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Case Series

Type 1 diabetes mellitus in the pediatric age group: a case series

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ABSTRACT

Diabetic ketoacidosis is the common initial presentation of type 1 diabetes mellitus in children. In a series of five cases of Type 1 diabetes mellitus who presented in the department of Pediatrics of our hospital, four children presented in the emergency department with diabetic ketoacidosis and severe dehydration. At the time of presentation, all the cases with diabetic ketoacidosis were managed according to the Milwaukee regimen as per the department protocol. None of our children developed any complications, including cerebral edema, during the treatment of diabetic ketoacidosis. The age distribution at the onset of Type 1 diabetes mellitus in our case series ranges from 1 year to 13 years. All the cases showed low c-peptide levels, high Anti- GAD antibodies and high HbA1c levels at the time of presentation. One of our cases also has celiac disease, hypothyroidism and hypercholesterolemia. One child was diagnosed to have hepatitis A infection during the hospital stay for the management of first episode of diabetic ketoacidosis, and another child developed hepatitis A infection after 2 years of diagnosis of type 1 diabetes mellitus. The child who developed hepatitis A infection later also had multiple admissions, once for non-compliance with hyperglycemia and once for an abscess with cellulitis in the neck. In one case, despite the child being clinically well and having normal growth and development, blood sugar levels are uncontrolled despite being on the maximum dose of human actrapid and glargine. Of all these cases, two are on regular insulin in the form of human Actrapid and basal insulin in the form of glargine, two are on regular insulin in the form of glulisine and basal insulin of degludec, and one is on insulin pump therapy with insulin lispro and a continuous glucose monitoring machine. All 5 children are on regular follow-up in the hospital for monitoring of growth and development, screening for complications, and optimal glycemic control.

Keywords: Type 1 diabetes mellitus, Diabetic ketoacidosis, Milwaukee regimen, Insulin pump therapy, HbA1c, Anti-GAD antibodies, Hepatitis A infection

INTRODUCTION

Type 1 diabetes mellitus is an autoimmune condition that affects pancreatic beta cells, leading to insufficient insulin production and clinically manifests as hyperglycaemia. The most common initial presentation of type 1 diabetes mellitus in the paediatric population is diabetic ketoacidosis, requiring intensive care management.[1,2] There may be a history of polyuria, polydipsia, and weight loss for days to months. In such cases, differential diagnoses like salicylate toxicity, pheochromocytoma, diabetes insipidus, hyperthyroidism, and pneumonia need to be ruled out. A few of the children can present with the smell of ketones, dehydration, abdominal pain, Kussmaul breathing, vomiting, and an altered mental status. Initial hospital management of diabetic ketoacidosis particularly in children presenting with altered sensorium, is challenging and requires meticulous monitoring. Subsequent management of such children requires insulin replacement and intensive effort by the healthcare providers, family members, and the patient for optimal growth and development of the child. Treatment is directed towards maintaining near normoglycemia while

simultaneously minimizing the risk of hypoglycaemia. With proper care and support, children and adolescents with type 1 diabetes can expect to lead long and fulfilling lives. The follow-up strategy in the hospital includes review of blood glucose monitoring charts maintained at home, HbA1c levels to check for glycaemic control over the last 3 months, thyroid and other endocrine function evaluations. Screening for celiac disease, hypercholesterolemia, renal function tests for nephropathy, ophthalmic examinations for cataracts and retinopathy, and neurological evaluations for neuropathy also need to be done.

Authors present a series of five cases of type 1 diabetes mellitus that presented in the department of paediatrics of our hospital, and the detailed management and follow-up to date.

Case 1

A one-year-old female child was brought to the emergency department with complaints of fever and rapid breathing. On examination, the child was sick-looking, dehydrated, and tachypnoeic with a respiratory rate of 56/min. She was not responding well to verbal commands and was irritable. The family had a recent visit to a coastal area in Gujarat for vacation, where the child developed the above symptoms and was rushed to the emergency department.

Clinical examination of the child revealed a heart rate of 126/min (tachycardia) and low blood pressure (less than the 50th centile). Respiratory system examination revealed vesicular breathing without any adventitious sounds. Cardiovascular system examination was otherwise normal. The gastrointestinal system was also normal. The nervous system examination revealed the child to be drowsy, without any meningeal signs. Given this, HGT was done immediately, which revealed RBS 460 mg/dl. The urine dipstick test also suggested glucose 2+ and ketones 4+. A chest X-ray was done later on, which was normal. On leading questions, the mother gave a history of polyuria, polydipsia, and polyphagia for the last one and a half months. A diagnosis of diabetic ketoacidosis was made and later on confirmed by laboratory values of blood sugar at 420 mg/dl and large ketones in the urine.

The child was managed in the PICU with the Milwaukee regimen and regular insulin infusion, which was titrated according to blood sugar levels. The child improved clinically after around 48 hours, and she was switched over to subcutaneous regular insulin. Further investigations revealed the child to have celiac disease and hypothyroidism. The child also had hypercholesterolemia. The child was on regular insulin injections of human Actrapid and basal insulin of injection glargine subcutaneously and was well controlled with glucose monitoring at home and HbA1c measurements on follow-ups. The child was also on a gluten-free diet, tablet thyroxine, and statins. At 8 years of age the child was shifted to insulin pump therapy, which is a sensory augmented automated hybrid closed-loop (AHCL) device, and the monitoring is done by a glucose monitoring sensor. The child is well controlled with continuous glucose monitoring and is on insulin lispro.

Case 2

A 13-year-old male child, 3rd by birth order, was brought by his parents in a semiconscious state with complaints of fever for 2 days, headache for 1 day, restlessness, and abnormal breathing for a few hours. On examination, the child was semiconscious and had an altered sensorium. Vital parameters: HR-150/min, RR-34/min deep breathing (Kussmaul breathing), saturation-99%, blood pressure-118/78 mmHg on left upper arm. Initial investigations revealed HGT- 497 mg/dl, serum ketones-5.8 mg/dl, urine ketones +4, urine glucose +1, ABG- pH-6.88, pCO2- 21.8, po2- 42.4, and Hco3- 3.9.

Therefore, the diagnosis of diabetic ketoacidosis (DKA) was established. Management started with IV fluids as per the Milwaukee regimen and short-acting insulin infusion, along with serum electrolyte correction. The resolution of symptoms was obtained 48 hours after starting therapy. Oral administration was then initiated, along with subcutaneous basal insulin (long-acting and rapid-acting insulin boluses). C-peptide levels were low, and GAD antibody levels were high. The child was admitted 1 month later, on 11 September 2021-13 September 2021, in view of poor compliance. Blood sugars were monitored, and insulin (human Actrapid) and injection (Lantus) were adjusted, and they were discharged with advice.

The next admission was on 28 January 2023-7 February 2023 with a complaint of swelling in the cervical region, which was clinically looking like an abscess, in which ultrasonography was suggestive of subcutaneous edema in the cervical region with a provisional diagnosis of cellulitis. Incision and drainage of the abscess was done, and the pus culture was positive for Staphylococcus aureus. Injection of cefotaxime was given for 10 days, and insulin dosages were increased and adjusted. The child was admitted again on 11 July 2024-25 July 2024 for generalized weakness with vomiting with decreased appetite, constipation, and low-grade fever. He was diagnosed with a hepatitis A infection. The patient was given symptomatic treatment and improved. The child was switched to injection lispro in place of human Actrapid in view of erratic food habits and inability to follow the 30 minutes prior regular insulin dose before food. Basal insulin glargine was continued at night.

Case 3

A 6-year-old male child was brought by his parents in December 2022 with complaints of fever for 2 days,

vomiting for 2 days, and decreased oral intake for 2 days. On examination, HR is 110/min and RR is 24/min. PP: Well-felt and mild dehydration present. The rest of the systemic examination was normal. The child started on maintenance IV fluids. Routine blood investigation revealed a CRP of 1.2 (positive), and the urine routine was suggestive of sugar 4+. The random blood sugar level was 320 mg/dL (incidental finding). Given the hyperglycemia, high HbA1c (10.4), and high fasting and postprandial blood sugar levels, a detailed diabetes mellitus workup was done.

The IgA anti-TTG antibody was negative, and hence, celiac disease was ruled out. The C-peptide level was 0.61 ng/ml (significantly low). The GAD 65 level was 25.02 IU/ml, which was high. The child was started on insulin therapy with regular insulin (human Actrapid) and basal insulin (injection glargine). The child was discharged on injection of human Actrapid 2 IU three times a day 30 minutes before meals and injection of Lantus (glargine) 6 IU at bedtime. 5 months later, the child was readmitted for uncontrolled blood sugar levels, and doses of insulin human actrapid were increased to 4U-8U-4U 30 minutes before each meal, and the dose of insulin glargine was 6 IU at bedtime. Blood glucose monitoring of the child at home revealed uncontrolled blood sugar levels, and the subsequent level of HbA1c was 9.6. The dose of injection glargine was increased to 10 IU at night, and the dose of insulin human actrapid was kept the same.

On follow-up visit, HbA1c (10.4) was poorly controlled, and the dose of insulin Actrapid and glargine was increased, and the patient was advised for follow up. On the follow-up date of 17 June 2025, the child is planned to be shifted to injection glulisine and degludec in view of uncontrolled blood sugar levels despite being on the maximum dose of insulin of human Actrapid and Lantus.

Case 4

One four-year-ten-month-old male child was brought by his mother to the emergency room in the department of Pediatrics with complaints of fever, lethargy, weakness, and decreased oral intake for 7 days. On leading questions, the mother gave a history of polyuria and polydipsia for 8 days and a history of weight loss for the last 2 months. The child is the only child and was reared by a single parent and had a history of two episodes of hospitalization in the past, in February 2023 for pneumonia and October 2023 for acute gastroenteritis. Anthropometric measurements of the child revealed weight below the 3rd percentile and height in between the 90th and 97th percentiles. Clinical examination of the child reveals a sacral dimple and slightly large ears; he was conscious but lethargic. He was febrile, and the low-grade fever continued for 8 days. There was some dehydration. The HGT on admission was 309 mg%, and the laboratory value was 677 mg% on admission. The VBG suggested mild metabolic acidosis with a pH of 7.309 with bicarbonate 13 mEq/l. The urine examination revealed glucose 2+ and ketones 2+. Urine protein was negative. Cardiovascular system examination was normal. Routine blood investigations revealed neutrophilic leukocytosis with hyponatremia (119 mEq/l) and hyperkalemia (5.23 mEq/l). Fever profiles for malaria parasite & PLDH, dengue NS1 & IgM, and Salmonella Typhi IgM card tests were negative. BUN and serum creatinine were normal. Serum bilirubin on day 1 of admission was 0.89 mg/dl. Serum alkaline phosphatase was slightly on the higher side (473.79 U/l). Serum ALT and AST could not be measured due to lipemic serum.

Hepatitis A IgM was reactive, Sr. Albumin was 2.6 gm/dl, and total protein was 4.9 gm/dl. Serum cholesterol was normal. Prothrombin time was 12.5/11.4 seconds, aPTT was 38.2/29 seconds, and INR was 1.1. The thyroid function test was normal, and anti-tTg-IgA was negative. The child was managed as per the Milwaukee regimen with a normal saline bolus and subsequent maintenance and intravenous insulin (human Actrapid) infusion at 0.1 U/kg/hr. The clinical improvement in the form of improved activity, sensorium, and decrease in the respiratory efforts was observed within 18 hours in our child. The child was shifted to subcutaneous insulin therapy after 40 hours of admission when the child started taking food orally.

Case 5

A four-year-old female child was admitted in January 2024 for pain in abdomen for 2 days, multiple episodes of vomiting, fever, rapid breathing and poor oral intake for 1 day. On examination HR- 160/min (tachycardia), RR- 28/min irregular breathing SPO2-95% with no adventitious sounds and child was conscious but irritable and lethargic with rest of the systemic examination being normal. Initial investigations revealed: HGT- 560 mg/dl, urine ketones +4, urine glucose 5+, VBG- pH- 6.9, pCO2- 19, po2- 34, and Hco3- 3.8 HbA1c- 10.2

On leading questions mother gave history of polyuria and polydipsia for 6 months. Diagnosis of diabetes ketoacidosis was made and child started on diabetes ketoacidosis management; iv fluids started as per Milwaukee regimes and regular insulin infusion along with electrolytes correction. After 48 hours when child was stable switched to subcutaneous insulin injection glulisine (rapid acting) 3units-2 units-2 units before each meal and degludec (long acting) 5 units at bed time. GAD antibody was low and celiac work up was negative.

In December 2025, the child had an upper respiratory tract infection took OPD treatment for same and dose of insulin glulisine was increased to 5units-5units-3 units before each meal and insulin degludec 7 units at bed time. On subsequent follow up HbA1c lowered and blood sugar monitoring at home shows-controlled blood sugar levels.

Table 3: Comparison of laboratory values and clinical presentation in the case series (n=144).

Case	Glycemia (mg/dl)	Hba1c (%)	Serum C-peptide levels ng/ml	Blood insulin (µui/ml)	Anti-GAD antibodies	Glycosuria	Presentation at diagnosis	Summary of the cases	Age at diagnosis and years of follow-up	Years of follow-up	Hba1c on last follow-up
1	460	10.6	0.86	1.4	High 66	positive	ketoacidosis	The presentation of diabetic ketoacidosis was at 1 year of age, and the child is also diagnosed with coeliac disease, hypothyroidism, and dyslipidemia. Initially child was on Lispro and the glargine. Currently child has been on an insulin pump with a CGM device for 7 years and is well controlled	1 year	12 years	8.10%
2	497	11.8	0.19 low	1.3	high- 72	positive	ketoacidosis	Repeated history of admission twice for non-compliance with hyperglycemia and once for cervical region abscess, and once for hepatitis A infection	13 years	5 years	9.40%
3	320	10.4	0.11 low	4.3 normal	high-25	positive	incidental detection of hyperglycemia	The child is clinically well with normal growth and development. However, the blood sugar levels are uncontrolled despite being on the maximum dose of human actrapid and glargine. The child is planned to be switched to glulisine and degludec and followed up.	6 years	4 years	10.40%
4	677	14.17	0.96	0.9	High- 36	positive	ketoacidosis	During the first admission, while being treated for ketoacidosis, the child developed hepatitis A infection. The child was admitted once for symptomatic hypoglycemia and is currently having early morning hypoglycemia despite being on minimum dosage of regular insulin and glargine.	4 years 10 months	1 year	8.80%
5	560	10.2	4.6	28.2	normal-8.45	positive	ketoacidosis	The child is well controlled with injection glulisine and degludec.	5 years	1 year	9.30%

DISCUSSION

Of the 5 patients of type 1 diabetes mellitus, 4 children presented to the emergency department of Pediatrics with diabetic ketoacidosis, which is the common initial presentation of type 1 diabetes mellitus in children.[1] Diabetic ketoacidosis is the most severe presentation of type 1 diabetes mellitus, which is characterized by hyperglycemia with metabolic acidosis and severe dehydration due to total or near-total insulin deficiency. All 5 children in our case series presented with severe metabolic acidosis with severe dehydration, and hyperglycemia. All of them had glucosuria and ketonuria. At the time of presentation, all of them had fever, acidotic breathing, and altered sensorium.

As per our institutional protocol Milwaukee regimen was followed for the treatment in all the cases, which includes a normal saline bolus of 20 ml/kg, and simultaneously, regular insulin infusion was started in a separate intravenous line at the rate of 0.1unit/kg/hour. Blood investigations were sent as per protocol, along with venous blood gas analysis. Continuation of intravenous fluids was done with 0.45% saline as per regimen.[2] As per guidelines, injection potassium chloride was added to intravenous fluids at 20 meq/500 ml, which was continued for 48 hours, which is similar to ISPAD guidelines.[3]

Persistent hypokalaemia was observed in case 2 even after 48 hours of injectable potassium correction; oral potassium was continued for another 3 days. Serial venous blood gas analysis was performed every 24 hours, which showed improvement in acidosis after 48 hours, along with an increase in serum bicarbonate levels. All the cases showed clinical improvement after 48 hours of admission and hence were switched to subcutaneous regular insulin. Basal insulin was started on day 5 of admission in the ratio of 40:60 and the doses were titrated as per the blood sugar monitoring chart done before and after breakfast, lunch, dinner and early morning. All the cases were also investigated for thyroid functions and celiac disease to rule out the most common associated autoimmune disorders.[4] All cases were discharged home after proper training of the method of insulin administration to parents, adequate nutritional counselling, advice for regular exercise and detailed explanation of the signs and treatment of hypoglycemia at home. They were also taught to maintain records of blood sugar monitoring at home.

Case 1 is on insulin lispro, case 2 and 5 are on insulin glulisine and degludec and case 3,4 and are on insulin human actrapid and glargine.[5-7] Case 4 developed Hepatitis A infection in the 1st admission during the management of Diabetic Ketoacidosis and Case 2 developed during the follow-up period after 2 years of initial presentation of Type 1 DM. The association of hepatitis A with type 1 diabetes mellitus is a matter of research.[8] Follow-up of these children consisted of an assessment of home monitoring blood sugar levels charts, 3 monthly HbA1c levels, celiac workup up and thyroid function test annually.

The HbA1c levels in the latest follow-up of all these children are: Case 1- 8.1 %, Case 2 - 9.4 %, Case 3 - 10.4 %, Case 4 -8.8 %, Case 5 – 9.3 %, Case 6 – 8.2 % which is comparable and fair control.[9,10] The reason for poor control in case 3 is likely to be due to intermittent snacking, decreased physical activity.

The insulin dosage for this child has been stepped up to 1.02 units/kg and will be followed up regularly with advice for increased physical activity and dietary modifications. Subsequent meticulous follow-up of all these 5 children will be done for growth and development, and meticulous screening will be done for complications, if any, due to type 1 diabetes mellitus.

CONCLUSION

Diabetic ketoacidosis is the common initial presentation of type 1 diabetes mellitus in children. Meticulous initial management of diabetic ketoacidosis following the Milwaukee regimen brings out an optimal outcome. The subcutaneous insulins of various types provide comparable outcomes. The management outcome with insulin pump therapy and multiple doses of subcutaneous insulin administration is comparable. The active involvement of the parents in preparing the diet, proper insulin administration, and motivation for the physical exercise is the cornerstone of the management of type 1 diabetes mellitus, which is reflected in follow-up, clinical examination, and investigations of such children in the hospital. High levels of anti-GAD and low c-peptide levels are consistently positive in our case series. Haemoglobin A1c is a very good indicator of optimal control of type 1 diabetes mellitus in pediatric patients. Multicentric studies of type 1 diabetes mellitus in children and long term follow up will further add to the experience and knowledge.

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