

**NORTHWEST COMMUNITY HEALTHCARE  
EMERGENCY DEPARTMENT  
SPECIALTY MANUAL**

**PEDIATRIC DKA GUIDELINE**

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**PURPOSE:**

The acute management of DKA in children is different from that of adults in that children are at risk for acute cerebral edema, with its accompanying high morbidity and mortality. The purpose of this policy is to provide age-specific care to the pediatric patient presenting in diabetic ketoacidosis, thus minimizing associated complications.

**POLICY:**

Pediatric patients, as defined by Northwest Community Hospital as patients <18 years of age, presenting with signs and symptoms of diabetic ketoacidosis, will be treated according to this guideline and sound clinical judgment.

**DEFINITION:**

Diabetic ketoacidosis (DKA) is a state of absolute or relative insulin deficiency resulting in hyperglycemia (Serum glucose >200 mg/dL) and an accumulation of ketone bodies in the blood, with subsequent metabolic acidosis where serum pH is < 7.3 and/or the serum bicarbonate is < 15 mEQ/L.

## **PEDIATRIC DKA - PAGE 2**

### **I. INITIAL EVALUATION:**

- Obtain and monitor vital signs, including blood pressure and temperature
- Determine degree of hydration and mental status

Key historical factors in determination of pediatric DKA include:

- Known history of diabetes w/concurrent missed shots or intercurrent illness (approximately 20-30% of DKA cases occur in previously undiagnosed diabetics).
- Classic triad in children is polydipsia, polyuria and weight loss (polyphagia unusual in children)
- Abdominal pain and/or vomiting
- Rapid, deep respirations
- Recent weight loss
- Fatigue/malaise

Key physical findings in pediatric DKA include:

- Dehydration
- Non-focal abdominal tenderness
- Lethargy or alteration in mental status
- Tachycardia and tachypnea
- Signs of intercurrent infection (frequent precipitating event)

### **II. TREATMENT:**

#### **A. INITIAL CARE**

- Address deficits in ABC's
- Initial Glasgow Coma Score
- Insert 2 large bore IV catheters for Moderate/Severe DKA
- Pulse oximeter
- Cardiac monitor

#### **B. INITIAL LABORATORY /DIAGNOSTIC STUDIES:**

- Obtain bedside glucose immediately upon presentation
- Obtain blood samples with IV placement for:
  - CBC w/diff
  - Basic Metabolic Panel
  - venous pH/venous blood gas OR arterial blood gas
  - Calcium (serum & Ionized)
  - Serum Phosphorus
  - Serum Magnesium
  - C-peptide
- Obtain urine to dip for ketones and send for urinalysis
- EKG if Serum K<sup>+</sup> >7 or <2

#### **C. CLASSIFICATION OF DKA SEVERITY:**

The severity of DKA is defined by the venous pH and may be further classified as mild, moderate and severe:

- Mild DKA: pH >7.2 and < 7.3, HCO<sub>3</sub> 10-15,
- Moderate DKA: pH 7.1-7.2, HCO<sub>3</sub> 5-10

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- Severe DKA: pH < 7.1, HCO<sub>3</sub> < 5,

**D. MEDICATION AND IV THERAPIES:**

**1. FLUID THERAPY**

**a. Mild DKA non-vomiting:** Oral rehydration and subcutaneous (SQ) insulin therapy is recommended – see below for calculations. All listed are U/kg/day which equals Total Daily Dose (TDD)

	<b>No DKA</b>	<b>DKA</b>
<b>Prepubertal</b>	0.25-0.5	0.75-1
<b>Pubertal</b>	0.5-0.75	1-1.2
<b>Postpubertal</b>	0.25-0.5	0.8-1

**For T1D regimen divide as follows:**

- 2/3 of TDD given before breakfast (2/3 is NPH and 1/3 is Lispro (Humalog®))
- 1/3 of remaining TDD is divided between pre-dinner & pre-bedtime (1/3 given before dinner as Lispro(Humalog®) and 2/3 given before bedtime as NPH)

**b. Moderate/Severe DKA (or Mild DKA w/Vomiting)**

**1. Initial Fluid Bolus** (1<sup>st</sup> hour of therapy): \*No insulin therapy initially

Start hydration with initial 0.9% NaCl (continued use after initial dose may result in hyperchloremic metabolic acidosis.)

- Normal saline 10 ml/kg over 60 minutes
- Shock Only – Normal saline 20 ml/kg IV push over 30 minutes

**2. Maintenance Fluids** (2<sup>nd</sup> hour of therapy): \*Start insulin therapy – see below

- Begin maintenance fluid as 0.9% NaCl calculated using chart below and run at 1.5x maintenance rate assuming 10% dehydration when initial bolus is complete (second hour)
- Replace Potassium (K<sup>+</sup>) with maintenance fluids (See below) once urine output has been established
- Do not give more than 4L of maintenance fluids in 24 hours . Rates should not exceed 2x the maintenance rate per hour.
- Consult Pediatric ED attending physician or pediatric hospitalist for dose and rate, as over-rapid administration of fluids can contribute to cerebral edema.

**Maintenance fluid calculation**

<b>Weight</b>	<b>24 hour fluid maintenance requirements (not to exceed 4L/m<sup>2</sup>/24 hours)</b>
<10 kg	100 ml/kg – initial fluid bolus
10 – 20 kg	1000 ml + 50 ml/kg for each kg over 10 kg minus the initial fluid bolus
> 20 kg	1500 ml + 20 ml/kg for each kg over 20

**Calculated Fluid Deficit:**

$$\text{Water deficit (in liters)} = (0.6) (\text{body wt in kg}) \times \{(\text{Measured Na}) - 1\}$$

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### 2. ELECTROLYTE REPLACEMENT

#### a. POTASSIUM

- DKA is associated with a total body depletion of potassium, regardless of the initial serum K<sup>+</sup>.
- Correction of acidosis and supplemental insulin both cause intracellular shift of K<sup>+</sup> into cells resulting in a fall in serum potassium concentrations.
- If initial serum K<sup>+</sup> < 5.5 and the patient is making urine (no renal failure) add 30-40 mEq of K<sup>+</sup>/L IV fluid. Give ½ as K-phosphate and the other ½ as KCl.
- If initial serum K<sup>+</sup> > 5.5, DO NOT add K<sup>+</sup> to fluids until serum K<sup>+</sup> falls below 5.5 mEq/dL
- Potassium salts can be added as phosphate, chloride, and/or acetate. It is recommended that neither the K-phosphate nor the K-acetate should constitute more than 15-20 mEq/L each.

#### Potassium Replacement

K <sup>+</sup> serum value	K <sup>+</sup> total mEq	KCL component	KPO4 component
< 5.5	40 mEq	20	20
>5.5*	0	0	0

\*Do Not add K<sup>+</sup> until serum K falls below 5.5 mEq/dL

#### b. PHOSPHORUS (PO<sub>4</sub>)

- Phosphate depletion occurs because of acidosis and urinary losses, and may lower ATP and 2, 3-DPG levels.
- Giving too much phosphate (i.e., more than 20 m Eq/L) may cause hypocalcemia and tetany.
- Check repeat phosphate levels if giving supplemental phosphate (K-phos)
- 1 ml of potassium phosphate has 3 m Mol phosphate/ml and 4.4 m Eq potassium/ml

20 mEq K Phosphate = 13.6 mMol K Phosphate

15 mEq K Phosphate = 10.2 mMol K Phosphate

10 mEq K Phosphate = 6.8 mMol K Phosphate

#### c. SODIUM

- DKA is a form of hypertonic dehydration and serum sodium value is dependent on several factors including net water and sodium losses prior to treatment, degree of hyperglycemia and degree of lipidemia
- Measured and corrected serum sodium values should rise as the serum glucose values decrease
- If the serum sodium fails to rise or if it experiences a significant fall this is suggestive of overly rapid rehydration and patient should be carefully monitored for signs of cerebral edema.
- The serum Na should rise by approx. 2.4 mEq/L for every 100 mg/dL fall in serum glucose.
- Serum sodium's expected rise can be calculated using the formula listed below for sodium correction based on decreasing serum glucose:

#### Sodium Correction:

$$\text{Corrected Na}^+ = (\text{Measured Na}^+) + (1.6) (\text{Glucose} - 100) / 100$$

### 3. INSULIN THERAPY GUIDELINES:

**Drip Instructions/Dosages:** Order the following concentrations for the Insulin drip based on weight:

- < 15 kg: 0.05 units/kg/hr (Insulin concentration is 0.5 unit/ml mixed 1:1)
- ≥ 15 kg: 0.1 units/kg/hr (Insulin concentration is 1 unit/ml mixed 1:1)

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### **Do not give IV or SQ bolus insulin**

- Do not start insulin until a fluid bolus has been given and maintenance fluids begun.
- The tubing for insulin infusion should be prepared by running 50 ml of the insulin solution through the tube as discard, to saturate binding sites on the tube lining.
- Do not discontinue insulin until pH normalized.

## III. ONGOING ASSESSMENT AND TREATMENT:

### A. ONGOING FLUID THERAPY

#### 1. DEXTROSE/GLUCOSE-CONTAINING SOLUTIONS

- When blood glucose < 250 mg/dl, change fluid to D5NS or D5LR
- Maintain blood glucose between 150-250 mg/dl. If necessary, higher concentrations of glucose may be obtained with supplemental PO intake or 7.5-10% dextrose containing IV infusions.
- Take the dextrose out of the IV when you stop the insulin drip.
- **Decreasing serum glucose** concentrations should be addressed by addition of dextrose to the intravenous solution. Do not drop the glucose by more than 100mg/dL/hr and maintain serum glucose between 150-250 mg/dL.
- The purpose of the insulin is to correct the ketoacidosis. Do not reduce or discontinue the insulin drip based solely upon the blood glucose. The insulin drip should be continued until the pH > 7.30 and/or the HCO<sub>3</sub> > 18, and the serum ketones have cleared.
- When the patient's status is appropriate for discontinuation of IV insulin, SQ Humalog may be given at the same time as stopping the IV insulin drip. If Regular insulin is given SQ, insulin drip should be stopped 30 minutes AFTER injection.
- Take the dextrose out of the IV when you stop the insulin drip.

#### 2. SODIUM BICARBONATE:

- Sodium bicarbonate is generally contraindicated. Acidosis should be treated with insulin and fluid replacement only. If sodium bicarbonate is given, it should only be given as a drip in cases of severe acidosis with shock, cardiac insufficiency or renal failure.
- **Do not give boluses of sodium bicarbonate.**
- Some studies have shown an independent association between the administration of sodium bicarbonate and the development of cerebral edema.

### B. MONITORING

- Hourly monitoring:
  - Bedside glucose (Continue Q 1 hour for bedside glucose > 600)
  - Strict I & O. Catheterization should only be undertaken if patient obtunded
  - Vital signs, including accurate temp.
  - Neuro checks, including pupils, mental status, and Glasgow Coma Score (adult or peds) \*See "Complications: Cerebral Edema" below
- Q 2 hour monitoring:
  - Serum glucose (Q 1 hour if bedside glucose >600)
  - Venous blood gas
  - Electrolytes
- Q 4 hour monitoring
  - Ionized Calcium
  - Magnesium
  - Phosphate
- Ongoing cardiorespiratory monitoring, including breathing pattern (persistence of Kussmaul respirations, etc.)

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### **C. DISPOSITION**

- Anticipate transfer to intensive care or tertiary care center for patients with severe acidosis, age less than 3 years, or respiratory compromise.
- Anticipate admission for patients with moderate acidosis tolerating SQ insulin and PO or IV fluids.
- Patients with mild acidosis and known history of IDDM may be discharged from the E.D.

### **IV. COMPLICATIONS:**

#### **A. CEREBRAL EDEMA**

The acute management of DKA in children is different from that of adults as children are at highest risk for acute cerebral edema. Cerebral edema in DKA occurs in 0.3-1% of children who develop DKA with reported mortality of 21-25%.. About 20% of cases occur prior to initiation of therapy so an initial assessment of mental status is very important.

Risk factors for developing cerebral edema include:

- New-onset diabetes with ketoacidosis
- Severe acidosis or dehydration at the time of presentation
- Age <5 years
- Excessive early fluid replacement
- Rate of decrease of serum glucose >100 mg/dL/hr
- Rapidly decreasing plasma osmolality or critically low osmolality during first 24 hours of therapy.

#### **1. ONGOING ASSESSMENT:**

Assess for development of cerebral edema. Symptoms from cerebral edema usually occur within the first 16 hours after initiation of therapy. Patients usually begin to show signs of recovery, and then demonstrate new deficits. Some researchers postulate that all patients in DKA have some degree of cerebral edema, though it is often asymptomatic. Signs of cerebral edema include:

- Severe headache
- Mental status changes
- Bradycardia/hypertension/respiratory insufficiency (Cushing's triad)
- Reemergence of vomiting
- Focal neurologic signs
- Papilledema
- Fixed or dilated pupils
- Age-inappropriate incontinence

#### **2. TREATMENT OF CEREBRAL EDEMA:**

- Mannitol 0.25 g/kg – 1 g/kg IV over 20 minutes
- Intubation may be necessary for airway protection, but aggressive hyperventilation should be avoided
- Raise head of bed to 30 degrees, and place head in midline position
- Consider a decrease in maintenance IV fluid rate to between 2/3 maintenance and daily maintenance unless patient is profoundly dehydrated.
- Consider hypertonic saline (3%) at a rate of 5-10ml/kg in patients unresponsive to mannitol therapy.

**B. OTHER COMPLICATIONS**

- Cardiac Arrhythmia
- Venous Thrombosis
- Aspiration
- Pancreatic Enzyme Elevation
- Hyperglycemic Hyperosmolar State (HHS) = serum glucose > 600, serum osmols > 320 with minimal ketosis in Type 2 Diabetes or in Type 1 diabetics who have profound polydipsia.

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**Pediatric DKA  
Treatment Algorithm**

**Definition of DKA**

- Glucose > 200
- Ketonuria
- HCO<sub>3</sub> < 15 mEq/L
- pH < 7.3

Consult Pediatric Endocrinology

Arrange Transfer if pH < 7.2

**Labs/Diagnostic with IV placement:**

VBG or ABG  
CBC w/Diff  
Chemistry panel, I Ca, Mg, PO<sub>4</sub>  
UA or POC for ketones  
C-peptide

**Monitors:** Pulse ox, Cardiac  
Assess: GCS

**Subcutaneous Insulin Guidelines**

All listed are U/kg/day which equals Total Daily Dose (TDD)

	No DKA	DKA
<b>Pre-pubertal</b>	0.25-0.5	0.75-1
<b>Pubertal</b>	0.5-0.75	1-1.2
<b>Post-pubertal</b>	0.25-0.5	0.8-1

\*See below for T1D dosing regimen

**\*For T1D regimen divide as follows:**

2/3 of TDD given before breakfast (2/3 is NPH and 1/3 is Lispro (Humalog®))

1/3 (remaining TDD) is divided between pre-dinner & bedtime (1/3 given before dinner as Lispro(Humalog®) and 2/3 given before bedtime as NPH)

**Mild DKA**  
(pH 7.2-7.3, HCO<sub>3</sub> 10-15)

No Vomiting: PO hydration, SQ Insulin (see chart)

Vomiting: NS IV fluid bolus 10ml/kg

SQ insulin per chart

Admit if unable to tolerate POs or unable to get immediate Endocrine follow-up

**Ongoing Monitoring**

Q 1hr: bedside glucose  
VS, I&O  
Neuro – GCS score

Q 2hr: Serum glucose  
VBG  
Electrolytes (basic)

Q 4hr: Ca, Mg, PO<sub>4</sub>  
Urine Ketones

EKG for K>5.5

**Moderate DKA**  
(pH 7.1-7.2, HCO<sub>3</sub> 5-10)  
Or  
**Severe DKA** (pH < 7.1, HCO<sub>3</sub> < 5)

Initial IV bolus 10ml/kg NS x 1 hour

Insulin Drip: < 15kg = 0.05U/kg/hr  
> 15kg = 0.1U/kg/hr

Maintenance IV: 0.9% NS @ 1.5xMaintenance + 20mEq KCL + 20mEq KPO<sub>4</sub> if K<5.5 and pt urinated

Transfer to PICU