Pediatric Diabetic Ketoacidosis (DKA):

Emergency Department Management Clinical Practice Guideline (CPG)

Protocol approved by:
Divisions of Pediatric Emergency Medicine and Endocrinology
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Clinical Practice Guideline for Diabetic Ketoacidosis

New Onset or Known Diabetic (Transferred from another facility)

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

New Onset Diabetes Mellitus

Evaluate ABCs

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
Chemistry Panel (Chem 7), Venous Blood Gas, Urinalysis

If New Onset:
Diabetes Battery, Hgb-A1C, C-peptide

If Febrile:
Blood and Urine cultures
Consider Chest X-ray

Initial Fluid Resuscitation
10-20 ml/Kg Normal Saline or Ringers Lactate over 20-30 minutes.
If shock present may need to give additional fluid.

Insulin Drip (Not Bolus)
Order Insulin (STAT) immediately upon arrival to ED.
Standard Concentration: 1 Unit/ml for patients > 20 Kg
Neonatal Concentration: 0.2 Units/ml for patients < 20 Kg
Insulin infusion rate is 0.1 Units/kg/hour.

Subsequent Fluid Resuscitation
1) Order 2 Bags of Fluid Simultaneously but do not start (see below and attachment).
   #1 – ½ Normal Saline with K+ added per table.
   #2 – D10 ½ Normal Saline with K+ added per table.
2) Total fluids should be run at 2.5-3.0 Liters/m2 for first 24 hours (see Body Surface Area calculation).
3) Patient should remain NPO.
4) Ondanestron (Zofran®) IV: < 5 kg = 0.5 mg; 5-30 kg = 1 mg; 30–60 kg = 2 mg; > 60 kg 4 – 8 mg as needed for nausea/emesis.
5) As serum glucose falls toward 250, must decide whether to decrease insulin or add glucose.
   - If remains acidic (pH < 7.25, HCO3 < 14) keep insulin at the same rate and add glucose (see attachment).
   - If acidosis resolving (pH > 7.25, HCO3 > 14) can reduce insulin by 0.02-0.05 Units/kg/hour and adjust ½ NS and D10 ½ NS to keep serum glucose 150-250 (see attachment).
   - The relative amount of ½ NS and D10 ½ NS can be adjusted for the falling glucose, but the total infusion rate should remain the same.

Potassium for Fluids
Serum K+ IV K+
3.0-4.0 60 mEq/L
4.0-5.5 40 mEq/L
> 5.5 None

Body Surface Area Calculation

\[
BSA = \sqrt{\frac{\text{Weight (kg)} \times \text{Height (cm)}}{3600}}
\]

Disposition
Contact Endocrine Attending on call after initial lab studies.
Admit PICU or TCU
Vital Signs with Quick Neuro Exam Q1-3 hours.
Bedside Glucose Q1 hour.
Chemistry Panel Q4 hours.
Urine Output and Ketones Q Void.
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 site for heparin lock 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 a 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 diabetic 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 20-30 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 (10%) dehydration, 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 (3/05) practice requires you to order the insulin as “0.1 unit/kg/hour”. Some suggest running 10-20 cc through the tubing before hooking up to the patient to “saturate binding sites”. A loading bolus of IV insulin is usually not needed, but if the patient is in shock or severe acidosis (pH < 7), 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 1.0 mEq/kg IV over 30 minutes, to be repeated as needed for persistent shock.
Management of Diabetic Ketoacidosis, continued (page 2)

II. STABILIZATION

IV FLUIDS

Order simultaneously two bags of IV fluids. The initial one will be ½ NS with potassium added according to the blood potassium (see table). The second bag should consist of D10-1/2NS, with the same potassium added, to be used when the blood glucose declines to 250 (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>* 3.0-4.0</td>
<td>60 mEq/l</td>
</tr>
<tr>
<td>4.0-5.5</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.

- Glucose/Insulin

After initial resuscitation, most diabetic children will need ½ NS with potassium as recommended above. As treatment proceeds, and as blood glucose approaches 250, 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 a 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 ½ NS solution, perhaps by half, and replacing this with the D10-1/2NS 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 1/2NS and D10-1/2NS as needed, to maintain blood glucose 150-250, while maintaining the same total IV fluid infusion rate.

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 ½ NS with 0-60 mEq/l K) should be run at 2.5 to 3.0 liters/m²/24 h for the first 24 hours. The patient should be NPO. As the blood glucose falls, the relative amount of 1/2NS and D10-1/2NS can be adjusted, but the total infusion rate should remain the same.
Management of Diabetic Ketoacidosis, continued (page 3)

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) *
  thrombotic events
  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 0.5-1.0 gm/kg IV STAT, 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.

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