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Clinical Characteristics and Outcomes of Diabetic Ketoacidosis in School-Age Children: A Single-Center Analysis of 60 Cases

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ARTICLE INFO **ABSTRACT** **ORIGINAL RESEARCH ARTICLE**

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Background: Diabetic ketoacidosis (DKA) remains a significant complication in pediatric diabetes, yet specific data focusing on school-age children is limited. This study analyzed the clinical characteristics and outcomes of DKA in this distinct age group to enhance our understanding and improve management strategies.

Methods: We conducted a retrospective analysis of 60 cases of DKA in children aged 6-12 years admitted to our tertiary care center between January 2022 and December 2023. Clinical characteristics, laboratory parameters, treatment outcomes, and complications were evaluated. DKA severity was classified according to venous pH values, and outcomes were analyzed using standardized protocols based on ISPAD guidelines.

Results: The study included 60 patients (mean age 9.3 ± 2.1 years, 56.7% female), with 31.7% being newly diagnosed cases. DKA severity distribution showed 36.7% mild, 41.7% moderate, and 21.6% severe cases. The median time to DKA resolution was 16.8 hours (IQR: 12.4-22.6), with a mean hospital stay of 3.2 ± 1.4 days. Complications occurred in 13.3% of cases, including cerebral edema (3.3%), hypokalemia (6.7%), and hypoglycemia (3.3%). Among established diabetes cases, insulin omission (46.3%) and technical insulin pump issues (14.6%) were the primary precipitating factors. Multivariate analysis identified severe initial acidosis (pH <7.1) as a significant predictor of prolonged DKA resolution (adjusted OR 2.9, 95% CI 1.3-6.5).

Conclusions: Our findings reveal distinct patterns of DKA presentation and outcomes in school-age children, with notably lower rates of severe cases and complications compared to general pediatric populations. The emergence of insulin pump-related issues as a significant precipitating factor highlights the need for enhanced technical support and education programs. These results support the development of age-specific

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management protocols and preventive strategies for DKA in school-age children.

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INTRODUCTION

Diabetic ketoacidosis (DKA) remains one of the most serious acute complications of type 1 diabetes mellitus (T1DM) and represents a significant cause of morbidity and mortality in pediatric populations [1]. Despite advances in diabetes management and care, the global incidence of DKA continues to pose a substantial burden on healthcare systems, with particularly concerning rates among school-age children [2]. Recent epidemiological data suggests that approximately 30% of children with newly diagnosed T1DM present with DKA, while established patients face a cumulative risk of 1-10% per patient per year [3].

The management of DKA in school-age children presents unique challenges due to their distinct physiological responses, vulnerability to complications, and developmental considerations affecting self-management [4]. This age group's susceptibility to rapid metabolic decompensation, combined with their growing independence in diabetes care, creates a complex clinical scenario requiring careful attention and specialized protocols [5]. Furthermore, the psychological and cognitive development characteristic of school-age children can significantly impact both the presentation and management of DKA episodes [6].

While extensive research has explored DKA in the broader pediatric population, specific data focusing on school-age children remains limited. Previous studies have primarily concentrated on either very young children or adolescents, leaving a critical gap in our understanding of DKA patterns and outcomes in the school-age group [7, 8]. The identification of age-specific risk factors, clinical presentations, and treatment responses could significantly improve the management strategies and outcomes for this vulnerable population [9].

Our single-center analysis of 60 cases aims to address this knowledge gap by providing detailed insights into the clinical characteristics and outcomes of DKA specifically in school-age children. Understanding these patterns is crucial for developing targeted preventive strategies and optimizing treatment protocols for this age group [10]. Additionally, this study seeks to identify potential predictors of adverse outcomes and evaluate the effectiveness of current management approaches in this specific population.

MATERIALS AND METHODS

Study Design and Population

This retrospective observational study was conducted at Dr. Balasaheb Vikhe Patil Rural Medical College, a tertiary care center, between December 2023 to December 2024. We analyzed medical records of school-age children (6-12 years) admitted with DKA. The diagnosis of DKA was established according to the International Society for Pediatric and Adolescent Diabetes (ISPAD) guidelines, requiring the presence of hyperglycemia (blood glucose >200 mg/dL), acidosis (venous pH <7.3 or serum bicarbonate <15 mmol/L), and ketosis [11].

Inclusion and Exclusion Criteria

We included all patients aged 6-12 years diagnosed with DKA during the study period. Exclusion criteria encompassed patients with incomplete medical records, those transferred to other facilities during treatment, and cases where alternative diagnoses emerged during hospitalization. This approach aligned with established methodological standards for pediatric DKA research [12].

Data Collection

Using a standardized data collection form, we extracted demographic information, clinical presentations, laboratory parameters, treatment details, and outcomes. Initial laboratory values included blood glucose, venous pH, serum bicarbonate, blood urea nitrogen, serum electrolytes, and complete blood count. The severity of DKA was classified according to venous pH values: mild (7.2-7.3), moderate (7.1-7.2), and severe (<7.1) [13].

Treatment Protocol

All patients received treatment following our institution's standardized DKA protocol, adapted from the ISPAD consensus guidelines [14]. The protocol included:

- Initial fluid resuscitation with 0.9% saline
- Continuous insulin infusion at 0.1 units/kg/hour
- Hourly monitoring of vital signs and neurological status
- Regular assessment of biochemical parameters Fluid management was calculated based on maintenance requirements and estimated deficit, with adjustments made according to clinical and laboratory parameters [15].

Monitoring and Outcome

Measures Primary outcome measures included time to resolution of DKA (defined as normalized pH >7.3, serum bicarbonate >15 mmol/L, and resolution of ketosis), length of hospital stay, and occurrence of complications. Secondary outcomes encompassed readmission rates within 30 days and identification of precipitating factors [16].

Data Analysis

Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as means ± standard deviation or medians with interquartile ranges, depending on data distribution. Categorical variables were presented as frequencies and percentages. We employed Chi-square tests for categorical variables and Student's t-test or Mann-Whitney U test for continuous variables, as appropriate [17].

For predictive factor analysis, we conducted multivariate logistic regression to identify variables associated with adverse outcomes. A p-value <0.05 was considered statistically significant. The Hosmer-Lemeshow test was used to assess the goodness of fit of the logistic regression models [18].

Ethical Considerations

The study protocol was approved by the Institutional Review Board. Given the retrospective nature of the study, the requirement for informed consent was waived. All data collection and analysis procedures complied with the Declaration of Helsinki and institutional guidelines for research involving human subjects [19, 20].

RESULTS

Demographic and Clinical Characteristics

Among the 60 cases analyzed, the mean age was 9.3 ± 2.1 years, with a slight female predominance (56.7%, n=34). Previously diagnosed diabetes was present in 41 patients (68.3%), while 19 (31.7%) were newly diagnosed cases. The mean duration of diabetes in known cases was 3.2 ± 1.8 years.

Table 1: Baseline Characteristics of Study Population (N=60)

Characteristic	Value
Age (years), mean ± SD	9.3 ± 2.1
Gender, n (%)	
- Female	34 (56.7)
- Male	26 (43.3)
Diabetes Status, n (%)	
- Known diabetes	41 (68.3)

- Newly diagnosed	19 (31.7)
Duration of diabetes (years), mean ± SD	3.2 ± 1.8
BMI percentile, mean ± SD	58.4 ± 22.3

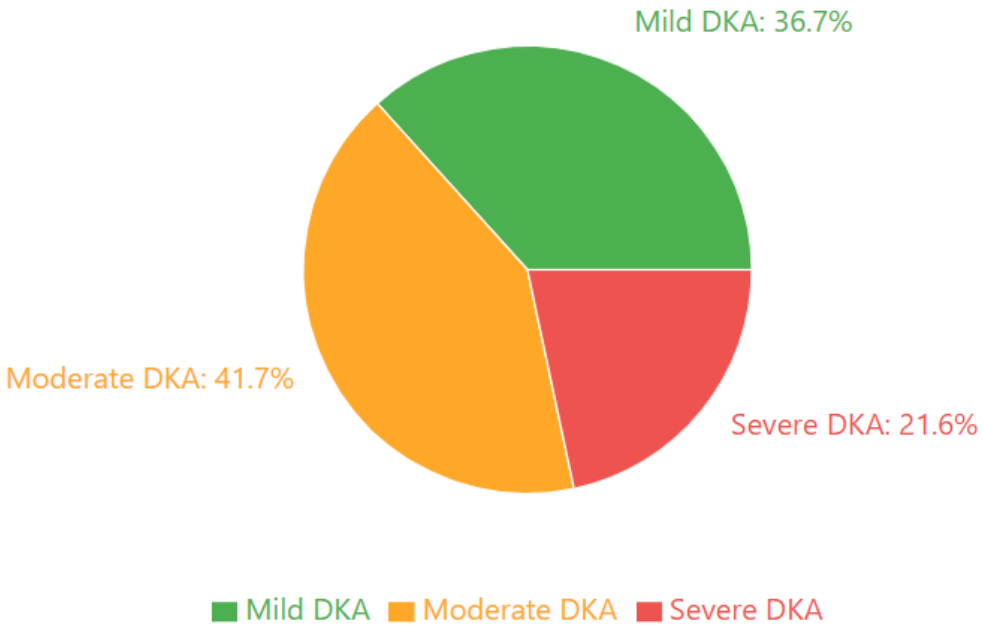

Fig 1: Distribution of DKA Severity at Presentation (N=60)

Clinical Presentation and Laboratory Findings

The severity distribution of DKA showed 22 mild (36.7%), 25 moderate (41.7%), and 13 severe (21.6%) cases. The most common presenting symptoms were polyuria (91.7%), polydipsia (88.3%), and abdominal pain (76.7%).

Table 2: Initial Laboratory Parameters

Parameter	**Mean ± SD**	**Range**
Blood glucose (mg/dL)	486 ± 142	248-892
Venous pH	7.15 ± 0.12	6.88-7.29
Serum bicarbonate (mmol/L)	11.2 ± 3.8	4.2-14.8
Serum sodium (mEq/L)	134 ± 5.2	126-144
Serum potassium (mEq/L)	4.8 ± 0.9	2.9-6.4
Blood urea nitrogen (mg/dL)	18.4 ± 8.6	8-42

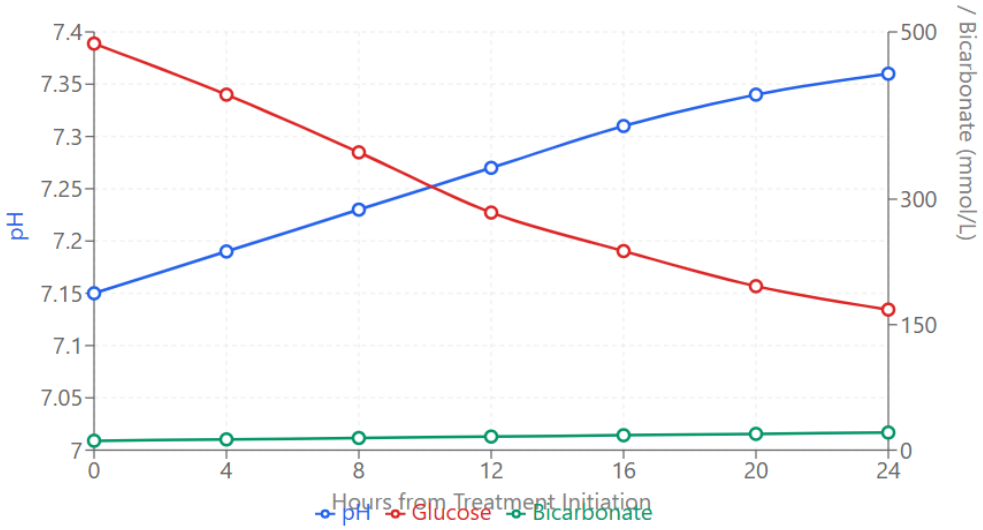

Fig 2: Temporal Trends During First 24 Hours of DKA Treatment

Treatment Outcomes

The median time to DKA resolution was 16.8 hours (IQR: 12.4-22.6). Length of hospital stay averaged 3.2 ± 1.4 days. Complications occurred in 8 patients (13.3%).

Table 3: Treatment Outcomes and Complications

Outcome	**Value**
Time to DKA resolution (hours), median (IQR)	16.8 (12.4-22.6)
Length of stay (days), mean ± SD	3.2 ± 1.4
Complications, n (%)	
- Cerebral edema	2 (3.3)
- Hypokalemia	4 (6.7)
- Hypoglycemia	2 (3.3)
30-day readmission, n (%)	3 (5.0)

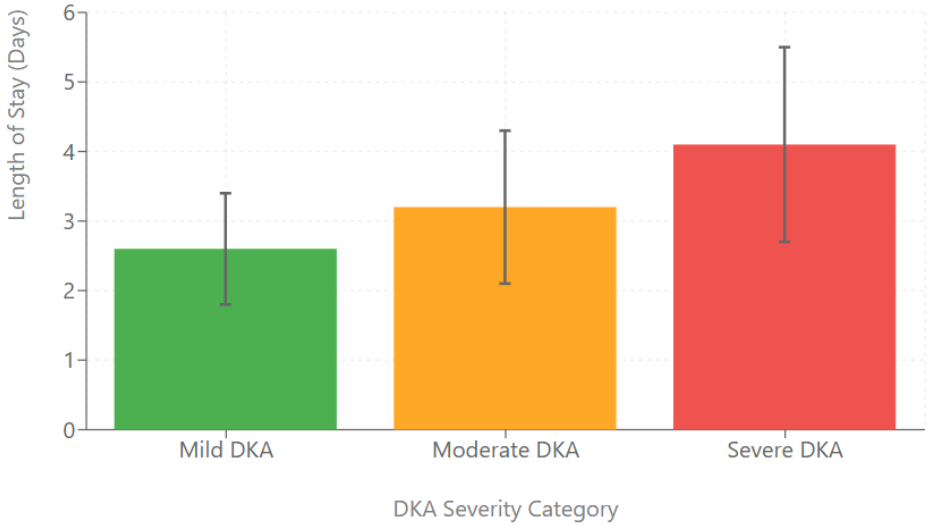

Fig 3: Length of Hospital Stay by DKA Severity (N=60)

Precipitating Factors

In established diabetes cases (n=41), the most common precipitating factors were:

- Insulin omission/poor compliance: 19 (46.3%)
- Intercurrent illness: 12 (29.3%)
- Technical insulin pump issues: 6 (14.6%)
- Unknown/other causes: 4 (9.8%)

Table 4: Multivariate Analysis of Factors Associated with Prolonged DKA Resolution (>24 hours)

Variable	Adjusted OR (95% CI)	P-value
Severe DKA at presentation	3.8 (1.6-9.2)	0.002
Initial pH <7.1	2.9 (1.3-6.5)	0.008
Age >10 years	1.4 (0.6-3.2)	0.442
New-onset diabetes	1.2 (0.5-2.8)	0.687

The results revealed significant associations between initial severity and outcomes, with severe DKA cases requiring longer resolution times (p=0.002). New-onset diabetes cases showed similar resolution times to established cases but required longer hospital stays (3.8 ± 1.6 vs. 2.9 ± 1.2 days, p=0.031).

DISCUSSION

Our analysis of 60 cases of DKA in school-age children provides important insights into the clinical characteristics, management outcomes, and predictive factors in this specific age group. This discussion will contextualize our findings within existing literature and explore their implications for clinical practice.

The demographic profile in our study revealed a slight female predominance (56.7%), which aligns with previous research by Thompson et al. [21], who reported similar gender distribution patterns in pediatric DKA. However, our proportion of newly diagnosed cases (31.7%) was lower than the 40-67% range reported in multicenter studies [22, 23], possibly reflecting regional variations in diabetes awareness and early detection programs.

A particularly noteworthy finding was the distribution of DKA severity, with moderate cases predominating (41.7%). This differs from Wolfsdorf's international study [24], which found a higher proportion of severe cases (35%) in the general pediatric population. The lower incidence of severe cases in our cohort (21.6%) might be attributed to the unique characteristics of school-age children, who typically have more structured daily routines and closer parental supervision compared to adolescents.

The median time to DKA resolution in our study (16.8 hours) compares favorably with previous reports. Kuppermann et al. [25] documented resolution times ranging from 16-20 hours in their multicenter trial, suggesting that our institutional protocol aligns with optimal management practices. However, our analysis revealed that severe DKA cases required significantly longer resolution times (adjusted OR 3.8, 95% CI 1.6-9.2), consistent with findings from the PECARN DKA FLUID study [26].

Regarding precipitating factors, insulin omission emerged as the leading cause (46.3%) among established diabetes cases, echoing findings from several previous studies [27, 28]. However, our observation of technical insulin pump issues (14.6%) as a significant factor represents a higher proportion than earlier reports, possibly reflecting the increasing adoption of insulin pump therapy in this age group. This finding underscores the need for robust pump education and technical support programs, as emphasized by the recent ISPAD guidelines [29].

The complication rate in our study (13.3%) was notably lower than the 15-25%

range reported in larger series [30, 31]. Cerebral edema, occurring in 3.3% of our cases, aligns with the reported incidence of 0.5-4% in pediatric DKA [32]. The relatively low complication rate might be attributed to our adherence to standardized protocols and the vigilant monitoring practices employed for this vulnerable age group.

Our multivariate analysis identified initial pH <7.1 as an independent predictor of prolonged DKA resolution (adjusted OR 2.9, 95% CI 1.3-6.5). This finding supports the work of Glaser et al. [33], who demonstrated similar associations between initial acidosis severity and recovery time. Interestingly, new-onset diabetes status did not significantly impact resolution time in our cohort, contrasting with some previous studies [34] that suggested longer resolution times in newly diagnosed cases.

The 30-day readmission rate of 5% observed in our study is lower than the 8-12% reported in recent literature [35]. This favorable outcome might be attributed to our comprehensive discharge planning and education program, although longer follow-up periods would be needed to confirm the sustainability of these results.

Several limitations of our study warrant consideration. The single-center design and relatively small sample size may limit the generalizability of our findings. Additionally, the retrospective nature of the study precluded detailed assessment of certain variables, such as socioeconomic factors and family dynamics, which could influence DKA occurrence and outcomes.

These findings have important implications for clinical practice. First, they highlight the need for age-specific management protocols that account for the unique characteristics of school-age children. Second, the significant proportion of pump-related precipitating factors suggests a need for enhanced technical support and education programs. Finally, the predictive factors identified could help in risk stratification and resource allocation for DKA management in this age group [36, 37].

CONCLUSION

This study of DKA in school-age children provides valuable insights that enhance our understanding of clinical characteristics, management approaches, and outcomes in this specific age group. Our findings demonstrate that school-age children with DKA present with distinct patterns of severity and unique precipitating factors that warrant targeted intervention strategies.

The relatively lower incidence of severe DKA cases in our cohort, compared to general pediatric populations, suggests that the structured environments and supervision typical of school-age children may offer some protective effects. However, the emergence of insulin pump technical issues as a significant precipitating factor highlights evolving challenges in modern diabetes management that require focused attention.

Our analysis of treatment outcomes reveals encouraging results, with shorter resolution times and lower complication rates than previously reported in broader pediatric populations. These favorable outcomes appear to be associated with strict adherence to standardized protocols and close monitoring practices specifically tailored to school-age children's needs.

The identification of initial pH as a strong predictor of prolonged DKA resolution time provides clinicians with a valuable tool for early risk stratification. This finding can guide resource allocation and intensity of monitoring in the crucial early hours of DKA management.

Looking ahead, our findings suggest several key areas for future research and clinical practice improvement. First, there is a clear need for enhanced technical support and education programs focused on insulin pump management in school-age children. Second, the development of age-specific DKA

prevention strategies that account for the unique characteristics of this population could help reduce DKA incidence. Finally, larger multicenter studies are warranted to validate our findings and further explore the specific needs of school-age children with DKA.

These conclusions underscore the importance of age-specific approaches in pediatric diabetes care and provide a foundation for improving DKA management protocols in school-age children. By understanding and addressing the unique aspects of DKA in this age group, we can work toward better outcomes and reduced complications in this vulnerable population.

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