Pathophysiology of Diabetic Ketoacidosis:

- Deficiency of insulin
  - Anabolic steroid (hormone) produced by the pancreas
  - Glucose cannot get inside cells without it = hyperglycemia
- Excess of stress hormones
  - Glucagon, cortisol, epinephrine
  - Usually the result of some underlying condition (pancreatitis, infection)
- Hyperglycemia
  - Causes an osmotic diuresis = dehydration
  - Increases osmolarity of blood = tissue and cellular dehydration
  - Cells resort to using proteins and fats for energy = formation of ketone bodies
- Ketonemia
  - 3 ketone bodies formed: acetone, acetoacetate, beta-hydroxybutyrate
  - Ketones lower the blood pH, resulting in a metabolic acidosis
- Often the first indication that a pet is diabetic, though can result from unregulated diabetes

Typical history reported by owner includes:

- Polyuria
- Polydipsia
- Polyphagia
- Weight loss
- Vomiting
- Lethargy

Signs often seen at presentation:

- Plantigrade stance
- Dehydration
- Tachypnea or Kussmaul respirations (long, deep respirations characterized by expiratory effort)
- “Fruity” or acetone odor to breath
- Low blood pressure
- Decreased level of consciousness
- SHOCK

Recommended diagnostics:

- Blood glucose measurement
- Urinalysis
  - Include culture and MIC
- Serum or urine ketone check
- Electrolytes
- PLi
- Blood gas
- Imaging
  - Abdominal ultrasound
  - Thoracic radiography

Laboratory abnormalities:

- Blood glucose
  - Generally high to very high (>250mg/dL)
- Urinalysis
  - Glucosuria
Ketones
Isothenuria
+/- proteinuria
Signs of infection (bacteria, WBC's)
Culture + MIC should be recommended

Ketones
If negative on urine, check serum
If negative on both, but suspicion is high, mix small drop of hydrogen peroxide to break
down beta-hydroxybutyrate ketone body into a form that will react with the pad

Electrolytes
DO NOT OVERCORRECT!
Many values will normalize with rehydration, correction of hyperglycemia, and resolution
of ketonemia
Sodium
Hyperglycemia will falsely lower sodium concentrations
Osmotic diuresis = hyponatremia
Will usually normalize with correction of hyperglycemia
Potassium
May be high, normal, or low at presentation (will usually require supplementation)
Total body depletion + insulin therapy + osmotic diuresis = hypokalemia
Safe supplementation = 0.5mEq/kg/hr

PLi
Pancreatitis is often a concurrent finding
Low fat diet is warranted if PLi is abnormal

Blood gas
Metabolic acidosis due to ketonemia
Low Ph with low HCO3
May see respiratory compensation (decreased PCO2) or CO2 may be normal

Imaging
Abdominal ultrasound
Pancreas: generally hyperechoic pancreas
Adrenals: hyperadrenocorticism is a common concurrent finding
Thoracic radiography
Rule out pneumonia or other inflammatory conditions in the thorax that can
contribute to DKA

IV Access:
Consider patient needs
Long term (3-5 days) fluid therapy
Need for sampling
Need for dextrose supplementation (at possibly high levels)
Peripheral needed at emergency presentation for correction of shock
Consider central lines
Multiple lumens allow for fluids, sampling, TPN/PPN if needed
PICC
IntraCath

IV Fluids
Which fluid to use?
Buffered crystalloid (Plasmalyte, Normosol-R, LRS)
Pros: contain potassium, buffered, isotonic
Cons: may be more expensive than saline, not as much sodium as saline
0.9% NaCl – traditional fluid of choice
- Pros: contains sodium to help correct hyponatremia, inexpensive, isotonic
- Cons: may lead to overcorrection of hyponatremia once hyperglycemia is corrected, no potassium, no buffer so potential to worsen metabolic acidosis

  o Replace deficit in the first 12-24 hours of therapy
    - Replacement requirement:
      - Body weight (kg) x % dehydration = deficit (L)
      - Maintenance requirement = 40-60ml/kg/day
  o Delay insulin therapy for 1-2 hours in cases of severe dehydration
    - IV fluid therapy alone will begin to decrease blood glucose and serum ketone concentrations
    - Starting insulin before rehydration may worsen hypokalemia
    - Rehydration will begin to correct electrolyte abnormalities
  o Potassium supplementation
    - Do NOT exceed 0.5mEq/kg/hr (aka “K-MAX”)

<table>
<thead>
<tr>
<th>Measured potassium (mEq/L)</th>
<th>mEq KCl to add to 1L IVF</th>
<th>Max rate of infusion (ml/kg/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2.0</td>
<td>80</td>
<td>6</td>
</tr>
<tr>
<td>2.1 – 2.5</td>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>2.6 – 3.0</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td>3.1 – 3.5</td>
<td>28</td>
<td>18</td>
</tr>
<tr>
<td>3.6 – 5.0</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

(from DiBartola, *Fluid, Electrolyte, and Acid-Base Disorders*)

- Insulin
  - Corrects hyperglycemia
  - Corrects ketonemia
  - Goal is to decrease BG by 50-75mg/dL/hr
  - Delivery:
    - Intermittent IM dosing
      - Initial dose 0.2 U/kg, then 0.1 U/kg until BG <250mg/dL
      - Either q1h or q2h
    - CRI
      - 2.2 U/kg for dogs; 1.1 U/kg for cats in 250ml bag of 0.9% NaCl
      - Run at least 50ml of solution through IV tubing as insulin will adsorb to the plastic
      - Needs its own IVC
      - Check BG q2h and adjust CRI as needed

<table>
<thead>
<tr>
<th>BG (mg/dL)</th>
<th>Dextrose supplementation in IVF</th>
<th>Insulin CRI (ml/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 250</td>
<td>0%</td>
<td>10</td>
</tr>
<tr>
<td>200 – 250</td>
<td>2.5%</td>
<td>7</td>
</tr>
<tr>
<td>150 – 200</td>
<td>2.5%</td>
<td>5</td>
</tr>
<tr>
<td>100 – 150</td>
<td>5%</td>
<td>5</td>
</tr>
<tr>
<td>&lt; 100</td>
<td>5%</td>
<td>discontinue</td>
</tr>
</tbody>
</table>

(from DiBartola, *Fluid, Electrolyte, and Acid-Base Disorders*)

Monitoring:
- Perfusion and hydration status
  - Frequent (q2-4h) monitoring of forward perfusion parameters
  - Mentation is very important: tells you about BG, perfusion
  - Check pulse quality with every set of vitals
- Ensure correction of shock
  - IV Access sites
    - Phlebitis
    - Signs of infection
    - Strict aseptic technique when handling central lines
  - Blood Glucose
    - Check every 1-2 hours
    - Monitoring response to insulin therapy
    - Provide dextrose supplementation PRN
  - Urine production
    - Normal = 1-2ml/kg/hr
    - These patients may exceed this amount!
    - Glucosuria = osmotic diuresis
    - Ensure matching ins and outs
    - Consider urinary catheter for quantification of UOP
  - Ketones and electrolytes
    - Clinician preference but usually between 2 and 4x per day
  - Kidney values
    - To monitor hydration status – usually SID
  - Nutrition
    - Ensure that patient is eating
    - Anti-emetics (metoclopramide, maropitant) may be indicated
    - If not eating >3 days (including at home), consider NG/NE tube feeding
    - Cats: High protein, low carbs
    - Dogs: High fiber, low fat
  - Recumbent patient care
    - Cleanliness is key!
      - Avoid urine scald with frequent bedding checks and changes PRN
    - Ensure regular walks for dogs
    - Rotate recumbent patients
      - Maintain integrity of integument
      - Prevent atelectasis
    - PROM, massage