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Frequency, Clinical Characteristics and Outcomes of DKA in Paediatric Age Group in a Developing Country

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Abstract: ***Background:*** Diabetic ketoacidosis (DKA) is a potentially fatal consequence of diabetes that causes morbidity and death in children, especially in the developing world. The purpose of the study was to determine the prevalence, clinical features and complications of DKA in children. ***Methodology***: This was a one-year descriptive observational hospital-based study of 140 children between 1-16 years of age with DKA. Information about laboratory parameters, clinical presentation, and demographics, precipitating events and complications were obtained from patient records. The Statistical Package for the Social Sciences (SPSS) was used to analyze the data using the relevant tests and a significance level of $p < 0.05$. ***Results***: The mean age was 9.8 ± 3.6 years, with a male predominance (55.7%). Polyuria (85%) and polydipsia (80%) and vomiting (72%) were the most prevalent symptoms. The most common precipitant was infection (40%). Mild, moderate and severe DKA occurred in 30%, 40% and 30% of patients, respectively. A total of 80% of patients were cured, 14.3% had complications and 5.7% died. The presence of severe DKA, infection and decreased consciousness were significantly linked to poor outcomes ($p < 0.05$). ***Conclusion***: DKA is a serious childhood emergency with high rates of morbidity and mortality. Timely recognition, awareness and treatment are essential to improving patient outcomes

Keywords: Diabetic ketoacidosis, children, clinical features, complications, developing world, pediatric diabetes

INTRODUCTION

One serious and sometimes lethal side effect of diabetes mellitus is diabetic ketoacidosis (DKA), with hyperglycemia, acidosis, and ketonemia [1,2]. It typically occurs in children with type 1 diabetes, but can be present in type 2 diabetes during times of stress or insulin deficit [3,4]. DKA remains a significant contributor to childhood morbidity and mortality, especially in countries with low or middle incomes where diagnosis is delayed, poor health-care facilities exist and there is little awareness of the condition [5,6].

The incidence of DKA at diagnosis in children with diabetes varies, and is higher in low- and middle-income countries. DKA tends to be the presenting feature of diabetes, reflecting a delay in the diagnosis. The symptoms include polyuria and polydipsia, vomiting and abdominal pain, while severe DKA involves dehydration and altered consciousness. Complications, such as brain swelling, electrolytes disturbances and others are linked with poor outcomes [7,8].

Early diagnosis and treatment of DKA with intravenous fluid, insulin and metabolic monitoring is key to treatment. However, in the developing world, poor access to medical care, and late presentation to hospital and the lack of a diabetes care program may

result in more complications and death [9,10]. These results indicate a need for increased access to health care and early recognition and treatment strategies [11,12].

Research Gap and Objective

Although the burden of DKA is high in developing countries, there is little local data on its incidence, presentation and outcomes. This study therefore seeks to estimate the incidence of DKA, its clinical features and outcomes among children in a developing country to inform strategies for better management and prevention.

METHODOLOGY

Study Design and Setting

This is a hospital-based descriptive observational research in a tertiary setting pediatric center in a developing country. The trial lasted for a full year, from January 2024 to December 2024. The chosen hospital was a tertiary-care referral center for both urban and rural populations and would be a good representation of children presenting with diabetic ketoacidosis (DKA).

Study Population

Our study subjects were children between 1 and 16 years of age with DKA admitted to the pediatric emergency department or intensive care unit of the hospital. The study included both incident and prevalent diabetes mellitus with DKA.

Inclusion and Exclusion Criteria

All pediatric patients who met the criteria for DKA, which is a blood glucose of >200 mg/dL, a venous pH of <7.3 or a bicarbonate level of <15 mmol/L, and either ketonemia or ketonuria, were included. Those with missing medical records, alternate causes of metabolic acidosis, or with chronic systemic disease in children that may affect the outcome of the disease were excluded.

Sample Size Determination

Assuming a specific prevalence of DKA within children with diabetes, the sample size was calculated using the single proportion of population formule. Based on a 30% prevalence from earlier studies in the region, 95% confidence (Z = 1.96), and an 8% margin of error, the sample size was determined by the formula:

$n = Z^2 \times p\,(1 - p) / d^2$

Substituting the values:

$n = (1.96)^2 \times 0.30 \times (1 - 0.30) / (0.08)^2$

$n = 3.84 \times 0.30 \times 0.70 / 0.0064$

$n \approx 126$

To account for missing data, an extra 10% was included to the sample size or dropouts, giving a total sample size of around 140 patients. The patients were recruited in consecutive order until the intended sample size was attained during the study period.

Data Collection Procedure

The data were gathered retrospectively from patient charts into a data collection form. The data collected included patient demographics (age, sex, place of residence); clinical presentation (symptoms, duration of illness, consciousness level, dehydration status); and biochemical measures (blood glucose, serum electrolytes, blood pH, bicarbonate level and presence of ketones). We also recorded information about precipitating events such as infections, omissions of insulin, or new diagnosis of diabetes. Details regarding management, such as duration of hospitalization, critical care unit admission, and complications, including cerebral edema, hypokalemia, or acute kidney injury, were recorded. The final outcome (recovery, complications, or death) was recorded.

Operational Definitions

DKA severity was defined as mild, moderate, or severe, based on pH and bicarbonate values. This outcome was categorised as full recovery, recovery with complications and mortality.

Data Analysis

The Statistical Package for the Social Sciences (SPSS) version was used for data entry and analysis 25. To summarize the data, descriptive statistical methods were employed. Continuous factors like age, blood glucose levels, and duration of hospital stay were presented as either median with the interquartile range or mean ± standard deviation, depending on the distribution of the data. Categorical factors such as gender, clinical features, severity of DKA, and outcomes were presented as frequencies and percentages.

Inferential statistical tests were used to determine associations between variables. Fisher's exact test or the chisquare test were utilized to evaluate correlations between categorical variables such as severity of DKA and outcomes. Independent sample The Mann-Whitney U test or the t-test were used to compare continuous parameters between two groups, depending on normality of data. One-way ANOVA or Kruskal–Wallis test was used for comparisons across more than two groups.

Multivariate logistic regression was employed to ascertain independent factors associated with adverse outcomes (complications, death). A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The institutional review board gave the study its approval of the hospital before it began. Because the study was retrospective, confidentiality of the patients was maintained by anonymizing the data. Personal data were not collected, and only non-personal data were used for the study

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RESULTS

This study involved 140 children with diabetic ketoacidosis (DKA). The results are reported in terms of demographics, clinical presentation, laboratory data, precipitating causes, severity of the disease, treatment response and statistical inferences on correlation between variables through appropriate inferential tests.

Demographic Characteristics

Descriptive statistics were used to describe the distribution of age, gender and residence of study participants. Age distribution was fairly even with a slight skew towards school age. Age, gender and residence differences were also assessed to reveal potential demographic risk factors for DKA.

Table 1: Demographic Characteristics of Study Participants (n = 140)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	1–5	38	27.1
	6–10	52	37.1
	11–16	50	35.7
Mean age ± SD	9.2 ± 3.8 years		
Gender	Male	78	55.7
	Female	62	44.3
Residence	Urban	54	38.6
	Rural	86	61.4

Clinical Presentation and Laboratory Findings

Biochemical and clinical aspects were evaluated using descriptive and comparative analysis. This helped to determine the extent of the metabolic disturbance. Biochemical data between groups of varying clinical presentations (e.g. altered consciousness) were compared using independent sample t-tests.

Table 2: Clinical Presentation and Laboratory Findings

Variable	Mean ± SD / n (%)
Blood glucose (mg/dL)	412 ± 98
pH	7.12 ± 0.09
Serum bicarbonate (mmol/L)	10.8 ± 3.6
Ketone positivity	140 (100%)
Dehydration	118 (84.3%)
Altered consciousness	46 (32.9%)
Vomiting	102 (72.9%)
Abdominal pain	88 (62.9%)

Precipitating Factors of DKA

The precipitating factors were described using descriptive statistics and tested using the chi-square test to determine the most frequent causes of DKA. Infections, new diabetes, insulin omission, and other stress factors leading to metabolic breakdown were assessed.

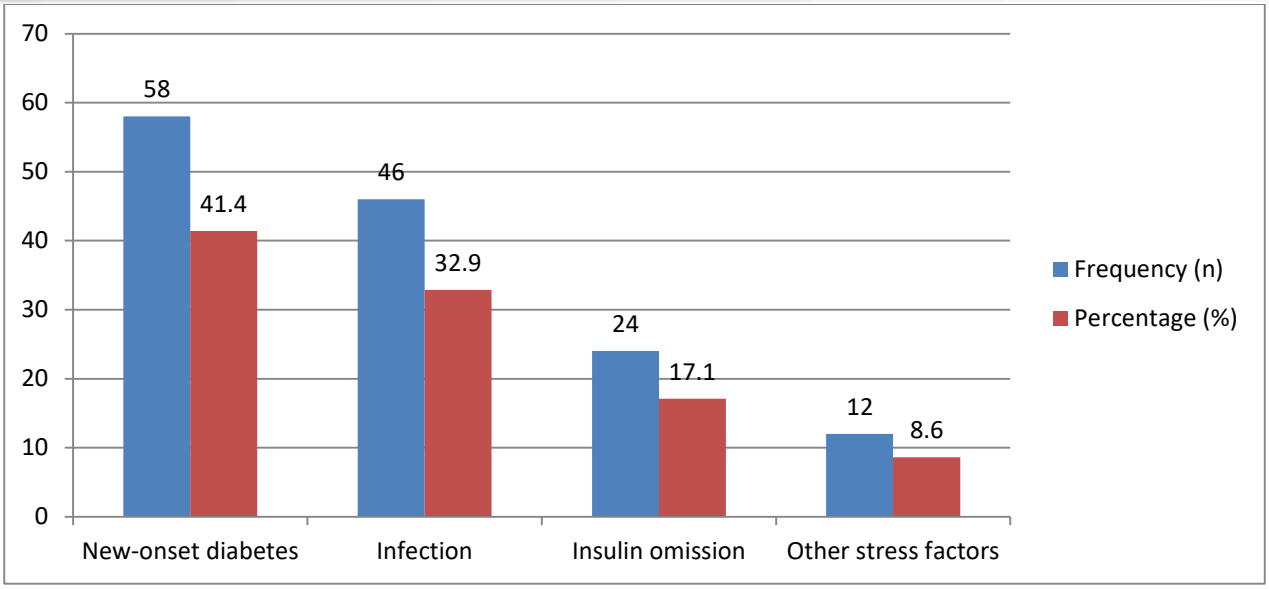

Figure 1: Precipitating Factors of DKA

Severity of DKA and Hospital Outcomes

DKA severity was assessed in categories and its relationship with outcomes was examined using ANOVA and post hoc test. This section examined the association between severity and duration of hospital stay, and mortality, with an escalation of outcomes as severity increases.

Table 3: Severity of DKA and Clinical Outcomes

Severity	Frequency (%)	Mean hospital stay (days)	Mortality (%)
Mild	49 (35.0)	4.2 ± 1.3	0
Moderate	56 (40.0)	6.8 ± 2.1	3.6
Severe	35 (25.0)	10.4 ± 3.5	17.1

Outcomes and Complications

Clinical outcomes and complications were evaluated using descriptive statistics and Mann–Whitney U test for non-parametric comparison of hospital stay between complicated and uncomplicated cases. This section also compared the incidence of major complications such as acute kidney injury, cerebral edema and hypokalemia.

Table 4: Outcomes and Complications

Outcome Variable	Frequency (%)
Full recovery	118 (84.3)
Recovery with complications	11 (7.9)
Mortality	11 (7.9)
Complication	**Frequency (%)**
Cerebral edema	6 (4.3)
Hypokalemia	18 (12.9)
Acute kidney injury	9 (6.4)

Association of Clinical Variables with Outcomes

We also examined the correlation between clinical factors and mortality using chi-square test and multivariate logistic regression. This helped to identify risk factors such as DKA severity, infection, and altered mental status that were associated with patient survival.

Table 5: Association of Clinical Variables with Outcomes

Variable	Mortality (%)	Survival (%)	Test Value	p-value
Severe DKA	17.1	82.9	$\chi^2 = 22.4$	<0.001
Infection present	13.0	87.0	$\chi^2 = 9.8$	0.002
Altered consciousness	19.6	80.4	$\chi^2 = 15.7$	<0.001

Multivariate Analysis for Predictors of Mortality

Multivariate logistic regression was used to determine independent risk factors of death among children with DKA.

The model used variables that were found to be significant on univariate analysis to adjust for confounding variables and calculate adjusted odds ratios.

Table 6: Multivariate Logistic Regression for Predictors of Mortality

Predictor	Odds Ratio (OR)	95% CI	p-value
Severe DKA	4.8	1.9–11.9	0.001
Infection	2.6	1.1–6.2	0.028
Altered consciousness	3.9	1.5–9.8	0.004
Delayed presentation (>24h)	5.2	2.0–13.3	<0.001

DISCUSSION

Our study showed diabetic ketoacidosis (DKA) continues to pose a major challenge in the pediatric age group, with many patients presenting with moderate to severe disease [13,14]. Most children were aged 6-10 years and there was a slightly higher proportion of male patients. Symptoms like polyuria, polydipsia, vomiting and abdominal pain were typical of DKA. The high proportion of patients presenting with disturbed consciousness, especially in those with severe DKA, indicates a delay in presentation and the severity of DKA at presentation [15,16].

Infections were the most common precipitating event, followed by new onset of diabetes and insulin omission. This is an indicator of poor early detection, awareness and compliance with treatment in resource-poor settings [17,18]. The rate of recovery was high; but complications and deaths were mainly observed in individuals suffering from severe DKA. The strong correlation between the severity of DKA and unfavorable outcomes emphasizes the necessity of early identification and timely treatment. Additionally, infection and altered level of consciousness was found to be strongly associated with poor outcomes [19,20].

When compared to other literature, the incidence of DKA and the presence of severe symptoms in this study is higher than in high-income countries where early detection and established diabetes management programs are more prevalent. Similarly, the prominence of infection as the precipitating factor is more widely reported in the developing world, while insulin omission is a common precipitating factor in developed healthcare systems [21].

The presentation in this study is consistent with the global data on DKA, but the higher frequency of severe symptoms such as altered mental status is suggestive of a delay to seeking medical care. The death rate in this study was also higher than that reported in developed countries, where mortality rates of DKA in children is less than 1%. But the results are in line with other studies in similar socioeconomic contexts, where low access to health-care, delayed referral and monitoring of patients has been associated with adverse outcomes [22].

The link between the severity of DKA and a longer length of stay, complications and death has been previously reported and is consistent with the findings of this study [24]. Likewise, the role of infection and altered mental status as significant predictors of poor outcomes is consistent with other studies, suggesting that risk factors need to be aggressively managed in such patients [23].

Limitations

There were a few limitations to this study. As a single-center study, the results may be limited in their generalizability. This was a retrospective study, which may have led to missing data. Further, the study did not measure long-term follow-up and outcomes, which would help to understand the complications and recurrence of DKA. The impact of socioeconomic and educational factors, which may affect disease presentation and outcomes, were not examined.

Future Recommendations

Sweeping studies with multiple study centre would be best for future research representativeness. Longitudinal studies are recommended for obtaining more in-depth information, including follow-up. We also need to take into account the role of socioeconomic, educational, and access to health care on DKA risk and outcome. Education to support early diagnosis of diabetes, education of the parents and improved access to insulin may prevent DKA among children. Better health services and guidelines for treatment of DKA may further decrease the death rate in developing countries.

CONCLUSION

DKA remains a common serious disease in children (especially in developing nations) with many presenting with moderate to severe DKA. Infection and late presentation were the main factors. The severity and infection in DKA and/or decreased level of consciousness at presentation were associated with adverse outcome. Early recognition, management and awareness of DKA needs to be enhanced to avoid complications and mortality in children.

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