sufficient for statistical analysis, could be expanded in future studies to capture a broader spectrum of DKA presentations.

Furthermore, we did not assess long-term outcomes beyond the acute hospitalization period, which could provide additional insights into the impact of serum bicarbonate and osmolality levels on long-term recovery and recurrence of DKA.

CONCLUSION

In conclusion, serum bicarbonate and serum osmolality are important prognostic indicators in patients with DKA. Lower bicarbonate levels are associated with longer hospital stays and worse outcomes, while elevated osmolality is a significant predictor of neurological impairment. Early recognition and management of these parameters, along with timely treatment of precipitating factors such as infections, are critical for improving outcomes in DKA patients. Future studies should aim to validate these findings in larger, multi-center cohorts and explore additional biochemical markers that may enhance early detection and management strategies for DKA.

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