Pediatric Diabetic Ketoacidosis (DKA):

Emergency Department Management Clinical Practice Guideline (CPG)

Protocol approved by:
Divisions of Pediatric Emergency Medicine and Endocrinology
Revised: 6/21

cardinalglennon.com
Clinical Practice Guideline for Diabetic Ketoacidosis

New Onset or Known Diabetes Mellitus: Transferred from another facility

- Evaluate ABC’s

New Onset Diabetes Mellitus

- 1. Determine how much fluid patient has already received
- 2. Determine rate of insulin infusion (if applicable)
- 3. Perform bedside glucose testing upon arrival

Known Diabetes Mellitus

- If altered mental status: Consider CT scan

Vital Signs

- Temperature, Pulse, Respiration, Blood Pressure, O2 Saturation, Weight (kg), Height (cm), Quick Neuro Exam

Laboratory Studies

- LFTs + Creatinine, Venous Blood Gas, Urinalysis
- If new onset Diabetes Panel, TSH, Hgb-A1C, C-peptide

Insulin Drip (Not Bolus)

- Order insulin (STAT) immediately upon arrival to ED
- Standard Concentration: 1 unit/ml patients > 20 Kg
- Neonatal Concentration: 0.2 units/ml patients < 20 Kg
- Insulin infusion rate = 0.1 Units/kg/hour

Initial Fluid Resuscitation

- 10-20 mL/kg Normal Saline or Lactated Ringers over 60 minutes

Disposition

- Consult Endocrine Attending after initial labs
- Admit to PICU or ICU - Items indicating more serious illness:
  - pH<7.10
  - Serum HCO3<5
  - Glasgow Coma Scale 12 or less
  - New onset DKA (vs. recurrent DKA)
- Patient age > 8
- Vitals Q1-3 hours
- Bedside glucose Q1 hr
- Chemistry panel Q4 hrs
- Ketones q void
- Strict I/O

Subsequent Fluid Resuscitation

1. Order 2 bags of fluid simultaneously
   Before starting see fluid instructions below and on p.3
   - IV Bag #1 - 1/2 NS w/K+ added per table
   - IV Bag #2 - D10 1/2 NS w/K+ added per table
   - Note - Consider NS instead of ½ NS if 2nd measured serum sodium is not rising appropriately (see page 3)
2. Total fluids - N.B. - Rehydration amounts may vary for new onset diabetes and subsequent DKA encounters:
   2.5-3 liters/m² for first 24 hours (see Mosteller Body Surface Area calculation)
3. Patient should remain NPO
4. Ondansetron (Zofran) IV: 0.1 mg/kg to max of 8 mg needed for nausea/vomiting.
5. As serum glucose falls toward 100, must decide whether to decrease insulin or add glucose.
6. If remains acidic (pH<7.25, HCO3<14) keep insulin at the same rate and add dextrose (see attachment)
7. If acidosis is resolving (pH>7.25, HCO3>14) can reduce insulin by 0.02 – 0.05 Units/kg/hr and adjust NS and D10W to keep serum glucose between 150 - 250 (see attachment)
8. The relative amount of fluid may be adjusted for the falling glucose, but the total infusion rate should remain the same

Potassium for Fluids

<table>
<thead>
<tr>
<th>Serum K+</th>
<th>IV K+</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - 4</td>
<td>40 mEq/L</td>
</tr>
<tr>
<td>5 - 5.5</td>
<td>40 mEq/L</td>
</tr>
<tr>
<td>&gt; 5.5</td>
<td>None</td>
</tr>
</tbody>
</table>

Equal parts K-acetate and K-phosphate

BSA Calculation

Mosteller Formula

\[
\text{BSA (m²)} = \sqrt{\frac{\text{height (cm)} \times \text{weight (kg)}}{3600}}
\]
MANAGEMENT OF DIABETIC KETOACIDOSIS

DKA, defined as the presence of ketonuria and metabolic acidosis (pH<7.30 and/or serum HCO3 < 15) and hyperglycemia, is a medical emergency. A presumptive diagnosis can usually be made at the bedside on the basis of history, glucometer check and urine dipstick.

I. RESUSCITATION

Establish Venous Access within 30 minutes of arrival. A second IV site for sampling is useful.

Admission Laboratory Studies:
On arrival, send venous blood STAT for sodium, potassium, chloride, HCO3, BUN, creatinine, glucose and pH. In severe DKA, an arterial pH may be needed. If infection is suspected (if fever is present), consider chest X-ray and cultures of blood and urine. A hemoglobin A1c, serum insulin and/or c-peptide, and autoimmune antibody studies (order as Diabetes Battery) should be considered in the new-onset child.

Initial Fluid Resuscitation
Once IV access is established, and while awaiting the results of the admission laboratory studies, administer normal saline (NS) or lactated ringer’s (LR) 20 cc/kg IV over 60 minutes. If shock or hypotension persists, give additional boluses of 10 cc/kg, or 20 cc/kg; however, DKA brings most children to the hospital with only moderate dehydration (10%), so larger initial boluses are usually not needed. The composition of subsequent rehydration fluids can await the admission laboratory studies (see below).

Initial Insulin Infusion
Once the diagnosis is established and the blood glucose is known, start IV regular insulin at a rate of 0.1 Unit/kg/hour. Current practice requires that you order 0.1 unit/kg/hour. Some suggest running 10-20 cc through the tubing before hookup up to the patient to "saturate binding sites". A loading bolus of IV insulin is not needed, but if the patient is in shock or severe acidosis (pH<7.0), you can precede the constant infusion with a loading bolus of 0.1 Unit/kg body weight. It is imperative that the physician check the insulin infusion once it is begun.

Sodium Bicarbonate Infusion
The use of sodium bicarbonate is controversial. It is rarely needed. The main indication is shock in the presence of pH <7.0. The dose suggested is 1 mEq/kg IV over 30 minutes to be repeated as needed for persistent shock.
II. STABILIZATION

IV FLUIDS
Order simultaneously two bags of IV fluids. The initial one will be 1/2 NS with potassium added according to the serum potassium level (see table). The second bag should consist of D10 1/2 NS, with the same potassium added to be used when the blood glucose declines to 300 (see below).

Potassium is ordered as equal parts K-acetate and K-phosphate

<table>
<thead>
<tr>
<th>Serum [K]</th>
<th>K in IV fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>*3 – 4</td>
<td>60 mEq/L</td>
</tr>
<tr>
<td>4 - 5.5</td>
<td>40 mEq/L</td>
</tr>
<tr>
<td>**&gt;5.5</td>
<td>none</td>
</tr>
</tbody>
</table>

* Larger amounts may be needed if [K] <3.0

** K at 40 mEq/L should be added as soon as [K] < 5.5

Sodium the sodium content should be increased if the measured serum Na+ is low and does not rise appropriately as the glucose falls. Na+ should rise 1.6 mEq/l for every 100 mg/dl drop in glucose. Replacement fluids after the isotonic bolus should be with ½ NS to NS, with the decision based on the patient's hydration status, serum Na+ concentration, and osmolality. The 2018 PECARN FLUID Study found no significant differences in DKA-related brain injury in 1,389 episodes of pediatric DKA between slower and more rapid fluid administration using either ½ NS or NS. Hyperchloremic acidosis was more common in the NS groups.

GLUCOSE TITRATION/ INSULIN
After initial resuscitation, most diabetic children will need NS with potassium as recommended above. As treatment proceeds, and as blood glucose approaches 300, you must decide either to decrease the rate of insulin or to add IV glucose, or both. The decision is based on the principle that persistent acidosis requires a continued need for high (0.1 Unit/kg/hour) rate of insulin infusion. If acidosis persists (venous pH < 7.25, HCO3<14), continue insulin at 0.1 Unit/kg/hour and maintain blood glucose at 150-250 by reducing the NS solution, perhaps by half, and replacing this with the D10 NS solution to maintain the same total rate of IV fluid infusion. If acidosis is resolving (HCO3>14, venous pH > 7.25), then insulin can be reduced to 0.05 – 0.08 Unit/kg/hour, with relative amounts of NS and D10 NS as needed to maintain blood glucose at 150-250 (See Table 1), while maintaining the same total IV fluid infusion rate.

Table 1: Ratio of D10 and NS maintenance Fluid

<table>
<thead>
<tr>
<th>Blood Glucose</th>
<th>% D10 maintenance fluid</th>
<th>% NS maintenance fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 300</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>200 – 299</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>&lt; 200</td>
<td>100%</td>
<td>0%</td>
</tr>
</tbody>
</table>

More than 0.1 Unit/kg/hour of insulin is almost never needed. Failure to control hyperglycemia at this rate usually means the infusion was prepared incorrectly.

INFUSION RATE
The post-resuscitation fluids (usually NS with 0-60 mEq /L K) should run at 2.5 to 3 liters/m2/24 hr for the first 24 hours. The patient should be NPO. As the blood glucose falls, the relative amount of NS and D10 NS can be adjusted, but the total infusion rate should remain the same.
THERAPEUTIC MONITORING: Admit to TCU or PICU (q 1-3 h VS, neuro checks)

- Hourly bedside blood glucose
- Electrolytes (Na, K, Cl, HCO₃), BUN every 4 hours;
- Serum K every 1-2 hours, if abnormal
- Urine ketones q void
- Urine output (Foley usually not needed)

III GOALS

CORRECT DEHYDRATION OVER 24-36 HOURS

MAINTAIN BLOOD GLUCOSE 150-200 ONCE STABILIZED

ANTICIPATE (AND CORRECT, IF NECESSARY) MAJOR COMPLICATIONS

- hypoglycemia
- hypo- or hyperkalemia
- pneumothorax/pneumomediastinum
- persistent acidosis (HCO₃<10 after 12 hours)*
- cerebral edema**

* Persistent acidosis is usually due to errors in carrying out standard treatment. The physician should check the insulin infusion, and re-order new solution to the bedside if necessary.

** This is the most common cause of death in DKA, usually occurring 8-12 hours into therapy, with little warning. The first signs are the complaint of headache and sudden decline in mental status (level of arousability and orientation). Part of the “neuro-check” therefore should include arousing and talking to the patient, since bradycardia, hypertension, blown pupil, and decorticate posturing are late findings. It should be treated with mannitol 0.5 – 1 gm/kg IV over 20 minutes or hypertonic saline (3%) 5 mL/kg over 10 - 15 minutes, elevation of the head of the bed, and other supportive measures, such as mechanical hyperventilation and perhaps dexamethasone. CT scan of the head can demonstrate its presence, but treatment should be given on clinical grounds with no delay. The cause is controversial, but the risk may be increased by excessive fluid administration, hyponatremia, and bicarbonate administration.

Demographic factors associated with increased risk for cerebral edema include severe DKA (pH <7.1, bicarb <5), new onset diabetes, and younger age (<5 years). All three variables are important in deciding disposition to the PICU vs. TCU.

Cerebral hypoperfusion and the effects of reperfusion, along with neuroinflammation are likely central to DKA-related brain injury.

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