Hyperosmolar hyperglycemic syndrome in a young boy

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ABSTRACT

We describe a 6-year-old boy who presented to the emergency department with the complaint of nausea and vomiting with diarrhea. Workup revealed a glucose level of 1904 mg/dL, and hyperglycemic hyperosmolar syndrome was diagnosed. Hyperglycemic hyperosmolar syndrome is very rare in the pediatric population, but recent published reports suggest that the incidence of this disorder may be increasing.

KEYWORDS Hyperglycemia; hyperglycemic hyperosmolar syndrome; osmotic diuresis; type 1 diabetes mellitus

Diagnostic features of hyperglycemic hyperosmolar syndrome (HHS) include a serum glucose concentration of >600 mg/dL, a serum osmolality of >330 mOsm/kg, and the absence of significant ketosis and acidosis. HHS is associated with a high mortality rate and must be addressed and monitored adequately.¹ Children diagnosed with HHS are candidates for admission to intensive care units for frequent reassessment, because it is suggested that the pediatric population is at greater risk of cerebral edema secondary to rapid reduction in glucose levels.^{1–3}

CASE DESCRIPTION

A 6-year-old boy with a known history of reflux nephropathy, dysplastic kidneys, stage III chronic kidney disease, and up-to-date immunizations presented to the emergency department with multiple episodes of nonbloody, nonbilious emesis and multiple episodes of nonbloody, watery diarrhea. The symptoms began 2 days prior. The emesis had the appearance of nonbloody, nonbilious stomach contents. The patient denied back pain, fever, cough, abdominal pain, and sick contacts. The patient's mother did report a high glucose level at a recent nephrology appointment. The boy was in no distress. There was no abdominal distension, tenderness, rebound guarding, hernia, or hepatosplenomegaly. Initial laboratory evaluation showed a glucose level of 1904 mg/dL, a creatinine of 2.17 mg/dL, an anion gap of 13 mEq/L, and elevated alkaline phosphatase. Beta-hydroxybutyrate was also negative. Urinalysis was negative for ketones, and serum

osmoles were 349 mOsm/kg. In the emergency department, the patient received a total of 30 mL/kg normal saline over three boluses, and a subsequent metabolic panel revealed a glucose level of <1600 mg/dL. The patient was admitted to the pediatric intensive care unit for management of HHS and acute kidney injury.

Endocrinology recommended an antibody panel and slow correction of dehydration and hyperglycemia with 0.45% normal saline maintenance fluids without the use of insulin to avoid symptomatic cerebral edema. The volume deficit was replenished and the patient's glucose was lowered to the low 200s over 36 hours with a goal correction rate of 75 mg/dL/h. His fluids were transitioned to dextrose 10% in 0.45% normal saline. He was placed back on an oral diet, and subcutaneous insulin provided glycemic control. He had no more symptoms of diarrhea or nausea, and he was transferred to the floor. Parental education was provided for newly diagnosed diabetes mellitus 1 and the patient was discharged directly to the endocrinology clinic for further education and follow-up of antibody panel results.

DISCUSSION

In the 35 years since the first report of HHS in a child in 1966, 26 pediatric cases have been described, but from 2001 to 2008 65 cases were reported.^{4–6} HHS is the result of a critical deficit of insulin leading to profound hyperglycemia and a release of the counterregulatory hormones glucagon, catecholamines, cortisol, and growth hormone. This

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hormone response leads to increased hepatic glucose production, increasing plasma glucose levels. In HHS, insulin action may be inadequate to facilitate glucose utilization by insulin-sensitive tissues but sufficient for the prevention of lipolysis and ketogenesis.⁷ The estimated fluid losses in HHS are twice that in diabetic ketoacidosis; the long duration of osmotic water loss leads to severe electrolyte disturbances.⁸

Unfortunately, there are no prospective data to guide management of HHS in a pediatric patient. It is recommended that pediatric patients with HHS be admitted to the intensive care unit. The goal of fluid therapy is to increase intravascular volume.⁸ During initial volume repletion, declining serum osmolality may lead to fluid shifts from intravascular to extravascular spaces, and ongoing urinary loss may persist for hours; therefore, ongoing fluid replacement is recommended. A fluid deficit of 12% to 15% of body weight can be assumed in pediatric patients, and a 20 mL/kg normal saline bolus is recommended. Subsequently, 0.45% or 0.75% sodium should be administered over 24 to 48 hours.^{8–13} Use of hypotonic fluid is preferred, because adult studies suggest that use of isotonic solutions during osmotic diuresis may increase serum sodium concentration, because the urine sodium concentration is hypotonic in comparison to serum.¹⁴ Early insulin treatment in HHS is unnecessary and may increase mortality. A rapid decline in glucose concentration with the use of insulin may lead to cerebral edema as well as circulatory compromise. If glucose levels are declining <50 mg/dL/h, insulin therapy may be considered.⁵ When insulin treatment is begun, continuous administration at 0.025 to 0.05 units/kg/h can be used initially. Boluses are not recommended in the pediatric population. Electrolyte imbalances may be more profound in HHS than in diabetic ketoacidosis, so potassium levels should be checked and replenished immediately.⁹

Complications of HHS in pediatric populations include thromboembolic events, but prophylactic heparin is not well studied, and its use is not currently recommended.¹⁵ Rhabdomyolysis may occur, and screening for creatine kinase levels is recommended every 2 to 3 hours for early detection; if detected, a nephrology consult should be made.¹⁴ Malignant hyperthermia has been described, but a cause has not been identified; treatment with dantrolene is recommended in these cases.¹⁴

The incidence of HHS in the pediatric population has been increasing. Some key features such as rhabdomyolysis and malignant hyperthermia are complications that are exclusive to pediatric cases. Though studies in adults may suggest that abdominal pain and emesis are less common in HHS than in diabetic ketoacidosis, they have been reported in over half of pediatric HHS cases. This diagnosis should be considered in young, overweight children with intractable emesis. Familiarity of conservative fluid management in children with diabetic ketoacidosis may lead to inadequate rehydration in children with HHS. Increased education on the

differences in management of diseases will lead to improved outcomes.

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