Diabetic Ketoacidosis in Children

Description/Etiology

Diabetic ketoacidosis (DKA) is a life-threatening medical emergency brought on by severe insulin deficiency, which usually results in hyperglycemia (i.e., abnormally high blood concentration of glucose). The excess glucose in the bloodstream acts as an osmole (i.e., molecule that attracts water) and draws water from the cells into the bloodstream. To compensate, the kidneys excrete excess glucose entering the bloodstream through a process called osmotic diuresis. Along with glucose, the kidneys excrete water and electrolytes, leading to dehydration and electrolyte imbalances. (For general information and details of the pathophysiology of DKA see Quick Lesson About ... Diabetic Ketoacidosis in Adults).

The majority of patients presenting with DKA are under the age of 19. A major difference between adults with DKA and children with DKA is that children are particularly at risk for cerebral edema (CE), which is extremely rare in adults. The risk for CE is increased if hyperglycemia and dehydration persist for more than several hours. The exact cause of DKA-related CE is unknown, but it is likely that there are many factors involved. One theory is that brain cells produce intracellular osmoles in order to balance out the excess glucose in the blood and prevent water from being pulled out of the brain cells into the blood, which would result in dehydration of brain cells. Subsequent treatment involving rehydration causes a drop in blood glucose levels. As the blood glucose drops, water moves into the brain cells causing them to swell (i.e., CE). For this reason, rapid fluid administration is discouraged. Total fluid deficits should be replaced over a 48-hour period so that the total fluid intake for each 4-hour period is less than 50 ml/kg.

Other complications in children with DKA include hyper- or hypokalemia with arrhythmias, sepsis, acute respiratory distress syndrome, pneumonia, pulmonary edema, rhabdomyolysis, and alveolar rupture.

Treatment goals for the management of DKA in children include correcting dehydration and acidosis, reversing ketosis, reestablishing near normal blood glucose levels, identifying and treating precipitating events, and avoiding complications. In their 2011 clinical practice guidelines, the International Diabetes Federation (IDF) and International Society for Pediatric and Adolescent Diabetes (ISPAD) recommend the following: Water and salt replacement with 0.9% saline for at least 4–6 hours followed by 0.45% saline with added potassium; low dose I.V. insulin replacement to correct hyperglycemia; potassium replacement; and cautious administration of bicarbonate if deemed necessary.

Facts and Figures

DKA affects approximately 30% of children with new-onset diabetes mellitus (DM) and in those with diagnosed DM who omit insulin or do not manage comorbid illness. An estimated 18% of cases of DKA occur in patients under the age of 20 years. CE complicates 1% of episodes of DKA in children and adolescents, but remains the major cause of long-term disability and death related to DKA. Mortality rates in patients with CE approach 90%. Among children under the age of 10 years, DKA accounts for 70% of DM-related deaths.
Risk Factors
Risk factors for DKA in children include insulin dependence, recreational drug use (RDU), and mental illness, which can result in non-adherence and/or pharmacologically-induced hyperglycemia. The prevalence of DKA is higher in children diagnosed at a younger age, of a minority race/ethnicity, living in a home with a low household income, and without private insurance.

Signs and Symptoms/Clinical Presentation
Individuals with DKA usually present in the emergency department, although some are already hospitalized for another condition or present in the outpatient setting with early DKA. Signs and symptoms of DKA include polyuria, polydipsia, nocturia, nausea, vomiting, abdominal pain, change in appetite, weakness, malaise, sudden weight loss, blurred vision, headache, drowsiness, fruity breath odor, dry mucous membranes, Kussmaul respirations (i.e., rapid, deep, and sighing breathing), tachycardia, hypotension (or hypertension if renal function is severely impaired), hypothermia, fever (if an infection is present), and coma.

Assessment
› Physical Findings of Particular Interest
  • Assess for polyuria, polydipsia, sudden weight loss, fruity breath, and dehydration
  • Assess for level of consciousness (LOC) and for infection
  • Obtain a medical and family history with attention to history of DM
› Laboratory Tests That May Be Ordered
  • Blood glucose testing, which reveals elevated blood glucose
  • Free-flowing capillary, venous, or arterial blood testing to monitor for acidosis
  • Blood tests to measure serum or plasma glucose, electrolytes including bicarbonate or total carbon dioxide, blood urea nitrogen, creatinine, osmolality, venous or arterial pH, pCO₂, calcium, phosphorus, and magnesium, HbA1c, Hgb, and Hct
  • UA to test for ketones
  • Blood, urine, or throat cultures if there is evidence of infection
› Other Diagnostic Tests/Studies
  • CT scan may be ordered if CE is suspected (for more information on assessment see the Quick Lesson, referenced above)
  • EKG may be ordered to monitor for arrhythmias due to hypokalemia

Treatment Goals
› Relieve Symptoms and Reduce Risk of Disease Complications by Administration of Prescribed Medications
  • Monitor vital signs, assess all physiologic systems (especially respiratory and neurologic), and review laboratory test results; assess for CE (for details see Red Flags, below); immediately report decline in LOC or other signs of potentially serious complications to the treating clinician and provide prescribed treatment; assist with intubation, as needed, and maintain mechanical ventilation, as prescribed
  • Administer mannitol or hypertonic saline, if ordered, to correct CE
    – The advantage of mannitol over hypertonic saline is that it promotes diuresis and also decreases blood viscosity, which increases blood flow to the brain and improves oxygenation
    – The advantage of hypertonic saline over mannitol is that it prevents hyponatremia and hypovolemia
  • Carefully administer other prescribed medications and monitor treatment efficacy and for adverse effects. Medications for the treatment of DKA in children are the same as those for adults (see the Quick Lesson, referenced above) with weight-based dosing
› Provide Emotional Support and Developmentally Appropriate Care and Education
  • Assess anxiety level and coping ability of patient and/or family; educate and discuss disease pathophysiology, potential complications, treatment risks and benefits, and the need for ongoing medical surveillance
  • Encourage adherence to the prescribed treatment regimen in school and social settings
    – Discuss alcohol and RDU privately with adolescent patients to promote honesty and with their families, as appropriate
  • Request clinician referral, if appropriate, to a social worker for identification of local resources, including programs for disease education and support groups
Food for Thought

Most children and adolescents with DKA have DM, type 1 (DM1), which is characterized by sudden-onset of severe insulin deficiency due to autoimmune destruction of insulin-producing pancreatic β-cells (see Quick Lesson About … Diabetes Mellitus, Type 1). In recent years, however, an increasing number of obese pediatric patients presenting with DKA have DM, type 2 (DM2), which occurs secondary to insulin resistance and/or impaired pancreatic insulin production (see Quick Lesson About … Diabetes Mellitus, Type 2).

Red Flags

- DKA is a medical emergency requiring admission to an intensive care unit for management
- Medications used in treatment of DKA can lead to death if improperly administered
- Insulin can bind to plastic IV tubing resulting in delivery of a decreased dose. Prior to initiating an insulin, infusion IV tubing should be primed with an insulin containing IV fluid to prevent binding
- Monitor at least hourly for signs and symptoms of CE, including
  - Abnormal breathing patterns
  - Lethargy, altered mentation and/or LOC, abnormal motor or verbal responses to pain
  - Specific neurological signs, including unreactive pupils and cranial nerve palsies
  - Age-inappropriate incontinence, headache, vomiting
  - Sustained decrease in heart rate of > 20 beats per minute
  - Diastolic blood pressure > 90 mm Hg

What Do I Need to Tell the Patient/Patient’s Family?

- DM management is challenging in a growing child, whose metabolic needs change frequently. Close monitoring and frequent clinician visits are critical
- Gradually assuming responsibility for their own care is important for adolescents
- For general information, see What Do I Need to Tell the Patient/Patient’s Family? in Quick Lesson About … Diabetes Mellitus, Type 1 referenced above

References