

**Pathway Inclusion Criteria:**

- Venous pH < 7.3
- Serum glucose ≥ 200 mg/dL
- Serum bicarbonate < 15
- Ketosis ( $\beta$ -OH-Butyrate ≥ 3 mmol/L or moderate urinary ketones ≥ 40)

**Exclusion Criteria**

**Signs and Symptoms:**

- Polyuria\*
- Polydipsia\*
- Fatigue\*
- Weight loss
- Anorexia
- Nausea
- Vomiting
- Abdominal pain
- Hyperventilation and deep (Kussmaul) respirations

**Differential Diagnosis**

\*Most common

**Initial Assessment**

- Obtain: blood gas, Chem 10,  $\beta$ -OH-butyrate, urinalysis
- Assess dehydration, respiratory and neurologic status
- *Address electrolyte abnormalities based on blood gas*

**If Inclusion Criteria met:**

- NPO
- Obtain IV access x2
- Infectious concerns: CBC, UA, blood & urine cx
- Calculate Corrected Na  
*Measured Na<sup>+</sup> + 1.6(serum glucose-100)/100*

**Concerns for Cerebral Edema?**

Yes

**1) Administer**

- 3% hypertonic saline (5 mL/kg/dose)  
or  
Mannitol (1 g/kg/dose)  
*Beware of diuresis in severely dehydrated patient*
- 2) Consider CT scan**  
(Administer mannitol or hypertonic saline PRIOR)

No

**POC glucose > 600 mg/dL or "high" reading?**

Yes

**Concerning for Hyperosmolar-DKA**

- Requires greater fluid resuscitation than DKA
- Greater risk of complications
- Stabilize circulation prior to initiating insulin

No

**Rehydration**

- 10-20 mL/kg NS over 30-60 minutes
- Then assess need for an additional IVF boluses (ex: signs of shock)

**Rehydration**

- 20 mL/kg NS over 30-60 minutes
- *Additional fluid boluses* should be given rapidly if necessary to restore peripheral perfusion

**Continued Management**

- If insulin pump in place, remove when starting IV insulin
- Check blood glucose (BG) prior to starting insulin

**Initiate IV insulin after completing initial rehydration**

*Start at 0.05 u/kg/hr if ≤ 5 years OR concern for hyperosmolar DKA*

**Start "2 Bag System" IVF at 1.5 x maintenance rate**

*Can base on blood gas results*

**Correct electrolyte abnormalities**

**Adjust "2 bag system" for changes in BG**

- Labs:
  - Q 1 hour BG
  - Q 2 hours Electrolytes, blood gas

*Aim to ↓ BG by 50-100 mg/dL per hour*

**Not Recommended**

- Sodium bicarbonate
- Insulin bolus

**Disposition Recommendations**

**Requires PICU care?**

Yes

Admit to PICU

No

Admit to Endocrinology

# Inclusion & Exclusion Criteria

## **Inclusion Criteria for DKA (moderate risk for cerebral edema, requiring intravenous fluids and insulin drip)**

- Age 12 months - 21 years
- Blood glucose  $\geq$  200-600 mg/dL
- Ketosis ( $\beta$ -OH-Butyrate  $\geq$  3 mmol/L or moderate urinary ketones  $\geq$ 40)
- Venous pH  $<$ 7.3 or serum bicarbonate  $<$  15 mEq/L

## **Inclusion Criteria for Hyperosmolar-DKA (moderate-high risk for cerebral edema, requiring intravenous fluids and insulin drip)**

- Age 12 months - 21 years
- Blood glucose  $>$  600 mg/dL
- Ketosis ( $\beta$ -OH-Butyrate  $\geq$  3 mmol/L or moderate urinary ketones  $\geq$ 40)
- Venous pH  $<$ 7.2 or serum bicarbonate  $<$  15 mEq/L
- Serum osmolality  $>$  320 mOsm/kg

\*Criteria apply when conditions met at any time during referring facility stay or NCH.

**If patient has signs of DKA but does not meet inclusion criteria, off pathway but discuss with Endocrinology Team.**

## **Exclusion Criteria**

- Inclusion criteria not met  
(see Sick Day Protocol for patients deemed to be low risk and contact Endocrinology)
- Hyperglycemic Hyperosmolar State (HHS) – must meet all:
  - Blood glucose  $>$  600 mg/dL
  - Venous pH  $>$  7.25
  - Serum bicarbonate  $\geq$  15 mEq/L
  - Absent to small urine ketones
  - Serum osmolality  $>$  320 mmol/kg

[Algorithm](#)

# Initial Assessment

- Airway, Breathing & Circulation (A,B,C's)
- Vital signs
- Hydration status
- Presence of signs of increased intracranial pressure:
  - Pupil asymmetry
  - ↑ blood pressure
  - ↓ heart rate
- Assess for shock as part of circulation assessment

[Assessment of Dehydration](#)

[Cerebral Edema](#)

| Normal Respiratory Rates   |                           |
|--|---------------------------|
| Age  | Rate (breaths per minute) |
| Infant   | 30-53                     |
| Toddler  | 22-37                     |
| Preschooler  | 20-28                     |
| School-age   | 18-25                     |
| Adolescent   | 12-20                     |
| 2020 American Heart Association<br>Pediatric Advanced Life Support |                           |

| Normal Heart Rates   |                  |                     |
|--|------------------|---------------------|
| Age  | Awake Rate (bpm) | Sleeping rate (bpm) |
| Neonate  | 100-205          | 90-160              |
| Toddler  | 100-180          | 90-160              |
| Preschooler  | 80-120           | 65-100              |
| School-age   | 75-118           | 58-90               |
| Adolescent   | 60-100           | 50-90               |
| 2020 American Heart Association<br>Pediatric Advanced Life Support |                  |                     |

| Normal Blood Pressures   |                  |                   |                       |
|--|------------------|-------------------|-----------------------|
| Age  | Systolic (mm Hg) | Diastolic (mm Hg) | Mean Arterial (mm Hg) |
| Neonate  | 67-84            | 35-53             | 45-60                 |
| Infant (1-12mo)  | 72-104           | 37-56             | 50-62                 |
| Toddler (1-2 y)  | 86-106           | 42-63             | 49-62                 |
| Preschooler (3-5 y)  | 89-112           | 46-72             | 58-69                 |
| School age (6-9 y)   | 97-115           | 57-76             | 66-72                 |
| Preadolescent (10-12 y)  | 102-120          | 61-80             | 71-79                 |
| Adolescent   | 110-131          | 64-83             | 73-84                 |
| 2020 American Heart Association<br>Pediatric Advanced Life Support |                  |                   |                       |

[Algorithm](#)

# Assessment of Dehydration

| Signs and Symptoms  | Degree of Dehydration      |                           |   |
|---|----------------------------|---------------------------|---|
|   | None or Mild               | Moderate                  | Severe  |
| <b>General Condition</b>  |                            |                           |   |
| <b>Infants</b>  | Thirsty, alert, restless   | Lethargic or drowsy       | Limp; cold cyanotic extremities; may be comatose        |
| <b>Children</b>   | Thirsty, alert, restless   | Alert; postural dizziness | Apprehensive; cold, cyanotic extremities; muscle cramps |
| <b>Quality of radial pulse</b>  | Normal                     | Thready or weak           | Feeble or impalpable                                    |
| <b>Quality of respiration</b>   | Normal                     | Deep                      | Deep and rapid  |
| <b>Skin elasticity</b>  | Pinch retracts immediately | Pinch retracts slowly     | Pinch retracts very slowly (> 2 sec)                    |
| <b>Eyes</b>   | Normal                     | Sunken                    | Very sunken   |
| <b>Tears</b>  | Present                    | Absent                    | Absent  |
| <b>Mucous membranes</b>   | Moist                      | Dry                       | Very dry  |
| <b>Urine output (parental report)</b>   | Normal                     | Reduced                   | None passed in many hours                               |
| Adapted from Gorelik MH, Shaw KN, Murphy KO. Validity and reliability of clinical signs in the diagnosis of dehydration in children. Pediatrics. 1995;99(5):1-6 |                            |                           |   |

[Algorithm](#)

# Differential Diagnosis

## Differential Diagnosis

- Hyperglycemic Hyperosmolar State (HHS)\*
- Lactic Acidosis
- Starvation Ketosis
- Alcoholic Ketoacidosis
- Uremic Acidosis
- Toxic Ingestion

### \*HHS Laboratory Definition (Must have all)

- Serum glucose > 600 mg/dL
- Absent to small urine ketones
- Serum osmolality > 320 mmol/kg
- Venous pH > 7.25
- Serum carbon dioxide  $\geq$  15 mEq/L

[Algorithm](#)

# Hyperosmolar DKA

## For Comparison, Moderate-Severe DKA and Hyperosmolar DKA

| <b>DKA<br/>(moderate-severe)</b>  | <b>Hyperosmolar DKA<br/>(requires greater fluid resuscitation than DKA)</b>  |
|---|--|
| <ul style="list-style-type: none"><li>• Blood glucose <math>\geq</math> 200-600 mg/dL</li><li>• Ketosis (<math>\beta</math>-OH-Butyrate <math>\geq</math> 3 mmol/L)</li><li>• Moderate urinary ketones (<math>\geq</math>40+)</li><li>• Venous pH <math>&lt;</math>7.3</li><li>• Serum bicarbonate <math>&lt;</math> 15 mEq/L</li></ul> | <ul style="list-style-type: none"><li>• Blood glucose <math>&gt;</math> 600 mg/dL</li><li>• Ketosis (<math>\beta</math>-OH-Butyrate <math>\geq</math> 3 mmol/L)</li><li>• Moderate urinary ketones (<math>\geq</math>40+)</li><li>• Venous pH <math>&lt;</math>7.2</li><li>• Serum bicarbonate <math>&lt;</math> 15 mEq/L</li><li>• Serum osmolality <math>&gt;</math> 320 mOsm/kg</li></ul> |

## Hyperosmolar DKA carries greater risk of complications than DKA:

- Shock with hemodynamic compromise
- Altered mental status
- Severe hypokalemia and hypophosphatemia
- Kidney injury
- Rhabdomyolysis
- Pancreatitis
- Thrombosis
- Malignant hyperthermia-like syndrome (fever, rhabdomyolysis and high mortality rates – can treat with Dantrolene)

[Algorithm](#)

# Severity Assessment for Risk of Developing Cerebral Edema & Recommended Disposition

## Low Risk Criteria

- pH  $\geq 7.2$
- serum carbon dioxide  $\geq 15$  mEq/L
- Able to tolerate oral fluids.
- Decreasing ketonuria (management initiated at home with sick day protocol)

### Disposition\*

Able to manage mild acidosis at home (per sick day protocol) if knowledgeable caregiver and able to easily return to main campus, if needed. Call Endocrinology on call provider to discuss disposition to admit versus discharge home.

***\*All patients with suspected New Onset Diabetes Mellitus should be admitted to the endocrinology service.***

## Medium Risk Criteria

- Not meeting low or high risk criteria
- Progression of ketonuria precluding home management
- Unable to tolerate oral challenge even in mild DKA
- Presence of unstable social situation

### Disposition

Admit to Endocrinology Service for IV insulin therapy after discussion with on call Endocrinology Provider.

## High Risk Criteria

- Lowest pH  $< 7.1$  age  $< 3$  years
- Lowest pH  $< 7.0$  age  $\geq 3$  years
- Blood glucose  $> 600$  mg/dL
- Corrected Serum Sodium  $> 155$  mEq/L
- New onset neurological deficit
- Clinical or radiographic concerns for cerebral edema

**Cerebral Edema**

### Disposition

Consider pediatric intensive care unit (PICU) for IV insulin therapy and ongoing monitoring. Strongly consider PICU admission based on labs at initial presentation.

**Algorithm**

# Cerebral Edema

## Risk Factors & Clinical Signs & Management

### Risk Factors for Cerebral Edema

- Age < 3 years
- Administration of bicarbonate
- Low PaCO<sub>2</sub> levels at presentation
- Excessive fluid resuscitation ( $\geq 40$  mL/kg bolus)

### Clinical Signs of Cerebral Edema

- Concerning or deteriorating mental status
- Headache
- Abnormal pupils
- Bradycardia or lower heart rate than expected for degree of dehydration\*
- Hypertension\*
- Altered breathing pattern (grunting, Cheyne-Stokes, apneusis)\*

\*When seen together are late signs and concerning for herniation

### Management of Suspected or Confirmed Cerebral Edema

**1) Administer:**

**3% hypertonic saline** (5 mL/kg/dose)

or

**Mannitol** (1 g/kg/dose) *Beware of diuresis in severely dehydrated patient.*

**2) Elevate head of bed**

**3) Discuss indications for CT scan with PICU** (administer mannitol or hypertonic saline **PRIOR**)

[Algorithm](#)

# Electrolyte Management

## Sodium (Na<sup>+</sup>)

|   |   |
|---|---|
| Corrected sodium calculation<br>Measured Na + 1.6 (serum glucose – 100)/100 | Useful for monitoring response to fluid therapy during DKA when hyperglycemia exists (glucose >100 mg/dL) |
| For corrected Na <sup>+</sup> < 140 mEq/L                                   | Maintenance fluid containing Normal Saline should be used if not started prior                            |
| For corrected Na <sup>+</sup> < 125 mEq/L                                   | Consider 3% Sodium Chloride   |

## Potassium (K<sup>+</sup>)

- For potassium < 3.0, give KCL 0.2-1 mEq/kg/dose (max 40 mEq) during initial fluid resuscitation. Recheck potassium level via poc blood gas to ensure ≥ 3.0 *prior to stating insulin drip*
- Include K<sup>+</sup> in continuous IV fluids at the time of initiation, unless true hyperkalemia (> 6 mmol/L) exists
- Adequate urine output should be demonstrated prior to initiating K<sup>+</sup> replacement

|  |   |
|--|---|
| For K <sup>+</sup> replacement, administer as <u>KPhos</u> and KCl <sup>-</sup> preferably | If <u>KPhos</u> unavailable, use K <sup>+</sup> acetate |
|--|---|

Suggested potassium components for continuous IV fluids

| <u>Serum K<sup>+</sup></u> | <u>KPhos (mEq/L)</u> | <u>KCL<sup>-</sup> (mEq/L)</u> |
|----------------------------|----------------------|--------------------------------|
| <4.5                       | 30                   | 30                             |
| 4.5-6                      | 20                   | 20                             |
| >6                         | None                 | None                           |

For hyper or hypokalemia, have patient on continuous ECG monitoring

**For hyperkalemia, please refer to the ED Hyperkalemia Clinical Pathway**

## Calcium (Ca<sup>++</sup>), Phosphorous (PO<sub>4</sub><sup>3-</sup>)

Closely observe calcium levels with KPhos administration since hypocalcemia may be induced

|  |   |
|--|---|
| Treat severe hypophosphatemia (Phos <1mg/dl) | Important especially if this is accompanied by clinical features (muscle weakness, cardiac dysfunction specifically, left ventricular dysfunction, symptomatic anemia, or respiratory depression) |
|--|---|

## Bicarbonate (HCO<sub>3</sub><sup>-</sup>)

Avoid routine HCO<sub>3</sub><sup>-</sup> administration since paradoxical CNS acidosis may develop & hypokalemia may be precipitated

*In life threatening hyperkalemia bicarbonate therapy may be administered*

[Algorithm](#)

# Recommended Treatments for Medium or High Risk Patients

## Intravenous Fluid (IVF) Administration & IV Insulin Phase *Fluid administration and IV insulin therapy occurs simultaneously*

### IVF administration:

- 1.5 X maintenance rate

For potassium < 3.0, give KCL 0.2-1 mEq/kg/dose (max 40 mEq) during initial fluid resuscitation. Recheck potassium level via POC blood gas to ensure  $\geq 3.0$  *prior to starting insulin drip*

### Two-Bag system:

- 10% Dextrose in NS
- NS

Calculation of maintenance IVF by 4, 2, 1 rule:

- 4 mL/kg/hour for first 10 kg
- 2 mL/kg/hour for second 10 kg mL/kg
- 1mL/kg/1mL/kg/hour for each kg over 20kg

### Insulin drip:

- Children  $\leq 5$  years of age OR concern for hyperosmolar DKA start insulin at rate of 0.05 unit/kg/hour
  - *Insulin drip rate may need to be adjusted for those children > 5yo if initial serum BG or electrolytes (serum osmolality < 320 mOsm/kg) do not support hyperosmolar DKA.*
- Children > 5 years of age start insulin drip at rate of 0.1 unit/kg/hour
- Aim to maintain BG between 150-250 mg/dL while patient is receiving insulin drip

### Adjust IVF composition based on BG:

- If BG decreases by more than 100 mg/dL in an hour, increase dextrose in IVF to higher concentration. If already on 10%, increase to 12.5%
- If BG is < 100 mg/dL, increase total IVF to 2 X maintenance or discontinue two-bag system and give dextrose 12.5% with same electrolyte content
- Recheck BG in 30 minutes after a change in IVF dextrose or adjustment of IV insulin

### Suggested potassium components for continuous IV fluids:

| <u>Serum K<sup>+</sup></u> | <u>KPhos (mEq/L)</u> | <u>KCL<sup>-</sup> (mEq/L)</u> |
|----------------------------|----------------------|--------------------------------|
| <4.5                       | 30                   | 30                             |
| 4.5-6                      | 20                   | 20                             |
| >6                         | None                 | None                           |

| Blood glucose (mg/dl) | 10 % Dextrose NS % of total IV fluids | Final dextrose concentration | Normal Saline % of total IV fluids |
|-----------------------|---------------------------------------|------------------------------|------------------------------------|
| > 300                 | 0                                     | 0                            | 100                                |
| 200- 300              | 50                                    | 5 %                          | 50                                 |
| 101- 199              | 100                                   | 10 %                         | 0                                  |

**Algorithm**

# Treatments Not Recommended

## **Bicarbonate therapy should not be used in children with DKA**

- Lack of clinical benefit
- Paradoxical central nervous system acidosis
- Associated with development of cerebral injury
- May slow the resolution of ketosis

## **Insulin bolus is not indicated**

- No clinical benefit
- May increase risk of cerebral edema
- May lead to hypoglycemia

## **Algorithm**

Rosenbloom AL. The management of diabetic ketoacidosis in children. *Diabetes Ther.* 2010;1(2):103-120.  
Cashen K, Petersen T. Diabetic ketoacidosis. *Peds in Review.* 2019. 412-420.

# PICU Admission Criteria

**PICU admission for any of the following:**

- New onset neurologic deficit
- Concern for cerebral edema

**Strongly consider PICU admission**

- pH < 7.1 for age < 3 years old
- pH < 7.0 for age ≥ 3 years old
- Initial blood glucose > 1000 mg/dL
- Corrected serum sodium > 155 mEq/L

[Algorithm](#)

# Quality Measures

## Process Metrics:

- Pathway visualization
- Utilization of Epic Order Set
- Blood glucose obtained within 30 minutes prior to departure from ED

## Outcome Metrics:

- Zero incidence of hypoglycemia (BG<60) during ED care
- Emergency Department length of stay

## Balancing Measures:

- Rate of inpatient transfer to the PICU within 6 hours of admission
- Return to Emergency Department/Urgent Care for diabetes related concern within 72 hours

[Algorithm](#)

# Key References

- Wolfsdorf JI, Glaser N, Agus M, et al. ISPAD Clinical Practice Consensus Guidelines 2018: diabetic ketoacidosis and the hyperglycemic hyperosmolar state. *Pediatr Diabetes*. 2018;19(Suppl 27):155-177.
- Kuppermann N, Ghetti S, Schunk J, Stoner MJ, et al. Clinical trial of fluid infusion rates for pediatric diabetic ketoacidosis. *N Engl J Med*. 2018;378(24):2275-2287. doi:10.1056/NEJMoa1716816.
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- Zeitler P, Schwartz S, Johnson R, et al. Hyperglycemia hyperosmolar syndrome in children: pathological considerations and suggested guidelines for treatment. *J Pediatr*. 2010;156(1):9-14.

[Algorithm](#)

# Pathway Team & Process

## Pathway Development Team

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Advisory Committee Date: *July, 2022*

Origination Date: *July, 2022*

Last Revision Date: *October, 2023*

Next Revision Date: *October, 2028*

## Clinical Pathway Development

This clinical pathway was developed using the process described in the NCH Clinical Pathway Development Manual Version 6, 2022. Clinical Pathways at Nationwide Children's Hospital (NCH) are standards which provide general guidance to clinicians. Patient choice, clinician judgment, and other relevant factors in diagnosing and treating patients remain central to the selection of diagnostic tests and therapy. The ordering provider assumes all risks associated with care decisions. NCH assumes no responsibility for any adverse consequences, errors, or omissions that may arise from the use or reliance on these guidelines. NCH's clinical pathways are reviewed periodically for consistency with new evidence; however, new developments may not be represented, and NCH makes no guarantees, representations, or warranties with respect to the information provided in this clinical pathway.

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**Algorithm**