Diabetic Ketoacidosis in Adults

Description/Etiology
Diabetic ketoacidosis (DKA) is a potentially life-threatening metabolic emergency that occurs as a complication of uncontrolled diabetes. Low serum insulin levels in DKA prevent glucose from entering the cells to perform normal metabolic functions, causing the cells to respond as if in a starvation state. The production of counter-regulatory hormones (e.g., catecholamines, cortisol, glucagon, growth hormone) in response to the low insulin levels exacerbates the perceived state of starvation. To compensate, the liver begins to break down stored glycogen and fat to produce glucose, which produces ketone acid byproducts that lead to metabolic acidosis and hyperlipidemia. Hyperventilation with deep, gasping breaths (i.e., Kussmaul respirations) can ensue as a compensatory mechanism to counteract the acidosis. The kidneys initiate osmotic diuresis to excrete the excess glucose that is entering the bloodstream. Unless impaired, the kidneys also excrete water and electrolytes, leading to dehydration and electrolyte imbalances. Blood becomes concentrated due to dehydration. Although electrolyte levels can be elevated according to the laboratory test results, the total body electrolyte stores in the tissues can be low. Electrolyte imbalances and hyperosmolarity (i.e., increased solution concentration expressed as osmoles of solute/kg of serum water) can result in cardiac arrhythmias and even coma. DKA in pregnancy can cause fetal distress, fetal malformation, fetal demise, and maternal mortality.

DKA occurs mainly in patients with diabetes mellitus, type 1 (DM1), but it can affect patients with diabetes mellitus, type 2 (DM2) or, rarely, patients with gestational diabetes (i.e., pregnancy-induced diabetes). Regardless of whether affected by DM1 or DM2, the patient can have impaired beta-cell (i.e., the pancreatic cells that produce insulin) function. Pregnant women have a reduced buffering capacity (i.e., the ability to compensate for pH imbalances), which makes them more susceptible to acidosis; they can be unable to produce enough insulin to meet fetal demands despite normal beta-cell function. The most common precipitating factors for DKA regardless of the type of diabetes are insulin administration errors, infection, and new-onset diabetes. Other known precipitating factors include medications (e.g., corticosteroids, thiazides, salicylates, atypical antipsychotics), recreational drug use, alcohol abuse, severe medical illness, starvation, surgery, trauma, pregnancy, and emotional stress.

The severity of DKA does not correspond to the blood glucose level; pregnant women with DKA can even have normal blood glucose levels. Most patients with DKA are seen in the emergency department and require admission to the ICU for close monitoring and management. The differential diagnosis includes hyperglycemic hyperosmolar syndrome (i.e., a life-threatening diabetic emergency with similar symptoms but without ketoacidosis) and other types of acidosis. Treatment includes insulin and glucose administration, fluid/electrolyte restoration, and resolution of the underlying cause. DKA is best prevented via patient education.

Facts and Figures
The reported incidence of DKA in adults with DM1 is 0–56 per 1,000 persons per year (Farsani et al., 2017). DKA incidence is 50% or 2 of every 100 persons with DM1. Approximately 20% of patients with DM1/DM2 initially present with DKA. DKA can occur at any age; 36% of cases occur in patients aged < 30 years, 27% occur in those aged 30–60 years, 23% occur in those aged 51–70 years, and 14% occur in those aged > 70 years.
DKA is the most common cause of death in patients with DM1 who are under the age of 40. The reported mortality rate for DKA is as high as 10%. There are more than 100,000 annual hospital admissions for DKA in the United States, and DKA accounts for 8–29% of all hospital admissions in patients with diabetes mellitus (DM).

**Risk Factors**

Two primary risk factors for DKA include insulin dependence and age < 25 years. Other significant risk factors include Black race, chronic alcohol abuse, recreational drug use, and mental illness, all of which often result in noncompliance with drug regimens and/or drug-induced hyperglycemia. Additional specific medical risk factors include new-onset DM, infection, gastroparesis, pancreatitis, stroke, myocardial infarction, abdominal crisis, and trauma, but any severe medical illness can trigger DKA.

**Signs and Symptoms/Clinical Presentation**

Common signs and symptoms of DKA include polyuria (i.e., excessive urination), polydipsia (i.e., excessive thirst), nausea, emesis, abdominal pain, change in appetite, weakness, malaise, sudden weight loss, blurred vision, headache, drowsiness, fruity breath odor, dry mucous membranes, tachycardia, hypotension, and hypothermia. As DKA progresses, Kussmaul respirations and coma can develop. Fever can be present in patients with a coexisting infection.

**Assessment**

- **Patient History**
  - Patient might report abdominal pain that resolves with treatment
  - Patient might report changes in mental status
- **Laboratory Tests That Can Be Ordered**
  - Serum glucose is usually > 250 mg/dL, although in pregnant women with DKA glucose levels can be within normal limits
  - Elevated serum β-hydroxybutyrate (β-OHB) and/or serum ketones
  - Complete metabolic panel shows HCO3 ≤ 15 mEq/L and anion gap > 10 in DKA
  - Arterial or venous blood gases can show a pH < 7.3
  - Urinalysis can reveal ketones and glucose
  - Blood cultures can be ordered if sepsis is suspected as a precipitating factor
  - Toxicology panel can be ordered if salicylate poisoning or drug use is suspected
- **Other Diagnostic Tests/Studies**
  - EKG usually shows sinus tachycardia in DKA, but can also show arrhythmias
  - Chest X-ray can be ordered if respiratory infection is a suspected cause of DKA

**Treatment Goals**

- **Administer Medications as Prescribed and Monitor for Complications**
  - Administer prescribed insulin (for precautions, see *Red Flags*, below)
    - Insulin molecules adhere to IV tubing. When hanging an insulin drip, flush the IV tubing with 50 mL of the insulin solution before connecting the tubing to the patient to promote administration of an adequate concentration of insulin
    - Administer IV fluids at the prescribed rate and adjust per order as laboratory values change (e.g., protocols usually start with 0.9% normal saline [NS] and progress to 0.45% NS and dextrose 5% in water [D5W] per lab values)
    - In rare cases, bicarbonate can be ordered. Bicarbonate should never be given in 0.9% NS because it creates a hypertonic solution and increases osmolality
  - Administer prescribed potassium, which is usually ordered as soon as potassium levels are normal because potassium levels can drop quickly as fluids and insulin take effect; phosphate, magnesium, and calcium replacement can also be ordered
  - Monitor the timely completion of lab draws and frequently check test results; report decompensation or lack of improvement. Initially, glucose is usually monitored hourly. Metabolic panels are usually drawn every 2–4 hours
  - Monitor every 2–4 hours including heart rhythm for the development of arrhythmias, neurologic status for signs of cerebral edema, and intake and output; frequently assess for signs of fluid overload
  - Monitor for deep vein thrombosis (DVT) and other thrombotic conditions
- **Provide Emotional Support and Patient Education**
  - Assess anxiety level and coping ability; promote emotional well-being and educate (for patient education, see below for *What Do I Need to Tell the Patient/Patient’s Family?*)
• Request referral, as appropriate, to a social worker for identification of local resources for educational programs, in-homecare, and support groups

**Food for Thought**

› It is difficult to predict which patients are at increased risk for experiencing recurrent episodes of DKA. In one clinical study, investigators found that few clinical differences existed between patients who experience one episode of DKA and those who experience multiple episodes (Cooper et al., 2016)

**Red Flags**

› Serum potassium must be at least 3.3 mEq/L before initiating insulin administration, because insulin can cause a swift drop in potassium levels
› Carefully monitor insulin drips because medication errors can be fatal (e.g., have a second nurse check the label on the bag and the infusion pump rate; prime the tubing and waste the first 50 mL of medication; administer subcutaneous insulin when the insulin drip is discontinued, as ordered)
› Patients with coexisting renal insufficiency or heart failure can have an atypical presentation and are particularly vulnerable to fluid overload during fluid resuscitation
› Complications of DKA include electrolyte imbalances, cerebral edema, thrombotic events (e.g., pulmonary embolism, stroke, DVT), and acute kidney injury

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

› Educate about the prescribed treatment regimen, proper medication administration, glucometer and ketone strip use, and the signs and symptoms of DKA

Follow the “Sick Day Rules” for self-managing diabetes during periods of illness

• Continue prescribed diabetic medications as usual
• Test blood glucose and urine ketones every 3–4 hours
• Report a glucose reading > 300 mg/dL or urine ketones to the treating clinician
• If nausea, eat frequent (e.g., 6–8 times a day), small meals of soft foods such as gelatin, soup, custard, or crackers
• If vomiting, diarrhea, or fever persists, continue calorie intake through liquids (e.g., orange juice, broth, or sports drinks) every 30–60 minutes
• Report nausea, emesis, or diarrhea promptly to the treating clinician
• If unable to keep liquids down, hospitalization can be necessary to prevent DKA

**References**
