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Prevalence, Clinical Profile, and Outcomes of Diabetic Ketoacidosis in Pediatric Patients at the Intensive Care Unit of King Fahad Hospital, Al-Baha, Saudi Arabia

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Abstract
Introduction: Diabetic ketoacidosis (DKA) is a severe acute complication of type 1 diabetes mellitus (T1DM) leading to pediatric morbidity and complications. Objectives: Analyze the prevalence, clinical profiles, and outcomes of DKA in children. Methodology: This retrospective cohort study explored the diabetic ketoacidosis in type I diabetes mellitus at the Pediatric Intensive Care Unit at King Fahad Hospital at Albaha, Saudi Arabia, between January 2022 and December 2023. Participants included children aged < 14 years. Data were collected from medical records of all admitted patients. The main outcomes were the average time needed to recover from DKA, and patient survival rates. Results: Total of 180 DKA cases were reviewed, and observed that 68.3% were recurring cases of type 1 diabetes mellitus admitted to PICU due to poor treatment adherence. The remaining 31.7% were newly diagnosed as diabetes mellitus due to the onset of DKA. The average patient age was 8.9 ([4.0]) years, with females representing two-thirds of this cohort. The most frequent precipitating factors were non-adherence to treatment (90%) and previous infections (10%). Common symptoms included abdominal pain (78.3%), as the principal source of decompensation. Conclusion: Recognizing characteristic symptoms is vital for early diagnosis, emphasizing the importance of a timely and well-structured management approach for improved

outcomes, reduced morbidity, improved recovery times, and shortened hospital stays. Moreover, no deaths were reported in this study.

Keywords: Children, Diabetes Ketoacidosis, Type1 Diabetes Mellitus (T1DM), Pediatric Intensive Care Unit (PICU)

1. Introduction

Type 1 Diabetes Mellitus (T1DM) is a chronic autoimmune condition that leads to a total or partial loss of insulin-producing cells within the pancreas. Consequently, patients with T1DM require external insulin sources to manage their energy metabolism (Burcul, Ivana, et al. 2019). Notably, recent studies and literature reviews reveal an annual global growth of 3–5% in the incidence of T1DM among younger populations (McKenna, Amanda, et al 2021). The prevalence of diabetic ketoacidosis (DKA), a serious complication of diabetes, at the onset of T1DM in children and adolescents aged 0–18 years continues to increase, as observed in recent 2013–2014 survey data (Rabbone, Ivana, et al. 2020). Data collection was most extensive in the Europe (76%), while sub-Saharan Africa presented the least amount of data, 8% (Patterson, Chris, et al 2014). An alarming number of T1DM onset cases were reported annually in the United States (13,000), India (10,900), and Brazil (5,000) (Patterson, Christopher C, et al 2019). The rates of DKA at the time of diagnosis diverged greatly, varying from 12.8–80%. The highest rates were documented in the United Arab Emirates, Saudi Arabia, and Romania, whereas the lowest was found in Sweden, the Slovak Republic, and Canada (Forouhi, Nita Gandhi, and Nicholas J2010, Usher-Smith, J. A, et al. 2012). The European and North American countries reported high to intermediate DKA incidences; Africa demonstrated intermediate occurrences; and Asia reported low rates (Lee, Hye Jin, et al. 2017). Studies indicate an extensive range of reported DKA incidences linked to initial T1DM diagnosis, from 15–67% across differing geographic locations (Roche, Edna F., et al. 2016). Living in a high-incidence region or possessing a higher level of education was protective factors for DKA. Serious complications of DKA extend beyond cerebral edema to hyperchloremia, hypokalemia, hyponatremia, shock, acute kidney injury, arrhythmias, and thrombotic thrombocytopenic purpura (Peng, Wei, et al 2021). Enhanced understanding of the pathophysiology and improved implementation of care guidelines and pathways for DKA have been instrumental in the significant reduction of DKA-related mortality in recent years (Abbas, Qalab, et al. 2018). In Saudi Arabia, epidemiological studies spanning 1985–2016 suggest a temporal shift in pediatric DKA incidence, fluctuating between 37.7% and 79.8% (Al Shaikh, Adnan, et al. 2019, Hornstein, Henriette, et al. 2018). A recent study identified precipitating factors for severe DKA, which include upper respiratory tract infections (URTI), pneumonia, unhealthy lifestyle, and excessive sugar consumption (Danne, Thomas, et al. 2018).

2. Objectives

In this study, we aimed to determine the prevalence of DKA in the Albaha region, focusing on the clinical features of patients who were admitted to the Pediatric Intensive Care Unit (PICU) at King Fahad Hospital in Albaha. Moreover, symptoms and signs, laboratory results, management, and complications linked to the disease following the application of a standardized management protocol, were investigated.

3. Methodology

This retrospective cohort study explored the DKA in T1DM at the PICU of King Fahad Hospital at Albaha, Saudi Arabia, between January 2022 and December 2023. Participants included children aged < 14 years, who were either newly diagnosed with DKA or have T1DM and were admitted due to DKA. Patients older than 14 years or those diagnosed with type 2 diabetes mellitus, were excluded. To gather the required data, the patient's files were examined, extracting information on age, sex, weight, height, clinical indications and hydration status. Moreover, essential data such as various laboratory tests were collected, along with a confirmed history of insulin usage and other medication adherence. The complications associated with DKA were also recorded. The guidelines from the Saudi Ministry of Health (MOH) protocol and International Society for Pediatric and Adolescent Diabetes (ISPAD) were applied (Wolfsdorf, Joseph I., et al 2018). Clinical practice consensus was followed for diagnosing

DKA: blood glucose level > 11 mmol/L; presence of ketonemia and ketonuria; blood gas analysis pH < 7.3; and bicarbonate level (HCO3) < 15 mmol/L. Subsequently, DKA was classified into three degrees: (1) mild, arterial pH decreased to between 7.2 and 7.3 and serum bicarbonate level decreased to 10–15 mEq/L; (2) moderate, arterial pH of 7.1–7.2 and a bicarbonate level of 5–10 mEq/L; and (3) severe, arterial pH below 7.1 and a bicarbonate level < 5 mEq/L. Patient management followed the MOH protocol, employing strategies such as rehydration, insulin infusion, and correction of acidosis and electrolytes. Subsequently, the length of stay in the intensive care unit and patient survival rates were recorded. This study was approved by the Ethical and Research Committee of King Fahad Hospital Albaha and aligned with the principles of the Declaration of Helsinki. The data gathered was analyzed using Microsoft Excel 2020. A P value < .05 at 95% confidence interval was considered statistically significant.

4. Results

Our study included 621 patients admitted to the PICU, of which 180 were diagnosed with DKA, representing 29% prevalence (Table 1). The average age of the patients was 8.9±4 years, ranging from 1 month to 14 years. Female comprise 66.7% (n=120) of the participants, while male constitute 33.3% (60 patients). Notably, 31.7% (n=57) had DKA as the first presentation in newly diagnosed children, while 123 (68.3%) patients with an existing T1DM diagnosis presented at the PICU with DKA. The DKA severity showed that 39.4% (n=71) are moderate, 32.8% (n=59) are severe, and 27.8% (n=50) are mild. The primary symptoms observed upon presentation were abdominal pain (78.3%, n=141), vomiting (73.9%, n=133), nausea (32.2%, n=58), polyurea (28.3%, n=51), dehydration (15.6%, n=28), headache (15%, n=27), kussmaul breathing (11.7%, n=21), drowsiness (8.3%, n=15), weight loss (7.8%, n=14), and polydipsia (7.2%, n=13), which were significant (P=.005). The average blood sugar at admission was 430.2±160 mg/dL. Metabolic acidosis, another sign of DKA, was noted in varying degrees of severity across the patient pool. The average bicarbonate level was 10.5 mmol/L and the average osmolarity at time of diagnosis was 305.8 mOsm/Kg. An electrolyte check was conducted and revealed hyponatremia in 22.8% (n=41), hyperkalemia in 5.6% (n=10), and hypokalemia in 3.9% (n=7) of the patients. Majority of the known patients with T1DM (90%), had DKA developed due to medication non-compliance, while infection was identified in 10% as the trigger (P=.04). On average, patients recovered from DKA in 14±6.8hours. Newly diagnosed patients had the longest duration to recover from DKA at 24 hrs. Two patients were confirmed to have hypothyroidism. One patient who developed insulin-dependent diabetes mellitus at the age of 7 months, presented with severe DKA due to an autosomal recessive genetic variant in the LRBA gene (Alzahrani, Ali., et al. 2023). All patients received intravenous hydration before insulin administration. The treatment approach and outcomes showed no significant difference between newly diagnosed patients and those with known T1DM. No episodes of arrhythmia, cerebral edema, or death were recorded in this study.

5. Discussion

The prevalence of DKA in this study was 29%, which aligns with the previous findings from the Albaha region; however, it was significantly higher compared to the nationwide average prevalence of 9.4–14% (Al-Ghamdi, Ahmed Hassan, and Abdelhameed Ahmed Fureeh 2018). Our study demonstrated a conspicuous sex disparity, with nearly two-thirds of the patients (66.7%) being female while male accounts for 33.3%. This translates to a female-to-male ratio of 2, and corroborates the trend reported in previous studies (Satti, Satti Abdulrahim, Imad Yassin Saadeldin, and Ali Saeed Dammas 2013). A substantial 31.7% of the admitted patients presented DKA as the initial indicator of their diabetes diagnosis, while 68.3% of them were already known to have diabetes (P=.007; 95%CI [12.3-35.7]), similar to other studies. These variations extended beyond symptoms to include differences in initial presentation, delay before symptom recognition, and outcomes of conducted laboratory tests. Studies bearing equivalent prevalence rates are documented not only within the country but are also corroborated by studies conducted across Europe (Patterson, Chris C., et al. 2012). However, the present study varies relatively from the earlier findings in the region, where an immensely higher proportion (82.1%) of newly diagnosed patients was reported. This highlights the efficacy of fluid and insulin treatment in combating severe acidosis conditions (Robert, Asirvatham Alwin, et al. 2018). Among those who are newly diagnosed with diabetes, the median recovery time-lagged at approximately 24 hours, which was significantly longer than the recovery time at 15 hours for patients with pre-existing condition (p=.005). Moreover, the newly diagnosed group exhibited notable severity

in symptoms such as heightened hyperglycemia, advanced stages of acidosis, hyperosmolarity, and increased clinical complications, which aligns with the established research trends (Patterson, Chris C., et al. 2012, Robert, Asirvatham Alwin, et al. 2018). This study aligns with the general practices by employing a continuous infusion of smaller dosages of insulin (0.05–0.1 IU/kg/hr) to avert hypoglycemia. Despite the global guidelines advocating for subcutaneous boluses, additional studies are needed to ascertain the outcomes of this administration approach. Notably, 90% of the patients developed DKA due to missed or adjusted insulin dosages. Only a small proportion of DKA cases (10%) were associated with previous infections or febrile illnesses, supporting the findings of few studies, but contrasting that of a study in India, which highlight that infections are the most common DKA precursor (Usher-Smith, J. A., et al 2012). In terms of severity distribution, moderate DKA emerged as the most common presentation at 39.4% (n=71), followed by severe at 32.8% (n=59), and mild at 27.8% (n=50), which is consistent with the study by McKenna A et a 2021. Conversely, Peng et al., reported that mild DKA was the most prevalent (Peng, Wei, et al. 2021). Abdominal discomfort was the most common symptom (78.3% [n=141]), followed by vomiting (73.9% [n=133]), and nausea (32.2% [n=58]), corroborating the findings of other studies (Robert, Asirvatham Alwin, et al. 2018, Albuali, Waleed H., and Mohammad H. Al-Qahtani 2022). No mortality was reported in this study, which is attributed to the adoption of clear protocols for diagnosing and treating hospitalized patients. Given the discrepancies in the reported findings, further studies on T1DM and DKA are warranted.

6. Conclusion

DKA is a common and major complication of T1DM, resulting in substantial increase in PICU admissions and morbidity if not promptly detected and managed. Recognizing characteristic symptoms is vital for early diagnosis, emphasizing the importance of a timely and well-structured management approach for improved outcomes. The implementation of the MOH protocol in our unit not only enhanced the quality of care but also reduced morbidity, improved recovery times, and shortened hospital stays. Moreover, no deaths were reported in this study.

Table1: Categorizes different statistics related to admitted patients with DKA seen at the Pediatric Intensive Care Unit.

variable	Pts number	percent	P value
PICU admission	621		
DKA	180	29%	
Gender			.007
Female	120	66.7%	
Male	60	33.3%	
Age			.006
<5 yr.	19	10.6%	
5-10 yr.	45	25%	
>10 yr.	116	64.4%	
Diagnosis			.007
New	57	31.7%	
K/c	123	68.3%	
Severity			.08
Moderate	71	39.4%	
Severe	59	32.8%	
mild	50	27.8%	
Risk factors			.04
Infection	18	10%	
Doses	162	90%	

Pts: patients, DKA: Diabetes ketoacidosis, P value: Probability of chance

Conflict of Interest: The authors declare no conflict of interest.

Informed Consent Statement/Ethics Approval: This study approved by ethical, research committee in King Fahad Hospital, Albaha, Saudi Arabia.

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