Diabetic Ketoacidosis (DKA)

Inpatient

Nationwide Children's — When your child needs a hospital, everything matters.

Center for Clinical Excellence

Inclusion Criteria

- Age >12 months
- Hyperglycemia with serum glucose ≥200 mg/dL
- Venous pH <7.3 or serum carbon dioxide <15 mEq/L
- Ketosis (β-OH-Butyrate ≥ 1 mmol/L) or moderate urinary ketones (≥40+)

Exclusion Criteria

- Hyperglycemic Hyperosmolar State (HHS)
- Patient in the ICU

Admit to Endocrinology Service

Consult Endocrinology if already admitted to another service.

Definitions & Diagnostic Criteria

Differential Diagnosis

Initial Assessment and Management

- Verify DKA diagnosis and rule out HHS
- NPO
- Focused history & exam (ABCs) to evaluate for:
  - Dehydration
  - Cerebral edema
  - Shock (hypovolemic, infectious)

Concern for Shock *or* Cerebral edema?

No

Initial Labs

- If >2hrs since last labs, obtain capillary blood gas (CBG), renal function panel (RFP), Mg and POCT β-OH-butyrate

- Complete Admission H&P (ADMITHP)

- If tachycardic or with recurrence of tachycardia after ED resuscitation, notify on call Endocrinology to discuss **additional IVF rehydration**

Continue insulin infusion (started in ED)

- Remove insulin pump if still in place

Continue "2 Bag System" IVF at 1.5 x maintenance rate

- Adjust "2 Bag System" for changes in blood glucose
- Give first dose of Basal Insulin on admission (unless last dose given within 24 hours) and then schedule Q24H

- Resident and RN to monitor for clinical improvement and deterioration
- Lab schedule:
  - Q1H – POCT BG
  - Q2H – Renal Function Panel (RFP), Mg, CBG, POCT β-OH-butyrate
- Correct electrolyte abnormalities
- After 4-6 hours on continuous insulin infusion, consider changing Normal Saline (NS) to ½ NS if normal neurologic status AND corrected Na >140 AND calculated serum Osm < 320
  - *Serum Osmolality (mOsm/kg) = 2 x [Na] + [Glucose/18] + [BUN/2.8]*
  - *Corrected Na = measured Na + 0.016 * (serum glucose -100)*

Go to Subcutaneous Insulin & Discharge when:

- Patient awake, alert, and hungry
  and
- Anion gap <12 ***or*** POCT β-OH-butyrate < 1.0 mmol/L ***or*** serum HCO_3 >15
  Anion gap = measured Na-Cl-HCO_3

Yes

- **Call ACT, then call Endocrinology**
  - Transfer to PICU as indicated
  - If **shock,** start IVF resuscitation with NS bolus push-pull, 20 mL/kg, max 1 liter
  - If **concern for** cerebral edema and herniation:
    - Elevate head of bed to 30°
    - Consider mannitol (1g/kg/dose) or 3% saline (5mL/kg/dose)
    - Beware of diuresis in severely dehydrated patients if giving mannitol
    - Consider CT head after mannitol or 3% saline given and patient stable

Escalation of Care

- RN to notify resident of any concern
- Focused exam (ABCs) to evaluate for:
  - Severe dehydration/shock
  - Cerebral edema

Monitoring by Nursing

- Vital signs and Neuro Checks Q1H
- Strict I/O
- Concerning symptoms:
  - Headache, abnormal breathing/ grunting/gasping, abnormal pupils
- **Ongoing communication with bedside caregiver/parent** for any concern about patient's symptoms and/or behavior is encouraged

Bicarbonate or insulin bolus administration has no benefit but potential risks

Inclusion & Exclusion Criteria

- Inclusion criteria, meeting ALL of below:
  - Age >12 months
  - Hyperglycemia with serum glucose ≥ 200 mg/dL
  - Venous pH <7.3 or serum carbon dioxide < 15 mEq/L
  - Ketosis (β-OH-Butyrate ≥ 1 mmol/L or moderate urinary ketones (≥40)

- Exclusion criteria*
  - **Hyperglycemic Hyperosmolar State (HHS)**
  - Pt in the ICU

* Components of criteria are at any point in time during presentation whether at NCH or non NCH facility.

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Definitions & Diagnostic Criteria

- **Diabetic Ketoacidosis (DKA)** can occur at new onset of any type of diabetes and can occur at any time after initial diagnosis (e.g. in the setting of illness, stress or missed insulin dosing). Presenting symptoms can include nausea, vomiting, abdominal pain, deep breathing (Kussmaul respirations), altered mental status and/or coma.
  - **Defined** as:
    - Glucose ≥ 200 mg/dL* AND
    - Ketosis (β-OH-butyrate) ≥ 1 mmol/L AND
    - Venous pH <7.3 or serum bicarbonate <15 mEq/L

*If initial glucose **> 600 mg/dL**, this is termed "hyperosmolar DKA" or "mixed HHS/DKA"

  - **Severity** of DKA is based on initial labs at presentation and can help to predict which patients are at higher risk of complications (e.g. electrolytes abnormalities and cerebral edema more likely to be present in severe DKA)

Severity	pH	Serum Carbon Dioxide
Mild	7.20 – 7.29	10 - 14
Moderate	7.10 – 7.19	5 - 9
Severe	< 7.10	< 5

- **Hyperglycemic Hyperosmolar State (HHS)**
  - Defined as:
    - Serum glucose > 600 mg/dL AND
    - Venous pH > 7.3 AND
    - Serum bicarbonate > 15 mEq/L AND
    - Absent to small urine ketones AND
    - Serum osmolality > 320 mOsm/kg

Serum Osmolality (mOsm/kg) = 2 x [Na] + [Glucose/18] + [BUN/2.8]

- **Kussmaul Breathing:**
  - Characteristics: Continuous deep and rapid breaths without periods of apnea.
  - Cause: Often associated with severe metabolic acidosis, such as DKA or kidney failure.
  - Significance: Indicates a serious metabolic disturbance requiring immediate medical intervention

- **Cheyne-Stokes Breathing:**
  - Characteristics: Alternates between deep, rapid breathing and shallow, slow breathing, with intermittent apnea.
  - Cause: Can be seen in increased intracranial pressure (ICP), traumatic brain injury (TBI) and other neurologic conditions as well as other conditions including congestive heart failure, chronic pulmonary edema or central sleep apnea.
  - Significance: Suggests impaired brainstem function and may indicate serious underlying conditions

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Focused History & Exam

Focused Physical Exam

- Airway, Breathing & Circulation (A,B,C's)
- Vital signs
- Glasgow Coma Scale (GCS)
- Pupils, for asymmetry and response to light

Signs of Clinical Improvement

- Improvement in Kussmaul breathing
- Decreasing HR
- Improvement in mental status (GCS score)

Signs of Clinical Deterioration

Signs of Shock:

- Hypotension
- Tachycardia, worsening or not improving
- Signs of poor perfusion (Hypovolemic), worsening or not improving
- Altered mental status, worsening or not improving

Signs of Cerebral Edema

- Concerning or deteriorating mental status
- New onset neurologic deficit
- 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, these are **late signs** and concerning for herniation.

Risk Factors for Cerebral Edema

- Age < 3 years
- Administration of bicarbonate
- Low $PaCO_2$ levels at presentation
- Excessive fluid resuscitation (≥ 40 mL/kg bolus)

Transfer to PICU as clinically indicated, including the following circumstances:

- Signs of Cerebral Edema or Shock (see above)
- 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

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Glasgow Coma Scale (GCS)

Behavior	Response	Score
Eye Opening Response	Spontaneously	4
	To Speech	3
	To Pain	2
	No Response	1
Verbal Response	Oriented to time, place and person	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
	No response	1
Motor Response	Obeys commands	6
	Moves to localized pain	5
	Flexion withdrawal from pain	4
	Abnormal flexion (decorticate)	3
	Abnormal extension (decerebrate)	2
	No Response	1

Total Score	Best Response	15
	Totally Unresponsive	3

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Differential Diagnosis

- Hyperglycemic Hyperosmolar State (HHS)
- Lactic acidosis
- Starvation ketosis
- Alcoholic ketoacidosis
- Uremic acidosis
- Toxic ingestion

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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

Bolus dose of insulin prior to continuous infusion is not indicated in the treatment of DKA

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

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Insulin Infusion & IV Fluids

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

<u>Serum Potassium MUST be ≥ 3.0, prior to starting continuous insulin infusion.</u>
If serum potassium < 3.0, give KCL 0.2-1 mEq/kg/dose (max 40 mEq), then recheck priority potassium level.

Insulin continuous infusion:

- Children ≤ 5 years of age **OR** concern for hyperosmolar DKA start insulin at rate of 0.05 unit/kg/hour
  - *Insulin continuous infusion 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 continuous infusion at rate of 0.1 unit/kg/hour
- Aim to maintain BG between 150-250 mg/dL while patient is receiving insulin continuous infusion

Two-Bag system:

- Start with:
  - 10% Dextrose in NS
  - NS
- After 4-6 hours on continuous insulin infusion, consider changing NS to ½ NS **if** normal neurologic status **AND** corrected Na >140 **AND** calculated serum Osm < 320
  - *Serum Osmolality (mOsm/kg) = 2 x [Na] + [Glucose/18] + [BUN/2.8]*
  - *Corrected Na = measured Na + 0.016 * (serum glucose -100)*

IVF Starting Rate:

- The combined IVF rate from both IVF bags should equal 1.5 x MIVF rate.

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
- 1mL/kg/hour for each kg over 20 kg

Adjust IVF composition and rate based on Blood Glucose (BG) level:

- Aim to maintain BG between 150-250 mg/dL while patient is receiving insulin continuous infusion

Most Recent Blood Glucose (mg/dL)	Goal Dextrose (%)	Normal Saline (+ additives)	Dextrose 10% (+ additives)
> 300	No Dextrose	1.5 x MIVF rate	1 mL/hr
200 - 300	D5	0.75 x MIVF rate	0.75 x MIVF rate
100 - 199	D10	1 mL/hr	1.5 x MIVF rate
< 100	D10 or D12.5	1 mL/hr	**2x*** MIVF rate *or discontinue 2-bag system and give dextrose 12.5% with same electrolyte content at 1.5x MIVF

- 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 MIVF rate 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

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Management of Electrolyte Abnormalities

Sodium (Na^+)

Corrected sodium calculation: *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^+ < 140 mEq/L	Normal Saline should be used as Maintenance fluid
For corrected Na^+ < 125 mEq/L	Consider ACT; consider 3% Sodium Chloride

Potassium (K^+)

- Adequate urine output should be demonstrated prior to initiating K^+ replacement
- Include K^+ in continuous IV fluids at the time of initiation, unless true hyperkalemia (> 6 mEq/L) exists
- Suggested potassium components for continuous IV fluid (If KPhos unavailable, use K^+ acetate):

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

If **Hypokalemia** (K<3.0):

- Initiate cardiac monitoring and give KCL, dosing per **NCH Electrolyte Infusion Guideline**: 0.2-1 mEq/kg/dose, max 40 mEq with infusion rate of 0.5 mEq/kg/hr, max 20 mEq/hr .
- Recheck priority potassium level to ensure ≥ 3.0 *prior to starting insulin continuous infusion.*

If **Hyperkalemia** (K ≥ 6):

- If hemolyzed sample, confirm non-hemolyzed hyperkalemia by venous blood draw or K^+ priority sample and obtain EKG to evaluate for peaked T waves. Manage per **IP Hyperkalemia Clinical Pathway**
- Despite total body potassium depletion, patients with DKA often present with elevated serum K^+ levels initially due to the shift of intracellular potassium driven by acidosis and insulin deficiency.

Calcium (Ca^{++}), Phosphorous (PO_4^{3-})

Monitor serum calcium (RFP Q2H) with KPhos administration since hypocalcemia may be induced. Discuss iv calcium bolus with Endocrinology fellow or attending if serum Ca is <7.

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 ($HCO3^-$)

Avoid routine $HCO3^-$ administration since paradoxical CNS acidosis may develop & hypokalemia may be precipitated

In life threatening hyperkalemia bicarbonate therapy may be administered

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Basal & Bolus Insulin Dosing

Definitions

- **Basal insulin:** long-acting insulin given Q24H (examples include Glargine (Lantus) & Degludec (Tresiba))
- **Bolus insulin:** rapid-acting insulin given for carbohydrate coverage, hyperglycemia and/or ketones (examples include Lispro (Humalog) & Aspart (Novolog))
- **Total Daily Dose (TDD):** estimated total insulin dose per day required by patient (includes basal and bolus insulin)
- **Carb ratio:** Estimate of grams of carbohydrates covered by 1 unit of bolus insulin
  - TDD is used to determine carb ratio as follows: 500/TDD
- **Correction/Sensitivity Factor (CF):** Estimate of BG decrease with 1 unit of bolus insulin
  - TDD is used to determine correction factor as follows: 1500/TDD
- **Ketone correction:** Estimate of additional BOLUS insulin needed to treat ketones. Dose calculated as a percentage of daily BASAL.
  - Typically, 5% for small ketones, 20% for moderate ketones, 30% for large ketones.
- **Target BG:** Typically 120mg/dL

Basal Insulin Dose Calculations

- Patient with **new onset** diabetes, calculate **basal insulin dose** as follows:

Patient Age	**Total Daily Dose (TDD)** (using actual body weight)	**Basal Insulin Dose**
1-3 years old	0.3 units/kg	50% of TDD
3-5 years old	0.5 units/kg	50% of TDD
6-11 years old	0.7 units/kg	50% of TDD
12 years and older	1 unit/kg	50% of TDD

- Patient with **known diabetes and home insulin regimen given by injections**, give home basal insulin type & home dose 24H from last dose given by family. If family does not know if or when last basal dose given, administer home basal insulin type & dose now

- Patient with **known diabetes on home insulin regimen given by pump**, discuss appropriate basal insulin dose and timing with endocrinologist on-call

Bolus Insulin Dose Calculation

*Epic "Insulin Calculator" is to be used for patients who require subcutaneous (or insulin pump) dosing of short-acting insulin therapy. Do **NOT** use the insulin calculator for an insulin continuous infusion or long-acting insulin dosing (such as Lantus).*

- Bolus insulin dose = [Carb intake/Carb ratio]
  - + hyperglycemia correction [(Current BG-Target BG)/CF] as needed
  - + Ketone correction as needed

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Subcutaneous Insulin & Discharge

DKA resolved when:

- Patient awake, alert, and hungry

and

- Anion gap* <12 ***or*** POCT β-OH-butyrate < 1.0 mmol/L ***or*** serum HCO_3 >15

*anion gap: measured Na-Cl-HCO_3

Transition to Subcutaneous Insulin:

- Obtain pre-meal POCT BG and β-OH-butyrate, 15 minutes or less prior to first meal at transition
- Allow patient to eat
- Administer subcutaneous **bolus insulin** for carbs eaten, hyperglycemia and residual ketones
- Turn off IV insulin infusion 15 min after subcutaneous bolus insulin administration
- IVF should be discontinued after DKA resolves and patient transitioned to subQ insulin. If patient is tachycardic or hypotensive and/or not taking adequate PO fluids, dextrose-containing IVF should be continued to manage residual ketosis.

Lab Monitoring After Transition to Subcutaneous Insulin:

- POCT BG qAC, qHS, qMN, q3am
- POCT β-OH-butyrate concurrent with POCT BG until POCT β-OH-butyrate is < 0.6mmol/L x 1
- RFP + Mg 4hrs after discontinuation of insulin infusion

Discharge when meeting criteria:

- Education (as needed) completed by:
  - Diabetes Nurse Educator
  - Registered Dietician
  - Social Work
  - Therapeutic Recreation
  - Psychology
- All prescriptions sent
- School orders sent
- Follow-up appointments set
- AVS completed

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Quality Measures

Goal

- Providing efficient inpatient care for patients with DKA while minimizing risk of complications.

Quality Measures

Process:

- Utilization of Order Set

Outcome:

- LOS
- Reduce incidence of hyperchloremic metabolic acidosis
- Reduce the time on continuous insulin infusion

Balancing:

- Frequency of Hypokalemia, Hypoglycemia while on insulin infusion
- Floor to ICU transfer rates
- Number of patients requiring restart of insulin continuous infusion after discontinuation
- Administration of 3% saline or mannitol prior to ACT arrival

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References

1. Glaser N, Fritsch M, Priyambada L, et al. ISPAD clinical practice consensus guidelines 2022: Diabetic ketoacidosis and hyperglycemic hyperosmolar state. *Pediatr Diabetes.* 2022;23(7):835-856. doi:10.1111/pedi.13406.

2. Shankar V, Haque A, Churchwell KB, Russell W. Insulin glargine supplementation during early management phase of diabetic ketoacidosis in children. *Intensive Care Med.* 2007;33(7):1173-1178. doi:10.1007/s00134-007-0674-3.

3. Hsia E, Seggelke S, Gibbs J, et al. Subcutaneous administration of glargine to diabetic patients receiving insulin infusion prevents rebound hyperglycemia. *J Clin Endocrinol Metab*. 2012;97(9):3132-3137. doi:10.1210/jc.2012-1244.

4. Mohamed A, Ploetz J, Hamarshi MS. Evaluation of Early Administration of Insulin Glargine in the Acute Management of Diabetic Ketoacidosis. *Curr Diabetes* Rev. 2021;17(8):e030221191986. doi:10.2174/1573399817666210303095633.

5. Thammakosol K, Sriphrapradang C. Effectiveness and safety of early insulin glargine administration in combination with continuous intravenous insulin infusion in the management of diabetic ketoacidosis: A randomized controlled trial. *Diabetes Obes Metab.* 2023 Mar;25(3):815-822. doi: 10.1111/dom.14929.

6. Kuppermann N, Ghetti S, Schunk JE, Stoner MJ, Rewers A, McManemy JK, Myers SR, Nigrovic LE, Garro A, Brown KM, Quayle KS, Trainor JL, Tzimenatos L, Bennett JE, DePiero AD, Kwok MY, Perry CS 3rd, Olsen CS, Casper TC, Dean JM, Glaser NS; PECARN DKA FLUID Study Group. Clinical Trial of Fluid Infusion Rates for Pediatric Diabetic Ketoacidosis. *N Engl J Med.* 2018 Jun 14;378(24):2275-2287. doi: 10.1056/NEJMoa1716816.

7. Seattle Children's Hospital, Gupta, M., Alanis R., Brumm, M., Burns, B., Courtney, A., Crandall, C., Hoffer, D., Rakes, L., Rasiah, J., Slater, A., Migita, D. (2024, November 13). *Diabetic Ketoacidosis (DKA) Pathway*. Available from: **https:www.seattlechildrens.org/pdf/DKA-pathway.pdf**

8. Harrison VS, Rustico S, Palladino AA, Ferrara C, Hawkes CP. Glargine co-administration with intravenous insulin in pediatric diabetic ketoacidosis is safe and facilitates transition to a subcutaneous regimen. *Pediatr Diabetes*. 2017;18(8):742-748. doi:10.1111/pedi.12462.

9. Doshi P, Potter AJ, De Los Santos D, Banuelos R, Darger BF, Chathampally Y. Prospective randomized trial of insulin glargine in acute management of diabetic ketoacidosis in the emergency department: a pilot study. *Acad Emerg Med.* 2015;22(6):657-662. doi:10.1111/acem.12673.

10. Children's Hospital Colorado, Topoz, I., Braund, C., Rewers, A., et al. July 2021. *Diabetic Ketoacidosis (DKA).* **https://www.childrenscolorado.org/globalassets/healthcare-professionals/clinical-pathways/diabetic-ketoacidosis.pdf**

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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 associates 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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