E-ISSN:2349-3267
P-ISSN:2349-5499
Research Article
Diabetic Ketoacidosis

Pediatric Review - International Journal of Pediatric Research
2021 Volume 8 Number 5 September October

Publisher
MEDRESEARCH
www.medresearch.in

Clinical, Demographic, Biochemical and Outcome Profile of Diabetic Ketoacidosis in Children with Type 1 Diabetes Mellitus

Solanki D.[1], Dhruw S.[2], Nirala D.[3*]

DOI: https://doi.org/10.17511/ijpr.2021.i05.04

[1] Dhiraj Kumar Solanki, Associate Professor, Department of Pediatrics, Pt JNM Medical College, Raipur, Chhattisgarh, India.

[2] Sneha Singh Dhruw, Assistant Professor, Department of Pediatrics, Pt JNM Medical College, Raipur, Chhattisgarh, India.

[3*] Deepak Kumar Nirala, PG Resident, Department of Pediatrics, Pt JNM Medical College, Raipur, Chhattisgarh, India.

Background: Type 1 Diabetes mellitus is one of the most common chronic, endocrine-metabolic syndrome of children and adolescents. India accounts for most of the children with T1DM in the Southeast Asia region. The present study was intended to study the clinical, demographic, biochemical and outcome profile of the children admitted with Diabetic ketoacidosis (DKA). **Material and methods:** A prospective, descriptive, observational study was conducted in the PICU tertiary care hospital over one year. A total of 54 cases admitted of age group 6 months to 14 years with DKA were included and categorized in mild, moderate and severe categories. Various clinical, demographic, biochemical parameters were compared for the association between severity and final outcome. **Result:** Out of 54 cases admitted with DKA, 39 (72.2%) patients were female, most of the cases belonged to rural areas. Dehydration (83.3%), nausea/vomiting (77.7%), Kussmaul's breathing (72.2%) were common presenting symptoms and signs of DKA. The severity of DKA was significantly associated with gender, area of residence, socioeconomic status, B.M.I. of the patient, presence of infection, insulin omission, DKA on 1st episode, presence of diarrhea, presence of shock, poor G.C.S. on admission and time required for resolution of DKA (p-value <0.05 for each). The mortality rate was 7.4%. **Conclusion:** In our study, the most common precipitating factor observed for DKA was an infection. For the long-term management strategy, education of the patients and their parents regarding infection control, regular blood sugar monitoring and proper Insulin dosing appear to be promising tools.

Keywords: Diabetic ketoacidosis, Type 1 Diabetes mellitus, Cerebral edema

Corresponding Author

Deepak Kumar Nirala, PG Resident, Department of Pediatrics, Pt JNM Medical College, Raipur, Chhattisgarh, India.
Email: dknirala97@gmail.com

How to Cite this Article

Dhiraj Kumar Solanki, Sneha Singh Dhruw, Deepak Kumar Nirala, Clinical, Demographic, Biochemical and Outcome Profile of Diabetic Ketoacidosis in Children with Type 1 Diabetes Mellitus. Pediatric Rev Int J Pediatr Res. 2021;6(5):236-244.
Available From
https://pediatrics.medresearch.in/index.php/ijpr/article/view/696

To Browse

Manuscript Received	Review Round 1	Review Round 2	Review Round 3	Accepted
2021-09-15	2021-09-17	2021-09-24	2021-10-01	2021-10-08

Conflict of Interest	Funding	Ethical Approval	Plagiarism X-checker	Note
Nil	NIL	Yes	19%	

Introduction

Diabetes mellitus is a metabolic disease of multiple etiologies, characterized by chronic hyperglycemia, resulting in disturbances of carbohydrate, fat, and protein metabolism resulting from defects in insulin secretion, insulin action, or both [1]. Type 1 diabetes mellitus (T1DM) is an autoimmune disorder caused by the immune-mediated destruction of pancreatic beta-cell mass, Leading to a limited secretion of insulin or complete cessation of the production of insulin, which ends up needing external insulin delivery for survival [2].

According to the International Diabetes Federation (2019), In India, the estimated number of incident (new) cases is found to be 1.59 lakh per year in children between 0–14 years old, while the estimated number of prevalent (existing) cases is 9.56 lakh. India accounts for most of the children with T1DM in the Southeast Asia region [3]. Data from developing countries like India, Pakistan, and Bangladesh, show mortality rates to range from 3.4% to 13.4% [4-7]. Diabetic ketoacidosis (DKA) is an acute life-threatening metabolic emergency, frequently requiring hospitalization in children with type 1 diabetes and remains their major reason for mortality [8,9]. There is a wide variation in the rate of children presenting with DKA as the initial manifestation of diabetes, depending on the study population. International studies have shown that between 15 - 70% of kids newly diagnosed Type 1 D.M. presented with DKA. The estimated risk of DKA in children and adolescents with established Type 1 D.M. is 1- 10 per 100 people/year [10]. Most patients with DKA recover when treated correctly. If left untreated, the patient may develop complications like cerebral edema, thromboembolism, acute respiratory distress syndrome (ARDS), disseminated intravascular coagulation (D.I.C.), electrolyte abnormalities, infections, and shock [11]. Early identification of ketoacidosis and aggressive management with insulin, intravenous fluids, and electrolytes replacement and identification and treatment of precipitating cause may change the natural course of the disease. Excessively rapid fluid resuscitation should be avoided to prevent cerebral edema, a rare but debilitating and potentially fatal complication of DKA [12]. Considering the above facts, a cross-sectional study was planned to check the clinical features, Demographic profile, precipitating factors, biochemical profile, and short-term outcome in diabetic ketoacidosis patients.

Aims and objectives

Aims: To study the clinical, demographic, biochemical and outcome profile of Diabetic ketoacidosis in children with Type 1 Diabetes mellitus

Objectives:

- To study the incidence, clinical features, demographic profile, precipitating factors, biochemical profile, immediate complications and short-term outcomes of diabetic ketoacidosis in children with Type 1 Diabetes mellitus.
- To find out the association between severity of DKA and clinical, demographic, biochemical parameters.
- To find out the correlation between outcome and different variables related to patients.

Material and Methods

Study Design: This was a prospective, cross-sectional, hospital-based and observational study.

Sample size: 54 DKA patients admitted during the study period.

Study Setting: Pediatric Intensive Care Unit (PICU) at Dr Bhim Rao Ambedkar Memorial Hospital, Raipur, C.G.

Study Duration: This study was conducted from January 2019 to December 2019.

Study subjects: All those patients aged from 6 months to 14 years with Type 1 D.M. with DKA.

Inclusion Criteria:

All those patients aged from 6 months to 14 years fulfilling the diagnostic criteria of Type 1 Diabetes Mellitus presenting to PICU with Diabetic ketoacidosis (DKA).

Exclusion Criteria:

- Neonatal Diabetes mellitus (0-6 months)
- MODY/Juvenile Diabetes mellitus
- Type 2 Diabetes Mellitus
- Non-diabetic Hyperglycemia.

Methodology/ Data Collection: After preliminary evaluation and management in the pediatric intensive care unit of this hospital, the detailed assessment of all patients was done and recorded in a pre-designed proforma after obtaining written informed consent from their parents. The proforma contained information on patient's gender, age, area of residence, socioeconomic status of the family according to modified Kuppuswamy scale, Body Mass Index (B.M.I.), level of consciousness, time of admission, duration of symptoms, family history of diabetes, consanguinity, significant presenting signs, symptoms. An attempt to detect the precipitating events were made in all children. The presence of infection/ intercurrent illness as indicated by a positive radiological imaging study or blood culture. This was supported by an elevated white blood cell count and clinical examination by the physician. The measure of compliance regarding insulin was based on the history given by the attendants of the patients. Insulin omission was defined as missing insulin injections on multiple days, especially immediately before or during the period of illness.

Detailed physical examination, including the vitals, anthropometry, and systems examination, was carried out. Essential laboratory parameters done on admission included blood glucose, urine ketone level by dipstick method, arterial/venous blood gas, sodium, potassium, calcium, complete blood counts, blood urea, serum creatinine, chest radiograph and an electrocardiogram. Urine examination was done for routine analysis and for detecting ketone body. C- reactive protein (C.R.P.), blood culture and sensitivity, urine culture, and sensitivity were sent to patients with suspected sepsis. HbA1c was done in all children to look for long-term glycaemic status. Complications including cerebral edema, cardiac arrhythmia, hypoglycemia, hypokalaemia, hypernatremia, infection and renal failure were recorded.

Time duration required for resolution of DKA and insulin infusion duration were recorded. The outcome in the form of survival and death were noted. Resolution of DKA was considered when the consciousness was normal, no vomiting, pH more than 7.3 and serum bicarbonate level more than 15.

DKA is defined as the presence of hyperglycemia (blood glucose >200mg/dL) with a venous pH <7.3 and bicarbonate <15mmol/L with associated Glycosuria, ketonuria and ketonemia in established cases of diabetes mellitus. DKA is categorized as mild (venous Ph < 7.3 and/or bicarbonate <15mmol/L), moderate (pH <7.2 and/or bicarbonate <10mmol/L), and severe (pH <7.1 and/or bicarbonate <5mmol/L). After categorization, various clinical, demographic and biochemical parameters were analyzed using appropriate statistical tools for association with severity of DKA and outcome.

Statistical analysis

- All relevant data was entered into pre-designed proforma and was analyzed using Microsoft SPSS software for windows TM version 22.0, I.B.M. TM Corp NY, and Microsoft excelM., Microsoft Inc U.S.A.
- Data are expressed as a percentage and mean ± D.
- Wherever possible, Chi-square test/ Fisher exact test and logistic regression test were used to analyze the significance of the difference between distributions of qualitative
- P-value <0.05 is considered statistically

Ethical Approval: This study was approved by the Institutional Ethics Committee.

Results

In the present study incidence of DKA in children with type 1 Diabetes Mellitus was 3.4%. The mean age of presentation was 9.76 ±3.88 years; the preadolescent age group was most affected, constituting approximately 50% of the total cases. The majority of the patients in this study were females 39 (72.2%), with a female to male ratio of 2.6:1. Mean B.M.I. was 13.31 ±3.515 kg/m2. Most of the children, 34 (63%), were from upper lower class IV socioeconomic status families as per the Modified Kuppuswamy scale. DKA patients from rural areas were approximately three times higher than DKA patients from urban areas, i.e. 41 (76%) of rural regions vs 14 (24%) from urban areas. Family history of Type 2 D.M. was found in only 3 (5.55%) patients. 22 (40.75%) cases presented with DKA as 1st episode of disease, and 32 (59.25%) cases of the DKA were already diagnosed case of Type 1 D.M. We found that out of 54 cases, 25 (46%) cases presented with severe DKA, 21 (39%) were of DKA with moderate severity and 8 (15%) cases with mild DKA.

Table 1. Association between severity of DKA with the demographic profile of pediatric patients with DKA.

Variables	N	Mild (N=8)	Moderate (N=21)	Severe (N=25)	p-value
Age group					
1 – 5 years	9	0	2	7	0.135
5 – 10 years	15	3	4	8	
> 10 years	30	5	15	10	
Gender					
Male	15	0	4	11	0.028*
Female	39	8	17	14	
Body Mass Index (kg/m2)					
<12	18	0	3	15	0.002*
12.1 -15	20	4	11	5	
15.1 – 18	12	3	7	2	
18.1 – 21	4	1	0	3	
Socioeconomic status					
High	3	0	0	3	0.005*
Middle	14	2	1	11	
Low	37	6	20	11	
Area of residence					
Rural	41	8	18	15	0.029*
Urban	13	0	3	10	
Family history of diabetes					
Yes	51	8	20	23	0.677
No	3	0	1	2	
Precipitating factor					
DKA 1st episode	22	5	6	11	0.043*
Insulin omission	20	3	5	12	0.024*
Infection	34	4	9	17	0.017*

The most common presenting symptoms were nausea/vomiting in 42 (77.77%), pain abdomen in 36 (66.66%), followed by fever in 35 (64.8%), Weakness in 27 (58%), polyuria in 18 (33.33%), polydipsia in 16 (30%) and headache in 15 (27.8%).

Table 2. Association between severity of DKA and symptoms/signs in paediatric patients of diabetic ketoacidosis.

Variables	N	Mild	Moderate	Severe	p-value
Symptoms					
Nausea/Vomiting	42	5	17	20	0.529
Pain Abdomen	36	3	14	19	0.132
Cold / Cough	25	5	11	9	0.329
Fever	35	4	13	18	0.493
Weakness	27	2	11	14	0.300
Polyuria	18	2	7	9	0.848
Polydipsia	16	2	8	6	0.553
Polyphagia	11	1	3	7	0.431
Diarrhoea	18	0	5	13	0.012*
Weight Loss	8	1	5	2	0.317
Headache	15	2	5	8	0.811
Seizure	2	0	0	2	0.300
Signs					
Dehydration	45	6	19	20	0.656
Shock	11	0	3	8	0.010*
Kussmaul Breathing	39	3	16	20	0.057
Tachypnea	13	4	6	3	0.075
Altered Sensorium/ drowsy	32	3	11	18	0.160
GCS					
<8	7	0	1	6	0.018*
8-12	20	1	7	12	
13-15	27	7	13	7	

Significant presenting signs were dehydration in 45 (83.3%), Kussmaul's Breathing in 39 (72.2%), altered sensorium in 27 (50%), tachycardia in 13 (24%), shock in 11 (20.3%), while abdominal distension and guarding was present in 6 (11.1%) and 3 (5.55%) cases were comatose. In the present study, infection in 34 cases (62.9%) was the most common precipitating factor of DKA, URTI being the commonest in 26 (48.1%), followed by acute gastroenteritis in 18 (33.3%), pneumonia in 10 (18.5%), U.T.I. in 7 (12.9%) and severe sepsis in 6 (11.1%). Mean R.B.S. was 394.72±92.2 mg/dl, and mean HbA1c on admission was 9.6 ±1.81%. The mean duration of insulin infusion required for resolution of ketoacidosis and changing over subcutaneous insulin was 38.98±17.61hrs. The mean duration of hospital stay was 9.09 ±2.75 days. The most common complication observed was shocking in 11 (20.37%) followed

By hyponatremia and hypokalaemia in 9 (16.6%), A.K.I. in 8 (14.8%), cerebral edema in 6 (11.1%) and 2 (3.7%) cases had hypernatremia. The mortality rate was 7.4%.

Table 3. Correlation between different clinical, biochemical and socio-demographic parameters in survivor's vs deaths (multivariate logistic regression analysis)

Clinical, biochemical or socio-demographic parameters in survivors vs deaths		Confidence Interval		p-value
	Odds ratio	Lower	Upper	
GCS level (< 8)	34.500	2.880	413.255	0.005*
Presence of cerebral oedema	11.500	1.261	104.860	0.030*
Need for mechanical ventilation	0.033	0.000	1.496.	0.997
Presence of shock requiring ionotropic support	0.068	0.000	1.454.	0.997
Length of hospital stay in days (> 7 days)	0.105	0.010	1.109	0.061
Age of patient (< 5 years)	6.097	0.537	69.218	0.015*
Gender of patient (male)	0.351	0.045	2.755	0.319
Socioeconomic Status (low)	2.333	0.300	18.146	0.410
Serum sodium level (<130 mEq/l)	4.147	0.372	46.230	0.048*
Serum potassium level (< 2.5 mEq/l)	1.923	0.133	361.417	0.380
pH value (<7.0)	1.195	0.374	3.823	0.763
Serum bicarbonate level (<5.0)	0.132	0.010	1.765	0.126
Serum osmolarity (>320)	0.389	0.045	3.324	0.388
Anion gap (>12)	0.850	0.030	0.202	1.000
Lactate level (>5)	0.070	0.130	0.532	0.998
Random Blood Glucose (>500 mg/dl)	1.084	0.070	16.678	0.954
Hb1Ac level (>12)	0.095	0.005	1.903	0.124
Duration of insulin infusion (>72hrs)	4.040	0.003	0.563	0.017*
Presence of Infection/sepsis	0.010	0210	0.773	0.998

The severity of DKA was significantly associated with gender, B.M.I. of the patient, socioeconomic status, area of residence and precipitating factors (p-value < 0.05 for each).

The presence of diarrhoea, presence of shock and poor G.C.S. on admission were significantly associated with the severity of DKA. (p-value <0.05 for each)

Present study suggest that likelihood of death was significantly higher among the patients who had age<5years (OR=6.09, p=0.015), poor GCS on admission (<8) (OR=34.5, p=0.05), cerebral edema (OR=11.5, p=0.03), hyponatremia (serum sodium <130meq/L) (OR=4.14, p=0.048) and requirement of insulin infusion >72hrs (OR=4.04, p=0.01

Discussion

DKA represents a decompensated phase of diabetes mellitus, which may require PICU admission, especially in the presence of cardiovascular instability, inability to protect the airway, altered state of consciousness, the presence of acute abdominal signs or symptoms.

In our study majority of the 39 patients (72.2%) were females with a female to male ratio of 2.6:1. These findings were similar to Ameyaw E et al. (2017) in Ghana, where 71.1% of subjects were female [13].

The mean B.M.I. of subjects in our study was 13.31±3.51kg/m2. These findings concordance to a survey by Syed M et al. (2011), who found that mean B.M.I. was 14.4 ± 2.9 kg/m2[10]. However, Al-Shaikh A et al. (2019) reported that patients who were diagnosed with DKA had higher B.M.I. (20.87 ± 5.21kg/m2) [14].

Our study shows that most of the children, 34(63%), were from upper lower class IV families, similar to the study by Basavanthapa et al. (2015) and Padma B.K. et al (2019) [15,16].

We reported most DKA patients were from rural areas, 41 (76%) DKA and only 14 (24%) from the urban areas. Basavanthapa et al. (2015) also reported that most of the patients, i.e. 41 (78%), were from rural areas [15]. In contrast to our study, Rashid I et al. (2019) found that 70% of patients belonged to urban areas, and only 30% lived in rural areas [17].

We observed that only 3 (5.55%) patients had a family history of Type 2 D.M. Similar findings were also noticed by Ababulgu RZ et al. (2020), who found a family history of D.M. in only 7(11.1%) patients [18]. However, Satti AS et al. (2013) reported a family history of diabetes (either type 1 or 2) in 59 (74%) cases which is significantly higher than in our study [19].

In our study, 32 (59.25%) of the DKA cases were already diagnosed with type 1 D.M., while 22 (40.75%) patients were newly diagnosed as type 1 D.M. on admission. Similarly, Bhardwaj P et al. (2017) found that 48.2% were newly diagnosed and 51.8% were previously diagnosed cases of diabetes [20]. But Basavanthapa et al. (2015), in their study, reported that almost 80.7% of patients were newly diagnosed type 1 D.M. [15].

We found that out of 54 cases, 25 (46%) cases presented with severe DKA, 21 (39%) patients with moderate DKA and 8 (15%) cases with mild DKA. Rashid supported this I et al. (2019), where most of the patients had severe DKA [17], whereas Kumar MV et al. (2017) reported 81% moderate DKA cases [21].

Most of the DKA cases, 34 (77.77%) presented to us with nausea/vomiting followed by pain abdomen in 36 (66.66%), fever in 35 (64.8%), weakness in 27 (50%), polyuria in 18 (33.33%), polydipsia in 16 (30%) and headache in 15 (27.8%). This symptomatology was similar to the experience by Satti SA et al., were vomiting and abdominal pain were the common presenting symptoms [19]. However, a study by Kanwal SK et al. (2012) reported polyuria, polydipsia as the commonest presenting features followed by vomiting, altered sensorium and abdominal pain [15].

Dehydration was the primary presenting sign in 83.3% cases, followed by Kussmaul breathing in 72.2% cases, altered sensorium in 50%, tachycardia was found in 24% cases, shock in 20.3% and 5.55% cases were comatose. This was comparable to the study by Neu A et al. (2003), where almost 53% had altered levels of consciousness, with 10.9% of them being unconscious [22]. Islam R et al. (2014) also found that Kussmaul's breathing and dehydration were the commonest clinical feature of DKA [23]. This is unlike the experience from Saudi Arabia, by Satti SA et al. (2013), where only 43.4% had clinical evidence of dehydration. It could be that our patients arrived relatively late to the hospital, or most of them were having vomiting/diarrhoea [19].

We found that 34 (62.9%) patients had intercurrent illness/infection as a major precipitating factor of DKA. 22 (40.7%) cases presented with DKA as 1st episode, 20 (37%) patients omitted insulin in more than two instances leading to precipitation of DKA, among 15 (27.7%) cases infection with insulin omission were precipitating factor, new-onset diabetes with sepsis was noted in 10 (18.5%). These findings were supported by Jayashree M et al. (2004), which shows that precipitating events identified by them were new-onset diabetes with sepsis (37%), new-onset diabetes alone (31%), insulin omission (15%), and infection with insulin omission (7%) [24].

In our study among intercurrent illness, URTI was most common and was found in 26 (48.1%) cases, followed by acute gastroenteritis in 18 (33.3%), pneumonia in 10 (18.5%) cases, urosepsis (U.T.I.) was present in 7 (12.9%) cases, 6 (11.1%) subjects had severe sepsis in the form of intercurrent illness, 3 (5.55%) cases presented with a skin infection and 1 (1.85%) patient presented with malaria. Mbugua PK et al. (2005) also reported respiratory, genito-urinary, and septicemia [25]. Similarly, Basavanthapa SP et al. (2015) said that the major precipitating factor for DKA was infection (most commonly viral fever, peritonitis, pneumonia and urinary tract infections) [15].

The most common complications noted during treatment in our study was shock in 11 (20.37%) cases; other complications seen were hyponatremia and hypokalaemia in 9 (16.6%), A.K.I. in 8 (14.8%), cerebral edema in 6 (11.1%) and hypernatremia seen in 2 (3.7%). These findings were almost similar, as seen in a study done by Bhardwaj P et al. (2017), where the shock was observed in 27.5% of patients, and 20.9% had cerebral edema. Metabolic abnormalities like hyponatremia, hypernatremia, hyperkalemia, hypokalaemia were seen in 44.8%, 13.7%, 24.1%, and 17.2% respectively [20].

In our study, the mean duration of insulin infusion required for resolution of ketoacidosis was 38.98 ±17.61 hrs, and the mean duration of hospital stay was 9.09 ±2.75 days; this was similar to study by

Varshney GA et al. (2015) they reported the median time for the arterial blood gases to become normal was 26 hrs. The average length of the hospital was 7.8 days [26].

In our study, among the demographic parameters, gender, area of residence, socioeconomic status, and B.M.I. of the patient were significantly associated with the severity of DKA. (P-value < 0.05 for each). Similarly, among clinical and biochemical parameters, presence of infection, insulin omission, DKA 1st episode, presence of diarrhoea, presence of shock, poor G.C.S. on admission, fever on admission, and time required for resolution of Diabetic ketoacidosis was significantly associated with severity of DKA. (P-value <0.05 for each). This was supported by Syed M et al. (2011), they observed that severity of diabetic ketoacidosis was significantly associated with the presence of infection, history of omission of insulin, poor compliance, presence of shock at the time of presentation, length of stay in the hospital, outcome ($p < 0.01$ for each of these associations) and Glasgow Coma Scale score (p=0.02) [10].

In multivariate logistic regression analysis done between survivors and deaths using different parameters in our study suggest that likelihood of death was significantly higher among the patients who had poor G.C.S. on admission <8 (OR=34.5, P=0.05), cerebral edema (OR=11.5, p=0.03), age <5years (OR=6.09, p=0.015), hyponatremia (serum sodium <130) (OR=4.14, p=0.048) and requirement of insulin infusion >72hrs (OR=4.04, p=0.017). This was in concordance with a study by Syed M et al. (2011), they observed the presence of cerebral edema, need for mechanical ventilation, low socioeconomic status, low serum sodium level, low serum potassium level, low arterial blood pH, presence of infection and stay in the pediatric intensive care unit were factors that significantly impacted the outcome of the patient [10]. Hence, children with these characteristics should be more intensively monitored.

Out of 54 cases admitted with DKA, 50 improved and were discharged, 4 (7.4%) patients died during treatment. This was comparable with the reported mortality rate from developing countries like India, Pakistan, and Bangladesh (3.4% to 13.4%) [9-12].

Conclusion

Diabetic ketoacidosis is a life-threatening complication of Type 1 Diabetes Mellitus in children and adolescents. Preadolescent and adolescent age groups are facing more risk of developing DKA with female predominance. The most common symptom and sign observed was nausea/vomiting and dehydration, respectively. DKA can be diagnosed within a few minutes by measuring blood glucose, ketones, and venous blood pH. Infections are the most common precipitating factor; therefore, preventive measures aiming at childhood infections can help in reducing the Incidence of DKA. Insulin omission (poor compliance) is an important modifiable precipitating factor for diabetic ketoacidosis in children with already diagnosed type 1 D.M. Counselling and education during hospitalization and discharge of patients and their parents/guardians with regards to the importance of regular blood sugar monitoring, and insulin dosing should be considered an important long-term management strategy.

Limitation of the study

The sample size was small, so it is not a true reflection of the Incidence of DKA in the country. We studied DKA only in children less than 14 years of age, as the criteria for admission in our PICU was below 14 years, and being a Government set up, most of the children presented were from rural areas with poor socioeconomic status.

Author's contributions

Dr Dhiraj Kumar Solanki: Study concept, study design, study supervision and finalizing the manuscript. **Dr Sneha Singh Dhruw:** Manuscript writing. **Dr Deepak Kumar Nirala:** Wrote the protocol, recruited patients, statistical analysis and prepared manuscript. All authors approved the final manuscript.

Reference

01. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2009 Jan;32 Suppl 1(Suppl 1):S62-7. *doi: 10.2337/dc09-S062 [Crossref][PubMed][Google Scholar]*

02. Van Belle TL, Coppieters KT, von Herrath MG. Type 1 diabetes: etiology, immunology, and therapeutic strategies. Physiol Rev. 2011 Jan;91(1):79-118.

Doi: 10.1152/physrev.00003.2010 [Crossref] [PubMed][Google Scholar]

03. Federation, I. D. "I. D. *F. Diabetes Atlas 9th 2019." International Diabetes Federation, Brussels, Belgium (2020) [Crossref][PubMed][Google Scholar]*

04. Zabeen, B, Nahar, J, Mohsin F, Azad K, and Nahar N. Diabetic ketoacidosis in children-an experience in a tertiary hospital. Ibrahim Medical College Journal, 2. 1 (2008): 17-20. *[Crossref] [PubMed][Google Scholar]*

05. Syed M, Khawaja FB, Saleem T, Khalid U, Rashid A, Humayun KN. Clinical profile and outcomes of paediatric patients with diabetic ketoacidosis at a tertiary care hospital in Pakistan. J Pak Med Assoc. 2011 Nov;61(11):1082-7. *[Crossref][PubMed] [Google Scholar]*

06. Tiwari LK, Jayashree M, Singhi S. Risk factors for cerebral edema in diabetic ketoacidosis in a developing country: role of fluid refractory shock. Pediatr Crit Care Med. 2012 Mar;13(2):e91-6. *doi: 10.1097/PCC.0b013e3182196c6d [Crossref] [PubMed][Google Scholar]*

07. Kanwal SK, Bando A, Kumar V. Clinical profile of diabetic ketoacidosis in Indian children. Indian J Pediatr. 2012 Jul;79(7):901-4. *doi: 10.1007/s12098-011-0634-3 [Crossref][PubMed] [Google Scholar]*

08. Basu A, Close CF, Jenkins D, Krentz AJ, Nattrass M, Wright AD. Persisting mortality in diabetic ketoacidosis. Diabet Med. 1993 Apr;10(3):282-4. *doi: 10.1111/j.1464-5491.1993.tb00060.x [Crossref][PubMed][Google Scholar]*

09. Edge JA, Ford-Adams ME, Dunger DB. Causes of death in children with insulin dependent diabetes 1990-96. Arch Dis Child. 1999 Oct;81(4):318-23. *doi: 10.1136/adc.81.4.318 [Crossref][PubMed] [Google Scholar]*

10. Bui TP, Werther GA, Cameron FJ. Trends in diabetic ketoacidosis in childhood and adolescence: a 15-yr experience. Pediatr Diabetes. 2002 Jun;3(2):82-8. *doi: 10.1034/j.1399-5448.2002.30204.x [Crossref][PubMed][Google Scholar]*

11. Abbas Q, Arbab S, Haque AU, Humayun KN. Spectrum of complications of severe DKA in children in pediatric Intensive Care Unit. Pak J Med Sci. 2018 Jan-Feb;34(1):106-109. *doi: 10.12669/pjms.341.13875 [Crossref][PubMed] [Google Scholar]*

12. Edge JA, Jakes RW, Roy Y, Hawkins M, Winter D, Ford-Adams ME, et al. The U. K. case-control study of cerebral oedema complicating diabetic ketoacidosis in children. *Diabetologia. 2006 Sep;49(9):2002-9. doi: 10.1007/s00125-006-0363-8 [Crossref][PubMed][Google Scholar]*

13. Ameyaw E, Asafo-Agyei SB, Thavapalan S, Middlehurst AC, Ogle GD. Clinical profile of diabetes at diagnosis among children and adolescents at an endocrine clinic in Ghana. World J Diabetes. 2017 Sep 15;8(9):429-435. *doi: 10.4239/wjd.v8.i9.429 [Crossref][PubMed][Google Scholar]*

14. Al Shaikh A, Farahat F, Saeedi M, Bakar A, Al Gahtani A, Al-Zahrani N, et al. incidence of diabetic ketoacidosis in newly diagnosed type 1 diabetes children in western Saudi Arabia: 11-year experience. J Pediatr Endocrinol Metab. 2019 Aug 27;32(8):857-862. *doi: 10.1515/jpem-2018-0548 [Crossref][PubMed][Google Scholar]*

15. Varshney, G. A. , Varshney, D. , Mehr, V. *, Kela, G., Kharia, R., Agrawal, G., & Gupta, R. Clinical profile and outcome of diabetic ketoacidosis in children at tertiary care hospital. Journal of Evolution of Medical and Dental Sciences, 4.31 (2015): 5329-5334 [Crossref][PubMed][Google Scholar]*

16. Padma B. K. , Deepa. (2019). *Clinico-laboratory characteristics and immediate outcome in children with diabetes mellitus. Journal of Evolution of Medical and Dental Sciences. 8. 1998-2001. 10.14260/jemds/2019/43 [Crossref][PubMed] [Google Scholar]*

17. Rashid, I. , Amin, A. , Mushtaq, H. F. *, & Sa'd Masood, M. (2020). Diabetic Ketoacidosis and Its Outcome in Children. Asian Journal of Multidisciplinary Studies, 8, 1 [Crossref][PubMed] [Google Scholar]*

18. Ababulgu RZ, Tesfaye BT. Characteristics and Outcomes of Children with Type-I Diabetes Mellitus Hospitalized for Ketoacidosis. Curr Diabetes Rev. 2020;16(7):779-786. *doi: 10.2174/1573399815666190906152125 [Crossref] [PubMed][Google Scholar]*

19. Satti SA, Saadeldin IY, Dammas AS. Diabetic

Ketoacidosis in children admitted to Pediatric Intensive Care Unit of King Fahad Hospital, Al-Baha, Saudi Arabia: Precipitating factors, epidemiological parameters and clinical presentation. Sudan J Paediatr. 2013;13(2):24-30. *[Crossref][PubMed][Google Scholar]*

20. Bhardwaj, P. , V. Yadav, and M. Sharma. *"Clinical profile and outcome of the children with diabetic ketoacidosis (DKA) in hilly Himalayan state of north India." Int J Res Med Sci 5.12 (2017): 5402-5 [Crossref][PubMed][Google Scholar]*

21. Kumar, Madhava Vijaya, and Kalappurayil Manjusha. "Precipitating factors, clinical profile and metabolic abnormalities of diabetic ketoacidosis in children with type 1 diabetes and their role in predicting the outcome. " hts teologiese studies/theological studies 4. 8 (2017): 393-400. *[Crossref][PubMed][Google Scholar]*

22. Neu A, Ehehalt S, Willasch A, Kehrer M, Hub R, Ranke MB. Varying clinical presentations at onset of type 1 diabetes mellitus in children--epidemiological evidence for different subtypes of the disease? Pediatr Diabetes. 2001 Dec;2(4):147-53. doi: 10. *1034/j.1399-5448.2001.20402.x [Crossref][PubMed][Google Scholar]*

23. Islam, R. , Akhter, S. , Shelim, R. , Mohsin, F. , *Begum, T., & Akhter, G. Precipitating factors, clinical features and outcome of diabetic ketoacidosis in children and adolescents admitted in a tertiary care hospital in Dhaka. Bangladesh Journal of Medical Science, 13.1 (2014): 53-57 [Crossref][PubMed][Google Scholar]*

24. Jayashree M, Singhi S. Diabetic ketoacidosis: predictors of outcome in a pediatric intensive care unit of a developing country. Pediatr Crit Care Med. 2004 Sep;5(5):427-33. *doi: 10.1097/01.pcc.0000137987.74235.5e [Crossref][PubMed][Google Scholar]*

25. Mbugua PK, Otieno CF, Kayima JK, Amayo AA, McLigeyo SO. Diabetic ketoacidosis: clinical presentation and precipitating factors at Kenyatta National Hospital, Nairobi. East Afr Med J. 2005 Dec;82(12 Suppl):S191-6. *doi: 10.4314/eamj.v82i12.9381 [Crossref][PubMed][Google Scholar]*

26. Varshney, G. A. , Varshney, D. , Mehr, V. *, Kela, G., Kharia, R., Agrawal, G., & Gupta, R. Clinical profile and outcome of diabetic ketoacidosis In children at tertiary care hospital. Journal of Evolution of Medical and Dental Sciences, 4.31 (2015): 5329-5334 [Crossref][PubMed][Google Scholar]*