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Diabetic Ketoacidosis in Children with Type-1 Diabetes in a Tertiary Hospital in Sokoto, North-Western Nigeria: Clinical Profile and Outcome

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Authors' contributions

This work was carried out in collaboration between both authors. Author MOU designed the study, wrote the protocol, performed literature search, managed statistical analysis and wrote the first draft of the manuscript. Author TY managed the literature search and critically reviewed the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Introduction: Diabetic ketoacidosis (DKA) is a life-threatening complication of type 1 diabetes (T1D). Few reports are available on DKA among children in North-west Nigeria.
Objective: To describe the clinical profile and outcome of children managed for DKA in the Paediatric Endocrinology Unit of Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto, North-western Nigeria over a ten-year period (January 2011- December 2020).
Methods: This was a retrospective review of the case records of all children managed for T1D between 2011 and 2020. Socio-demographic and clinical data of those with DKA were extracted and analysed using SPSS version 23.
Results: Ten (62.5%) out of 16 children with T1D had DKA, comprising 8 males and 2 females; M: F ratio 4:1. Majority (90%) were adolescents aged 10-15years. The mean age ± standard deviation (SD) at diagnoses of T1D was 11.1 ± 3.14 years; DKA was the presenting manifestation of diabetes in 4 (40%) children, while 6(60%) were known diabetics with an average of 2-episodes per patient. The median duration of symptoms was 5 days (range 1-42 days). Abdominal pain (90%), polyuria (80%), fast breathing (70%), vomiting (70%), altered consciousness (70%), dehydration (100%) and

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Kussmaul respiration (70%) were the common presenting features. The mean blood glucose, bicarbonate and venous PH at admission were 23.28± 7.14 (range; 12.3-33.3) mmol/L, 14.1± 3.41 (10-21) mmol/L and 6.96± 0.06 (6.92-7.00) respectively. Co-morbid conditions included infections (80%), predominantly malaria (70%). There was no mortality.

Conclusion: DKA is common in male adolescents, with good management outcome in our facility. Abdominal pain, dehydration, polyuria and Kussmaul respiration were the commonest presenting features. A high index of suspicion of DKA is recommended in any child, particularly, male adolescents with the aforementioned features. Effort should be made to confirm diagnosis and prompt treatment instituted.

Keywords: Ketoacidosis; type 1 diabetes; clinical profile; children; outcome; tertiary.

1. INTRODUCTION

Diabetic ketoacidosis (DKA) is an acute, major, life threatening complication that mainly occurs in patients with type 1 diabetes (T1D), and is the foremost cause of death in these patients [1]. It is the end result of the metabolic abnormalities resulting from a severe deficiency of insulin or insulin effectiveness, the latter occurs during stress, as counter regulatory hormone block insulin action [2]. The biochemical definition of DKA includes a triad of hyperglycemia (Random Blood Glucose [RBG] >200mg/dl or 11.1mmol/l), acidosis (serum bicarbonate [HCO_3] < 15mmol/l and/or venous PH < 7.3), together with glucosuria, ketonemia, and/or ketonuria [3]. Diabetic ketoacidosis can occur at disease onset; before T1D is recognised or diagnosed, it can also occur in known patients with T1D (established diabetes), particularly during inter-current illnesses, and especially, if self - monitoring is unavailable, insulin is unaffordable or not being provided correctly [4]. Diabetic ketoacidosis may also occur due to poor metabolic control, inappropriate interruption of insulin pump therapy, psychiatric disorders, difficult family circumstances and lower socioeconomic status [5]. There is wide geographic variation in the frequency of DKA at onset of diabetes and rates inversely correlate with regional incidence of TID [3,6]. International studies have reported frequencies of 15 - 70% in new onset T1D patients [3,7,8], higher rates of 75-88% were reported in some studies in Nigeria [9-11] On the other hand, the risk for DKA in patients with established T1D is 1-10% per patient/year [5,12,13] A study in Enugu, southeast Nigeria reported prevalence of DKA amongst children emergency room admissions of 0.13% (1.3/1000) [14].

Diabetic ketoacidosis is associated with significant morbidity and mortality in the paediatric population. Cerebral injury is the major cause of mortality and morbidity in DKA and cerebral oedema accounts for 60-90% of all DKA deaths [3,15-16]. Studies have shown that clinically overt cerebral oedema developed in 0.5-0.9% of episodes of DKA [3]. Other causes of morbidity and mortality include hypoglycemia, infections, cardiac arrhythmias caused by electrolyte disturbances, central nervous system haemorrhage or thrombosis, renal failure and intestinal necrosis [6,15]. Timely recognition, appropriate management; preferably in centres with experience in DKA management are essential to minimize complications and mortality.

There are few reports on DKA in the childhood diabetic population in Nigeria [10,14,17-18] and other African countries [1,19,20]. Most of these reports focused on DKA at onset of T1D only. A prior study in Sokoto [21], looked at childhood diabetes as a whole, without focus on the clinical profile and outcome of DKA as a complication of T1D. Studying the clinical profile and outcome of DKA in children, therefore, would help to improve its early recognition, and consequent prompt treatment and/or referral by attending heath care providers, particularly in undiagnosed children with T1D, thereby preventing adverse outcomes. It would also help in counselling and giving diabetic education to children and adolescents with T1D so as to prevent its reoccurrence.

This study aimed to describe the clinical profile and outcome of DKA in both newly diagnosed diabetic children and those with established diabetes over a ten-year period, in the paediatric Endocrinology unit of Usmanu Danfodiyo University Teaching Hospital (UDUTH), Sokoto.

2. MATERIALS AND METHODS

This study was conducted in UDUTH, Sokoto. Usmanu Danfodiyo University Teaching Hospital is an 860 bed capacity tertiary health facility that serves as a major referral centre to most

secondary health facilities and private hospitals in Sokoto. It also serves neighbouring states such as Zamfara, Kebbi and Niger States, and a contiguous neighbouring country, Niger Republic. The paediatric department of the hospital provides general and specialist paediatric care to children ≤ 15 years in Sokoto and environs. (15 years is the paediatric cut off age in UDUTH).

Sokoto is the capital of Sokoto state, located in the extreme north-west of Nigeria. It lays between latitude 10^0 and 14^0 N and longitude 3^03^1 N and 7^07^1 E of the equator. Most of the ethnic groups in Nigeria are represented but the majorities are the indigenous Hausa's and Fulani's. The state is basically an agrarian society with low western literacy level. The majority of the indigenous people live in rural areas and most of them are engaged in subsistent farming, fishing and livestock breeding. A cross-section of all socioeconomic classes is well represented in the metropolis.

This was a 10-year retrospective review of hospital records of all patients managed for T1D at the Paediatric Endocrinology unit of UDUTH Sokoto, from 1st January 2011 to 31st December 2020.

Relevant data were retrieved from the case files of all children who were diagnosed and managed for T1D within the 10-year review period, and entered into a written pro-forma. The data retrieved included age at presentation with DKA (the age at last episode of DKA was recorded for children who have had more than one episode), age at diagnosis of T1D, year of diagnosis, duration of diabetes, gender, tribe, place of domicile, parents occupation and highest educational attainment, duration of symptoms, number of DKA episodes, precipitating/co-morbid conditions, clinical features, outcome of admissions (discharge or death), availability of personal blood glucose monitoring and clinic follow up. Both new-onset T1D and children with established diabetes with DKA were included. The clinical features and characteristics of the last episode of DKA were recorded in patients who had more than one episode since diagnosis of T1D.

DKA was defined as presence of hyperglycemia (RBG > 11mmol/L or 200mg/dL), with a venous PH <7.3 and/or HCO_3 < 15mmol/L and associated glycosuria, ketonemia and/or ketonuria. The severity of DKA was classified as mild (venous PH < 7.3 or HCO_3 < 15), moderate (venous PH < 7.2, HCO_3 < 10), and severe (venous PH < 7.1, HCO_3 < 5) [3,6].

Nutritional status was determined using the Body Mass Index (BMI)-for-age (kg/m2); underweight was defined as BMI-for-age < 5th percentile, normal weight as 5th-85thpercentile, and Obesity > 95th percentile of the National Centre for Health Statistics (NCHS) age and gender specific reference growth charts [22].

Socioeconomic status of the families was determined using the Revised Scoring Scheme for classification of socio-economic status, by Ibadin and Akpede [23]. The social class was determined by combining the highest educational attainment and occupation of the parents, and the mean of the four scores (2 for the mother and 2 for the father) to the nearest whole number was the social class assigned to the family. Social classes 1-2, 3-4, and 5-6 were considered as upper, middle and lower socioeconomic classes respectively.

2.1 Data Analysis

The data obtained from the case files were analysed using the Statistical Package for Social Sciences (version 23, IBM Corp, USA). Descriptive analysis such as the mean, median, and standard deviation (SD) was done. Continuous variables were tested for normal distribution using Shapiro Wilk test. Normally distributed variables were presented as mean ± SD, while skewed data were summarised using median and range. Categorical variables were presented as frequency and percentages.

3. RESULTS

A total of 10(62.5%) out of 16 children with T1D had DKA at some point in their management over the 10-year study period. Nine (90%) of them were managed during the latter five years of review between 2015 and 2020. Five children had normal weight and five were underweight. No child was overweight or obese. The mean duration of diabetes from time of diagnosis till point of review/ last DKA episode was 2.55 ± 2.51 (0.08-7.00) years.

3.1 Socio-Demographic Characteristics of the Study Population

Of the 10 children with DKA, 8(80%) were males with male to female ratio of 4:1. Nine (90%) children were ≥ 10 years, out of which 5(50%) were aged 13-14 years. The mean age ± SD at diagnosis of T1D was 11.1 ± 3.41years with a

range of 5-14 years. Seven (70%) children were Hausa's by tribe, 9 (90%) resided within Sokoto metropolis and 8(80%) were from lower socioeconomic class families. As depicted in Table 1.

3.2 Pattern of Presentation, Frequency, and Precipitating Factors of DKA in Children

Four (40%) patients were newly diagnosed at the time of review whilst 6 (60%) were known diabetics (established T1D) with recurrent DKA. One episode of DKA each was recorded in 4 children (all newly diagnosed), 2 episodes each were recorded in 5 children and 3 episodes in 1 child. Overall 17 DKA episodes [(1×4) + (2×5) + (3×1) = 17episodes] were managed over the 10-year period of review giving an average frequency per child of 1.7(~ 2episodes).

Infection (80%) was the most common precipitating factor of DKA, and malaria constituted the majority of these (70%). As depicted in Table 2.

3.3 Duration of Symptoms and Length of Hospitalization of Children with DKA

The median duration of symptoms of all 10 children before presentation to our facility was 5 days (range 1-42 days) and the mean length of hospitalization was 9.4 ±6.2 days (range 3-21) days. The mean duration of symptoms prior to presentation in the newly diagnosed children was 26.25 ± 15.46 (range 5-42) days, whereas in those with established diabetes it was 5.17 ± 4.54 (range 1-14) days. This is depicted in Table 3.

3.4 Clinical Features of DKA in Study Population

Table 4 shows the clinical features of DKA in children studied. The most common symptoms were abdominal pain (90%), and polyuria (80%), while the most frequent signs were dehydration (100%), Kussmaul respiration (70%), and wasting (70%). The least common features were acetone breath and hypovolaemic shock (10% each).

3.5 Laboratory Parameters of Children with DKA at Admission

The mean RBG at admission was 23.28± 7.14 mmol/l (range 12.3-33.3mmol/l), mean serum HCO_3 was 14.11± 3.41mmol/l (range 10-21mmol/l), and mean venous PH was 6.96± 0.06 (range 6.92-7.00). Eight (80%) children had mild DKA while 2(20%) had severe DKA. The mean

Table 1. Socio demographic characteristics of study population

Variables	Frequency (Total no=10)	Percentage (%)
Age at DKA episode (years)		
<10^	1	10
10-15	9	90
Age at diagnosis of diabetes (years)		
5-7	2	20
10-11	3	30
13-14	5	50
Gender		
Male	8	80
Female	2	20
Place of domicile		
Sokoto metropolis	9	90
Kebbi (semi-urban)	1	10
Tribe		
Hausa	7	70
Fulani	2	20
Igbo	1	10
Socio-economic Status		
Upper class	0	0
Middle class	2	20
Lower class	8	80

Mean age at diagnoses of T1D= 11.1 ± 3.41years, ^ 6 years old

Table 2. Pattern of presentation, frequency and precipitating factors of DKA in children

Variables	Frequency (percentage)
DKA episodes studied	
Newly diagnosed T1D	4 (40)
Established T1D	6 (60)
DKA present at diagnosis of T1D	
Yes	9 (90)
No	1 (10)
Frequency ofDKA episodes^	
One	4 (40)
Two	5 (50)
Three	1 (10)
Precipitating factor	
Infection	8 (80)
o Malaria	7 (70)
o UTI	1 (10)
Insulin omission	1 (10)
Unidentified	1 (10)

^Interval between DKA episodes ranged from 6 to 72 months

Table 3. Duration of symptoms and length of hospitalization of children with DKA

Duration (Days)	Newly diagnosed (no=4)	Established T1D (no=6)	All (no=10)
		Mean ± SD (range)	
Symptoms	26.25 ± 15.46 (5-42)	5.17± 4.54 (1-14)	*13.6± 14.48 (1-42)
Hospitalization	12.50 ± 6.35 (6-21)	7.33± 5.65 (3-18)	9.4± 6.2 (3-21)

**Median duration of symptoms in children with DKA was 5 days; range (1-42) days; (Shafiro Wilks test value = 797, df = 10, P = 0.013)*

Table 4. Clinical features of DKA in study population

Clinical features	No (%)		No (%)
Symptoms		**Signs**	
Abdominal pain	9 (90)	Dehydration	10 (100)
Polyuria	8 (80)	-Mild	0 (0)
Vomiting	7 (70)	-Moderate	5 (5)
Fast breathing	7 (70)	-Severe	5 (50)
Polydipsia	7 (70)	Hypovolaemic shock	1(10)
Altered consciousness	7 (70)	Kussmaul respiration	7(70)
Weakness	6 (60)	Wasting	7 (70)
Weight loss	3 (30)	Fever (T>37.5oC)	3 (30)
Fever	3 (30)	Acetone breath	1 (10)
Polyphagia	2 (30)		
Diarrhoea	1(10)		

serum sodium was 132.94 ± 13.53, potassium; 5.3± 1.2, urea; 11.3± 4.3 mmol/l and creatinine; 1.5± 0.9 mg/dL. As depicted in Table 5.

3.6 Outcome of Management of DKA

All the patients were managed in the Emergency Paediatric Unit (EPU) of the hospital. They all received appropriate treatment which included intravenous fluid resuscitation, insulin infusion (which was changed to subcutaneous insulin after resolution of DKA) and potassium supplements, according to the International Society of Paediatric and Adolescent Diabetics (ISPAD) treatment guidelines [3].

One (10%) patient had clinical features suspicious of cerebral oedema in the course of treatment (deteriorating consciousness level after an apparent improvement); was treated with

Table 5. Laboratory parameters of children with DKA at admission

Blood parameters	Mean (SD)	Min	Max	Urine parameters	No (%)
Glucose (mmol/l)	23.28 (7.14)	12.30	33.30	Glucosuria	
HCO3	14.10 (3.41)	10.00	21.00	1+	1(10)
Sodium	132.90 (13.52)	113.20	153.20	2+	3(30)
Potassium	5.30 (1.19)	3.90	7.60	≥ 3+	6(30)
Chloride	96.95 (9.70)	83.00	110.00	Ketonuria	
Urea	11.30 (4.30)	5.90	21.80	*nil	1(10)
Creatinine (mg/dl)	1.48 (0.87)	0.70	2.90	1+	1(10)
^Venous PH	6.96 (0.06)	6.90	7.00	2+	5(50
Total WBC (cells/µl)	14.10 (6.21)	4.70	23.20	3+	3(30)

** The patient with absent urine ketones also had Acute Kidney Injury*

^ Venous PH was available only in two patients who had a normal serum HCO3 which was incompatible with the degree of clinical acidosis.

intravenous mannitol and recovered. Similarly, one (10%) patient had clinical and laboratory features of Acute Kidney Injury (AKI; defined as an acute decrease in glomerular filteration rate leading to elevated serum creatinine and decrease urinary output) He was managed conservatively and recovered. No patient received sodium bicarbonate.

There was no mortality. All the patients were discharged on subcutaneous insulin (9 patients on free mix twice daily regimen of regular and intermediate insulin, and I patient on pre mix 70/30 insulin), and were being followed up in the paediatric endocrinology clinic as at the time of review.

3.7 Availability of Glucose Meters and Self-Monitoring of Blood Glucose

All the children had their personal blood glucose meters procured before discharge, their parents and/or caregivers alongside with the children were taught how to use the glucose meter, and record the glucose reading in a book. They all monitored their blood glucose at least twice daily at home either personally or assisted by parents/caregivers and all had glucose readings recorded in exercise books which were brought along to clinic during follow up. Insulin was available most times for free, through donations from non-governmental organizations (life for a child) especially in the latter five years of review (2015-2020). The parents/caregivers procured insulin whenever free insulin was exhausted.

4. DISCUSSION

In this 10-year retrospective review, diabetic ketoacidosis was seen in 62.5% of children with T1D, comprising of both newly diagnosed and children with already established diabetes. A similar rate of DKA was reported in an earlier study in our centre done almost a decade ago but amongst newly diagnosed diabetic children only [21]. This shows that DKA remains an important and common complication of T1D, which may occur at the onset of diabetes or anytime during the course of the disorder. In the context of evolving type 1 diabetes, DKA is frequently an indicator of diagnostic delay, whereas in the context of established diabetes, DKA is indicative of either insulin omission, poor metabolic control or sub optimally managed inter current stress episodes [24]. The end result of which is profound insulin deficiency, which leads inevitably to poor peripheral glucose uptake, unrestrained hepatic glucose production, proteolysis and lipolysis. The resultant intracellular starvation is accompanied by counter regulatory hormone (“Stress”) response with increasing levels of glucagon, epinephrine, cortisol and growth hormone, exacerbating the hyperglycaemia and ketogenesis. The impact of these hormonal abnormalities is resultant hyperglycemia with osmotic diuresis and dehydration, when intake of fluids fails to match losses, progressive ketosis and ketoacidosis; as insulin deficiency fails to suppress lipolysis [25].

More than three-quarter of the children with DKA were males; similar to the reports from India [26] and Ethiopia [19]. However, the majority of other studies reported female preponderance [5,14,17,24,27]. The reason for this disparity in gender is not clear but could be because infection was a major triggering factor of DKA in our study, similar to the Indian [26] and Ethiopian study [19]; given the biological and genetic vulnerability of males to infection [28], which also tends to be severe in them, thus resulting in infection-caused inflammation, pro-inflammatory

cytokine release, and counter-regulatory hormones that lead to insulin resistance/deficiency and metabolic deterioration to DKA [25]. It could also, to some extent, be attributed to the higher societal value for male children in the study area, which has a positive impact on health seeking behaviour, and to a little extent, related to the gender distribution of the T1D population in our unit; wherein males were slightly more than females. Bui et al. in Melbourne, Australia [24], attributed the female preponderance reported in their study to a greater likelihood of family conflict and behavioural problems, and a greater likelihood of weight reduction associated with insulin omission in females with T1D. Their conclusion was supported by their findings of a female: male ratio amongst the newly diagnosed T1D (with DKA) of closer to an equal sex distribution, and the number of admissions involving females with recurrent episodes of DKA being almost double that of males.

Majority of our study population were adolescents aged 10-15years, in agreement with reports from Nigeria [10,29], other African countries [1,19] and Asia [5,26,27], probably because majority of our study population were 10 years and above at the time of diagnosis of T1D and they either presented with DKA at time of diagnosis or at a later time, thus diabetes was more frequently diagnosed in adolescents than younger children in our series and this also applies to DKA, a complication of T1D.

The stress of puberty and the insulin antagonizing effect of pubertal and growth hormone contributes to the progression to DKA in the adolescent age group. It is also possible that adolescents pay less attention to their symptoms and present to the hospital at a later stage with metabolic deterioration. Our finding of adolescents' preponderance however, is contrary to those of some previous researchers who reported that DKA was more common in younger ages [7,19]. The reasons proffered by them include difficulty in recognizing excessive urination in toddlers who are in nappies and difficulty of the young age group to ask for water; unawareness and lack of knowledge by parents and health care providers about the signs and symptoms of diabetes in younger children, and the fact that the classic symptoms of diabetes may not be obvious or may be difficult to differentiate from acute common infections, in addition to a more rapid beta cell destruction at younger age [30,31]. It is worthy to note that the previous studies in which DKA was commoner in younger children were conducted on only the newly diagnosed T1D children in contrast to current study. It seems that, the higher the incidence of DKA in younger children, the lower the mean age at diagnosis of T1D [17].

Majority of our study population were from lower socioeconomic class, in consonant with the reports from Enugu [14], and Ife [18], South- East and South-west, Nigeria respectively. The latter study reported an inverse relationship between socioeconomic class and the frequency of DKA. The current study supports this earlier report. A likely explanation for this is that lower parental education achievement and lower income of the family which both reflects socioeconomic status, negatively impacts on the health seeking behaviour of the family, particularly in an environment such as we have, where there is lack of health insurance in most families, and patients pay out- of- pocket; this leads to late presentations when the children have already deteriorated to DKA. This finding may also be a reflection of the socioeconomic status of the environment in which the study was conducted.

Our finding of a longer mean duration of symptoms before admission (three and half weeks) in the newly diagnosed children compared to five days in children with established diabetes who had recurrence of DKA, could be attributed to delayed presentation and/or late referral, delayed diagnosis and/or misdiagnosis by previously visited health workers. For instance abdominal pain may be misdiagnosed as acute abdomen or UTI, fast breathing as pneumonia and altered consciousness as cerebral malaria, particularly in the new onset diabetes. Similarly, the mean length of hospital stay in the newly diagnosed children (12 days) was longer than that of children with established diabetes (7 days), probably because of the time taken to stabilize blood glucose after commencement of subcutaneous insulin with meals, other likely reasons include the several sessions of diabetic education and counselling (including nutritional counselling), that is usually given as a routine for all newly diagnosed diabetic patients and their families after resolution of DKA, and before discharge in our facility. The patient and/or parents needed to be able to give insulin injections correctly before discharge. Also, due to a low literacy rate, it took long to teach them the injection technique and storage of insulin and to be certain that the parents were able to manage

the child at home. The finding of shorter length of hospitalization in the known diabetics is not surprising, because the patients/families were already aware of the diabetes, with knowledge of the symptoms, thus there was a tendency to seek medical attention earlier than when they were unaware of diabetes. Early presentation, diagnosis, and prompt treatment therefore, in a centre with specialists trained/experienced in managing childhood diabetes and DKA, is pertinent to reducing length of hospital stay and adverse outcome in children with DKA.

The clinical features observed are similar to those reported in studies from Nigeria [10,11,14,17], other parts of Africa [1,19], and Asia [5,26,27], with only slight differences, particularly in the order of frequency. Whilst abdominal pain was the commonest symptom in our study, similar to a study in Himalayan, North India [26], polyuria [5,10,14,18], respiratory distress [19,27] and vomiting [27], were the commonest symptoms reported from studies within{10, 14, 18} and outside Nigeria [5,19,27]. Most of the Nigerian studies [10,14,18] set out to study DKA in the newly diagnosed T1D patients. This may explain why polyuria was the commonest presenting symptom of DKA seen in these studies, more so that previous authors had reported polyuria, as being commoner in the newly diagnosed T1D children with DKA compared to those with established diabetes with DKA [27].

The mechanism for abdominal pain in DKA is multifactorial and includes hyperglycemia mediated impaired gastrointestinal motility (oesophageal, gastric, and gallbladder), rapid expansion of the hepatic capsules, mesenteric ischemia precipitated by volume depletion [32]. It has been reported that prevalence of abdominal pain increases as arterial PH and serum bicarbonate decline [32]. It is worthy to note that more than three quarter of our study population presented with polyuria, and a little less than three quarter, with polydipsia, therefore classical symptoms of polyuria and polydipsia may not be volunteered in a few cases of DKA and would have to be sought for. More than two third of the children presented with vomiting and altered consciousness, this results from metabolic acidosis. Some researchers [32] reported that the degree of altered consciousness was strongly associated with the degree of acidosis, while others have raised concerns of remarkable discrepancy between clinical and laboratory findings of patients [31]. The latter group of researchers [31], found a quarter of children in their study population with severe dehydration and impaired consciousness having normal arterial PH of 7.3 or more, and one-fifth of the children with PH < 7 who were considered to have normal consciousness and only mild dehydration. They did not assay serum bicarbonate. This reported discrepancy was somewhat similar to our observation, although the discrepancy we observed was between serum bicarbonate levels, and clinical symptoms of acidosis; as we found normal levels of serum bicarbonate in one-fifth of study population who had symptoms compatible with acidosis such as vomiting, abdominal pain, kussmaul respiration, altered consciousness and moderate/severe dehydration, whereas a concurrent venous PH done in these children revealed severe acidosis (PH<7.1). Based on this observation, we suggest that where feasible, both serum bicarbonate and venous PH be done to document acidosis in children with DKA. It would be worthwhile for future studies to investigate the association/ correlation of venous PH, serum bicarbonate and clinical features suggestive of acidosis in children with DKA.

It is not clear why acetone breath was one of the least common features of DKA in current study, although similar observation was reported by Ndu et al in Enugu, south east, Nigeria [14]. There is however, a likelihood that the attending doctors in the emergency room were unfamiliar with the characteristic fruity odor of acetone which may have resulted in its low documentation or because the majority of the patients studied had mild ketoacidosis; since acetone is formed by the non enzymatic conversion of acetoacetate; one of the ketone bodies [2].

Our finding of good outcome could be related to the fact that all the patients had the benefit of being managed by a trained specialist in the field of paediatric endocrinology/ diabetes, and more than three-quarter of them had mild DKA. This is in addition to the availability of Non Governmental Organisation NGO-donated insulin, particularly during the latter half of the review period wherein more cases were seen, probably as a result of increased awareness.

We reported a small number of children with DKA, though, a total of 17 episodes of DKA were managed in these children over the study period. `It is expected that the findings from this study would create awareness on the pattern of

presentation and outcome of DKA in children in our environment and aid prompt recognition and diagnosis of the condition. The study highlights the importance of early presentation and/or referral, and the appropriate treatment of children with DKA according to standard treatment guidelines. It also brings to light the need for continued awareness creation on recognition of T1D and DKA in children, through education of all health care providers, at all levels within the community, as well as the need for specialized training of health care providers (doctors and nurses) in the care of diabetic children. This would help build a strong diabetic team, pertinent to maintaining a good management outcome of DKA in our facility and similar environs in sub-Saharan Africa, where the burden of infectious diseases is overwhelming and less attention is given to endocrine diseases like childhood diabetes by the health sector and policy makers. It is essential for hospitals to adopt a workable treatment guideline in the management of DKA in children.

5. CONCLUSION

In conclusion, DKA is common in male adolescents from lower socioeconomic class families with a good management outcome in UDUTH, Sokoto. Abdominal pain, polyuria, dehydration, and Kussmaul respiration were the most frequent presenting features. A high index of suspicion of DKA is recommended in any child, particularly, male adolescents with the aforementioned features. Effort should be made to confirm diagnosis quickly and prompt treatment instituted and/or appropriate referrals made to centres having specialists with expertise in management of DKA and diabetes in general.

6. STUDY LIMITATIONS

The major limitation of this study was the small number of children studied. This would not allow for strong statistical inferences. Secondly, the retrospective nature of the study is prone to recall bias, misclassification bias and incomplete data. Despite these limitations, this study has highlighted the clinical profile of the children with DKA, which may not be significantly different, were the sample size larger.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Approval for the study was obtained from the Research and Ethics Committee of the Usmanu Danfodiyo University Teaching Hospital, Sokoto (UDUTH/HREC/2018/No 667)

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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