Canine Diabetic Ketoacidosis

Alice Huang, VMD, & J. Catharine Scott-Moncrieff, Vet MB, MS, MA, Diplomate ACVIM & ECVIM
Purdue University

Physical Examination
- Polyuria
- Polydipsia
- Polyphagia
Patient may have only 1 or more of these signs.

Laboratory Results
- Blood glucose (BG): Hyperglycemia (> 200 mg/dL)
- Blood gas (venous or arterial): Metabolic acidosis
- Urine dipstick: Glucosuria; ketonuria or ketonemia
  Serum ketones can be measured if urine is unavailable.

Diabetic Ketoacidosis

1. IV Isotonic Crystalloid Therapy
   - Shock fluid therapy is warranted if cardiovascular instability is present: Full shock dose of fluids is 90 mL/kg; start with ¼ to ⅓ dose and reassess until stable
   - Correct dehydration, provide maintenance needs, and replace ongoing losses over 6 to 24 hours:
     - % dehydration × body weight (kg) × 1000
     - 20 mL/kg/day (insensible losses)
     - 20 to 40 mL/kg/day (maintenance sensible losses)
     - Account for vomiting, diarrhea, & polyuria (ongoing sensible losses)

2. Electrolyte Supplementation (see Table 1, page 70)
   - Monitor serum potassium Q 4–6 H until within reference interval and stable; then Q 12–24 H
   - Monitor serum phosphorus Q 4–6 H until > 1.5; then Q 6–24 H
   - When supplementing potassium and phosphorus concurrently, take into account the amount of potassium contained in the potassium phosphate
   - Consider magnesium supplementation in instances of refractory hypokalemia

3. Regular Insulin
   - Continuous rate infusion (CRI) protocol:¹
     - Add 2.2 U/kg of regular insulin to 250 mL of 0.9% saline
     - Allow 50 mL of insulin solution to run through administration set because insulin adheres to plastic
     - Administer solution as shown in Table 2 (page 70)
   - Intermittent low-dose IM protocol:
     - Administer 0.2 U/kg regular insulin IM initially; 1 hour later begin IM injections of 0.1 U/kg every hour
     - If BG < 250 mg/dL make 5% dextrose solution with hydration fluids and change dosing regimen to 0.1 to 0.4 U/kg SC insulin Q 4–6 H
   - For either protocol:
     - Monitor BG Q 1–2 H
     - Goal for either protocol is to maintain BG between 200 and 300 mg/dL
     - Do not decrease BG faster than 70 to 100 mg/dL/H

BG = blood glucose; CRI = constant rate infusion; NPH = neutral protamine Hagedorn

**Diagnostic Tree / NAVC Clinician’s Brief / April 2011**

This algorithm can be downloaded and printed for use in your clinic at cliniciansbrief.com.

---

**Monitoring**
- Physical examination: Respiratory rate/effort, heart rate, pulse quality
- Hydration: Central venous pressure, weight, skin turgor, mucous membrane quality
- Electrolytes: Potassium, phosphorus, +/- magnesium
- Ketones: Serum, urine
- Blood glucose
- Blood gas and acid/base status
- Appetite/emesis
- As needed: Packed cell volume/total solids, serum biochemical profile, blood pressure

---

**Hyperadrenocorticism**
(see Hyperadrenocorticism: Why Wait to Test, page 70)

---

**Ketones present?**
- Yes
  - Continue IV fluids and electrolyte supplementation
  - Continue regular insulin administration, either CRI or IM (can administer via SC route if patient is hydrated)
- No (or trace)
  - Switch to SC Long-Acting Insulin
    - Neutral protamine Hagedorn (NPH) insulin (0.25–0.5 U/kg SC Q 12 H initially); consider starting at higher dose if patient previously diagnosed with diabetes mellitus and known to require higher doses of insulin
    - Lente (not currently commercially available)

---

**Eating consistently?**
- Yes
  - Switch to SC Long-Acting Insulin
  - Neutral protamine Hagedorn (NPH) insulin (0.25–0.5 U/kg SC Q 12 H initially); consider starting at higher dose if patient previously diagnosed with diabetes mellitus and known to require higher doses of insulin
  - Lente (not currently commercially available)
- No
  - Continue IV fluids and electrolyte supplementation
  - Continue regular insulin administration, either CRI or IM (can administer via SC route if patient is hydrated)

---

**Hydrated?**
- Yes
  - Continue IV fluids and electrolyte supplementation
  - Continue regular insulin administration, either CRI or IM (can administer via SC route if patient is hydrated)
- No
  - Switch to SC Long-Acting Insulin
    - Neutral protamine Hagedorn (NPH) insulin (0.25–0.5 U/kg SC Q 12 H initially); consider starting at higher dose if patient previously diagnosed with diabetes mellitus and known to require higher doses of insulin
    - Lente (not currently commercially available)

---

**Underlying cause of insulin resistance identified?**
- Yes
  - Hyperadrenocorticism
    - Neutral protamine Hagedorn (NPH) insulin (0.25–0.5 U/kg SC Q 12 H initially); consider starting at higher dose if patient previously diagnosed with diabetes mellitus and known to require higher doses of insulin
    - Lente (not currently commercially available)
- No
  - Continue IV fluids and electrolyte supplementation
  - Continue regular insulin administration, either CRI or IM (can administer via SC route if patient is hydrated)

---

**Further Investigation**
- It is essential to identify the underlying cause of the increase in diabetogenic hormones (catecholamines, glucagon, glucocorticoids, growth hormone, and estrogen) that lead to the ketogenic crisis:
  - Physical examination
  - Complete blood count
  - Serum biochemical profile
  - Urine culture
  - Canine pancreatic lipase immunoreactivity (cPLI)
  - Abdominal radiographs
  - Abdominal ultrasound
  - Thoracic radiographs
  - Pancreatitis
  - Urinary tract infection
  - Renal failure
  - Cholangiohepatitis
  - Pyometra
  - Skin disease
  - Heart disease
  - Neoplasia

---

**Switch to SC Long-Acting Insulin**
- Neutral protamine Hagedorn (NPH) insulin (0.25–0.5 U/kg SC Q 12 H initially); consider starting at higher dose if patient previously diagnosed with diabetes mellitus and known to require higher doses of insulin
- Neutral protamine Hagedorn (NPH) insulin (0.25–0.5 U/kg SC Q 12 H initially); consider starting at higher dose if patient previously diagnosed with diabetes mellitus and known to require higher doses of insulin

---

**Treat Any Concurrent Conditions**
- Pancreatitis
- Urinary tract infection
- Renal failure
- Cholangiohepatitis
- Pyometra
- Skin disease
- Heart disease
- Neoplasia
Table 1. Electrolyte Supplementation

<table>
<thead>
<tr>
<th>Serum Potassium Concentration (mEq/L)</th>
<th>Potassium Chloride Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 3.5 (maintenance)</td>
<td>0.05–0.1 mEq/kg/H</td>
</tr>
<tr>
<td>3–3.5</td>
<td>0.1–0.2 mEq/kg/H</td>
</tr>
<tr>
<td>2.5–3</td>
<td>0.2–0.3 mEq/kg/H</td>
</tr>
<tr>
<td>2–2.5</td>
<td>0.3–0.4 mEq/kg/H</td>
</tr>
<tr>
<td>&lt; 2</td>
<td>0.4–0.5 mEq/kg/H</td>
</tr>
<tr>
<td>Serum Phosphorus Concentration (mg/dL) Potassium Phosphorus Dose</td>
<td></td>
</tr>
<tr>
<td>2–2.5</td>
<td>0.03 mmol/kg/H</td>
</tr>
<tr>
<td>1.5–2</td>
<td>0.06 mmol/kg/H</td>
</tr>
<tr>
<td>1–1.5</td>
<td>0.09 mmol/kg/H</td>
</tr>
<tr>
<td>&lt; 1</td>
<td>0.12 mmol/kg/H</td>
</tr>
</tbody>
</table>

Table 2. CRI Infusion of Insulin Solution

<table>
<thead>
<tr>
<th>BG Concentration (mg/dL)</th>
<th>IV Hydration Fluids</th>
<th>Rate of Insulin Solution (mL/H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 250</td>
<td>0.9% saline</td>
<td>10</td>
</tr>
<tr>
<td>200–250</td>
<td>0.9% saline + 2.5% dextrose</td>
<td>7</td>
</tr>
<tr>
<td>150–200</td>
<td>0.9% saline + 2.5% dextrose</td>
<td>5</td>
</tr>
<tr>
<td>100–150</td>
<td>0.9% saline + 5% dextrose</td>
<td>5</td>
</tr>
<tr>
<td>&lt; 100</td>
<td>0.9% saline + 5% dextrose</td>
<td>Discontinue</td>
</tr>
</tbody>
</table>

Hyperadrenocorticism: Why Wait to Test?

Although hyperadrenocorticism is one of the most frequent causes of insulin resistance, it is not appropriate to test for it during a diabetic ketoacidosis crisis because false positives would be expected. Diagnostic testing for hyperadrenocorticism should not be performed until the patient has been systemically healthy for at least 2 weeks. Appropriate regulation of diabetes mellitus may be difficult to achieve prior to diagnosis of concurrent hyperadrenocorticism.

See Aids & Resources, back page, for references & suggested reading.

BG = blood glucose