Algorithm for the Management of Diabetic Ketoacidosis (DKA)

Immediate Assessment

Clinical History
- Polyuria
- Polydipsia
- Weight loss
- Abdominal pain
- Fatigue

Clinical Signs
- Assess dehydration
- Polyuria
- Polydipsia
- Vomiting
- Confusion
- Lethargy/drowsiness + vomiting
- Smell of ketones
- Deep sighing respiration (Kussmaul)

DKA diagnosis confirmed by initial labs:
- Hyperglycemia with glucose greater than (>200 mg/dL
- pH less than (<)7.3 or HCO3 less than (<)15, and
- Ketoneemia or ketonuria

Contact diabetes physician

Shock?
- Yes
  - Shock (reduced peripheral pulses)
  - Reduced conscious level/coma

- No
  - Not in shock
  - Dehydration greater than (>5%)

Resuscitation
- Airway + NG tube
- Breathing (100% oxygen)
- Circulation (0.9% saline 10-20 ml/kg over 1-2hr and repeat until circulation is restored. Do not exceed 40mL/Kg)

Initial Interventions
- Saline 0.9% 10-20 ml/kg bolus
- Obtain ECG if K is over 6 or under 3 mEq/L
- Start regular insulin IV at 0.1 units/kg/hour after bolus complete
- IV fluids at 1.5X maintenance

Monitoring
- Hourly POC blood glucose
- Strict I/Os
- Neurological status at least hourly
- VBG and BMP q2-4 hours
- Obtain ECG if K is over 6 or under 3

If acidosis not improving or If deterioration, Contact diabetes physician

Re-evaluate
- IV fluid calculations
- Insulin delivery system and dose
- Need for additional resuscitation
- Consider sepsis

DKA Resolution
- pH greater than (>7.3
- Serum bicarbonate greater than (>18 mEq/L
- Clinically well, tolerating oral fluids

Transition to SC insulin
- Contact diabetes physician for doses and timing

If neurological WARNING SIGNS
- headaches, slowing heart rate, irritability, decreased conscious level, incontinence, or specific neurological signs are present

- Then, exclude hypoglycemia
- Is it cerebral edema?

Management
- Elevate head of bed
- Give mannitol 0.5-1.0 g/kg or hypertonic saline
- Restrict IV fluids by one-third
- Contact ICU and diabetes physician
- Consider cranial imaging only after patient stabilized

*Potassium Supplementation Table

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See potassium supplementation table above
SUMMARY

Diabetic ketoacidosis (DKA) is a life-threatening medical emergency requiring immediate evaluation and treatment. Please notify the diabetes physician on call through One Call for all patients with known or suspected DKA.

DIAGNOSIS

• **Triage Assessment** in the Emergency Department
  o Triage as Level 2
  o Immediate clinical evaluation
  o Vital signs
  o History regarding presentation

• **DKA is defined by:**
  o Hyperglycemia with blood glucose (BG) greater than 200 mg/dL, and
  o pH less than (<) 7.3 or HCO3- less than (<) 15 mEq/L, and
  o Ketonemia or ketonuria

• **Monitoring**
  o Vital signs
  o Neurologic assessment including Glasgow Coma Scale
  o Point-of-care blood glucose (POC BG)

TREATMENT

• **Clinical Management in the Emergency Department or Urgent Care**
  o Place IV
  o Place cardio-respiratory monitors
  o NPO
  o Initial labs: venous blood glucose (VBG), basic metabolic panel (BMP), Mg, Phos, beta-hydroxybutyrate (BOHB), urinalysis (UA), hemoglobin A1C
  o Place orders using the ED DKA order set: insulin, intravenous fluids (IVF), lab monitoring

• **Suspect cerebral edema** if patient has the following:
  o Persistent vomiting, severe headache, mental status changes, GCS less than 13, or focal neurologic abnormalities

• **Inpatient Clinical Management**
  o Vital signs monitoring and neurologic checks
  o Maintain on cardio-respiratory monitors
  o Place orders using the ED DKA order set: insulin, intravenous fluids (IVF), lab monitoring

• **Transition to subcutaneous insulin**
  o Timing
  o Types of insulin
### TARGET POPULATION

**Inclusion Criteria**
- Children up to 21 years of age
- Patients referred for admission for diabetic ketoacidosis
- Patients admitted for evaluation and treatment of diabetic ketoacidosis
- Patients identified with diabetic ketoacidosis during their hospital stay

**BACKGROUND | DEFINITIONS**

Diabetic ketoacidosis (DKA) is a life-threatening condition. Almost 1 in 100 children with DKA will develop cerebral edema, which has a mortality rate of 21-24%. Those with severe DKA have a much higher mortality and risk of complications. Meticulous attention to the details of therapy and the child's clinical course can decrease this risk. A patient who is unresponsive to vocal commands or presents with hypotension is rare and requires immediate critical care in a hospital. Urgent critical care and diabetes consultation should be obtained.

**DKA is defined by:**
- Hyperglycemia with glucose greater than (> 200 mg/dL, and
- pH less than (< 7.3 or HCO₃⁻ less than (< 15, and
- Ketonemia or ketonuria
IN THE EMERGENCY DEPARTMENT

Please notify the diabetes physician on call through One Call for all patients with known or suspected DKA

Clinical Assessment

- Initial assessment and treatment:
  - Weigh patient, vitals, Glasgow Coma Scale, and pupil assessment
  - Check bedside glucose (point-of-care blood glucose or POC BG)
  - Assess signs/symptoms of DKA, which may include (but may not necessarily be present): polyuria/polydipsia, weight loss, breath with “fruity” odor (smell of ketones), Kussmaul breathing, altered mental status, abdominal pain, vomiting, fatigue, or candidiasis.
  - Do a full exam to look for concurrent infection, including GU to assess for candidiasis/abscesses.

- Admission to the PICU:
  - In general, admission to the PICU is recommended if the pH is less than (<) 7.15, HCO$_3^-$ is less than (<) 5 mEq/L and/or the child has mental status changes but the decision to admit should be based on clinical judgment of the diabetes physician and PICU attending.
  - Mental status changes may be difficult to assess in young children. Consider admission to the PICU for children under 5 years of age based on the clinical judgment of the ED attending, PICU attending and diabetes physician.
  - Initial response to medical therapy should be used in admission decision-making.

Cerebral edema

Suspect cerebral edema if the patient has persistent vomiting, severe headache, mental status changes, GCS less than (<) 13, or focal neurologic abnormalities. Rapid changes in serum Na, in either direction, also increase risk and should prompt increased vigilance for other signs of edema.

If cerebral edema is suspected, consider the following:

- Elevate the head of the bed.
- Decrease fluid rate to 0.75x maintenance and switch to isotonic fluids.
- Hypertonic saline (3%) 2.5-5 mL/kg IV over 15 minutes or mannitol 1 g/kg IV over 15 minutes
- Consider endotracheal intubation for GCS less than (<) 8. For intubation, use ICP precautions and target ETCO$_2$ matching the patient’s pre-intubation pCO$_2$ or no higher than 30-35 mmHg – CALL PICU FOR ASSISTANCE with ETCO$_2$ targets and ventilator settings.
- Do NOT give dexamethasone or sodium bicarbonate.
- Do NOT delay treatment of cerebral edema to obtain imaging.
- Contact the diabetes physician on call and PICU.

Diagnostic Tests | Laboratory Studies

Initial Labs:

- Stat venous blood glucose (VBG), basic metabolic panel (BMP), Mg, Phos, beta-hydroxybutyrate (BOHB), urinalysis (UA)
- If glucose is greater than (>) 600 mg/dL, draw a serum osmolality
- HbA1C
- Any additional labs as warranted by clinical presentation
Osmolality can be calculated by:\[2(Na + K) + \frac{\text{glucose}}{18}\]
The goal is to decrease the osmolality gradually (~10 mOsm/hr)
Na correction for elevated glucose = \text{serum Na} + (1.6) \frac{\text{serum glucose} - 100}{100}
Obtain a serum lipase if patient has persistent nausea, vomiting or abdominal pain

**NOTE:** Contact the on call diabetes physician once the initial labs have returned

**Labs following IV bolus(es)**
- VBG, BMP every 2 hours
- Consider BOHB once bicarbonate is greater than (> 14 mEq/L
- Stop VBG once pH is greater than (> 7.3
- POC glucose every hour (POC glucose must also be obtained after NS bolus(es) and prior to starting insulin drip
- If POC glucose greater than (> 600 mg/dL, send sample to lab for serum glucose

**Clinical Management**

**Order set and initial clinical management**
- If you suspect DKA, place orders using the “ED DKA” order set.
- **NOTE:** some patients may be enrolled in a research study with a separate order set
- Place PIV
- Diet: NPO
- Monitors: place on cardio-respiratory monitors

**Initial Fluids**
- Administer a 10mL/kg normal saline bolus over 60 minutes (a 20mL/kg bolus may be given over 60 minutes for significant dehydration or rapidly if the patient is in shock or hypotensive). Repeat as necessary to maintain adequate circulation. Unless impaired circulation persists, do not give more than 40 mL/kg in bolus fluids in the first 4 hours.

**Following IV NS Bolus(es)**
- Vitals and neurological assessment (nursing)
- Following IV NS bolus(es), place a second PIV for frequent laboratory sampling

**Insulin**
- Disconnect insulin pump if patient is currently on their home insulin pump.
- Start IV regular insulin at 0.1 units/kg/hr – do NOT give a bolus of insulin. Insulin therapy should be started 1 hour after the initial rehydration bolus was started but should not be delayed for more than 2 hours after starting IV hydration. Do NOT start while bolus is still running.
- If unable to start a second IV, DO NOT DELAY INSULIN DRIP! Insulin is compatible with the MIVF and can be Y-ed in with fluids. Contact pharmacy for questions regarding medications, fluids, and compatibility.

**Fluids**
- Prior to selecting intravenous fluid composition and rate, assess for cerebral edema and renal function (see specifics below).
- Standard IV are 3/4 NS + 20 mEq/L potassium acetate + 20 mEq/L potassium phosphate run at 1.5X maintenance. Also, order a bag of D10 + 3/4 NS + 20 mEq/L potassium acetate + 20 mEq/L potassium phosphate to have at the bedside.
• Write a total fluid order
  • This may vary based on medication shortages or physician judgment.
  • Consider lower fluid rates if increased risk for cerebral edema is suspected (e.g. patient has already received significant fluid resuscitation, altered mental status, rapid fall in glucose).
  • Fluids may need to be adjusted based on serum potassium.

  • Potassium supplementation
  • If hyperkalemia (K greater than 6, K>6) or hypokalemia (K less than 3, K<3) is present, perform an ECG to assess T-waves.

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• When the blood glucose is approaching or is less than (<) 250 mg/dL, the dextrose containing bag (bag 2) will need to be Y-ed into bag 1, keeping total fluids at 1.5x maintenance.
  • Goal blood glucose range is 100-250 mg/dL.
  • Goal for fall in blood glucose: should not exceed 100 mg/dL/hour (after initial normal saline bolus is given).
    • Titrate the two bags based on current blood glucose and rate of blood glucose fall to maintain the blood glucose within the goal.
  • Do NOT decrease the insulin unless the dextrose rate is at its maximum (D12.5 at 100% of fluids) or you have spoken to the on-call diabetes physician.

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<th>Blood glucose (mg/dL)</th>
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For Network of Care locations:

The following chart is for reference only, consult the on-call diabetes provider for specific fluid recommendations and insulin drip rates:

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IN THE INPATIENT UNIT

Please notify the diabetes physician on call through One Call for all patients with known or suspected DKA.

Clinical Assessment

Assessment

- Weigh patient, vitals, Glasgow Coma Scale
- Place on cardio-respiratory monitors
- Neurologic checks every hour
- **Cerebral edema**: If a patient with DKA develops symptoms suggestive of cerebral edema (GCS greater than (>)) 13, mental status changes, focal neurologic abnormalities, worsening vomiting, severe headache, inappropriate bradycardia or hypertension):
  - Call RRT and/or code as appropriate.
  - Elevate the head of the bed to 45 degrees.
  - Decrease the total IV fluid rate to 0.75X maintenance.
  - Contact the inpatient attending and diabetes physician.

Diagnostic Tests | Laboratory Studies

Labs

- POC BG every hour while on an insulin drip
- VBG, BMP every 2 hours
- Consider BOHB once bicarbonate is greater than (> ) 14 mEq/L
- Stop VBG once pH is greater than (> ) 7.3 and stop BMP once bicarbonate is greater than or equal to (> ) 18

Clinical Management

Order Set

- Place admission orders using the “MED IP DKA ADMISSION” order set.
- **NOTE**: If the patient is on a study protocol, you will need to order medications per study protocol.

Insulin

- Continue IV regular insulin at 0.1 units/kg/hour.

Fluids

- Standard IVF are 3/4 NS + 20 mEq/L potassium acetate + 20 mEq/L potassium phosphate run at 1.5X maintenance. Also, order a bag of D10 + 3/4 NS + 20 mEq/L potassium acetate + 20 mEq/L potassium phosphate to have at the bedside.
  - These may vary based on medication shortages or physician judgment
  - Consider lower fluid rates if increased risk for cerebral edema suspected (e.g. patient has already received significant fluid resuscitation, altered mental status, rapid fall in BG).
  - Fluids may need to be adjusted based on serum potassium.
- **Potassium supplementation**
  - If initial serum K is greater than (> ) 5.5, oliguria, acute renal failure, or cardiac arrest: do NOT put potassium in fluids.
If hyperkalemia (K greater than 6, K>6) or hypokalemia (K less than 3, K<3) is present, perform an ECG to assess T-waves.

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  - Goal blood glucose range is 100-250 mg/dL.
  - Goal for fall in blood glucose: should not exceed 100 mg/dL/hour (after initial normal saline bolus is given).
  - Titrate the two bags based on current blood glucose and rate of blood glucose fall to maintain the blood glucose within the goal.
  - Do NOT titrate the insulin unless the dextrose rate is at its maximum (D12.5 at 100% of fluids) or you have spoken to the on call diabetes physician.

The chart below is a suggestion for rates:

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- If the blood glucose continues to drop while patient is running bag 2 (the dextrose fluids) at 100% of total fluids, stop the insulin drip and recheck BG every 15 minutes until the BG is greater than (>150 mg/dL, and restart the insulin drip with D12.5% fluids running at 100%.
- If D12.5% fluids are not available, decrease the insulin drip by 0.02 units/kg/hour every 30 minutes until BG is greater than (>100.
- If IVF are running at 100% with D12.5% fluids and BG is less than (<100, stop the insulin drip and recheck BG every 15 minutes until the BG is greater than (>150 mg/dL and restart the insulin drip at 0.02 units/kg/hour lower than the previous rate.
- Do not decrease IV insulin below 0.04 units/kg/hour unless long-acting insulin has been given.
IN THE PICU

Please notify the diabetes physician on call through One Call for all patients with known or suspected DKA.

Clinical Assessment

Assessment

• Weigh patient, vitals, assess pupillary reflexes, Glasgow Coma Scale
• Place on cardio-respiratory monitors
• Neurologic checks every hour
• **Cerebral edema**: If a patient with DKA develops symptoms suggestive of cerebral edema (GCS less than (<)13, mental status changes, focal neurologic abnormalities, worsening vomiting, headache, inappropriate bradycardia or hypertension):
  o Notify PICU attending
  o Elevate head of the bed to 45 degrees
  o Decrease the total IV fluid rate to 0.75X maintenance and switch to isotonic fluids.
  o Give hypertonic saline (3%) 2.5-5 mL/kg IV over 15 minutes or mannitol 1 gm/kg IV over 15 minutes.
  o Consider endotracheal intubation for GCS less than (<) 8 or rapidly declining cardiorespiratory or mental status. For intubation, use RSI with ICP precautions and ventilate initially to target ETCO₂ matching the patient’s spontaneous pre-intubation pCO₂ but no higher than 30-35 mmHg.
  o Do NOT delay treatment of cerebral edema to obtain imaging.
  o Notify diabetes physician of clinical situation.

Diagnostic Tests | Laboratory Studies

**Initial Lab Schedule**

• POC BG every hour while on insulin drip
• VBG, BMP every 2 hours
• Consider BOHB once bicarbonate is greater than (>) 14 mEq/L
• Stop VBG once pH is greater than (>) 7.3 and stop BMP once bicarbonate is greater than or equal to (≥) 18

Clinical Management

**Order Set**

• Place admission orders using the “MED IP DKA ADMISSION” order set.
• **NOTE**: If the patient is on a study protocol, you will need to order medications per study protocol.

**Insulin**

• Continue IV regular insulin at 0.1 units/kg/hour.

**Fluids**

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  - Titrate the two bags based on current blood glucose and rate of blood glucose fall to maintain the blood glucose within the goal.
  - Do NOT titrate the insulin unless the dextrose rate is at its maximum (D12.5 at 100% of fluids) or you have spoken to the PICU and diabetes physician.

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- If IVF are running at 100% with D12.5% fluids and BG is less than (<)100, stop the insulin drip and recheck BG every 15 minutes until the BG is greater than (>150 mg/dL and restart the insulin drip at 0.02 units/kg/hour lower than the previous rate.
- Do not decrease IV insulin below 0.04 units/kg/hour unless long-acting insulin has been given.
TRANSITION TO SUBCUTANEOUS INSULIN

For patients on subcutaneous insulin injections

- Order their subcutaneous insulin using the “INSULIN SUBQ *INJECTION* + HYPOGLYCEMIA” order set, which includes orders for HYPOGLYCEMIA.

- **Timing of transition:**
  - When pH is greater than (> 7.3 and serum bicarbonate (on BMP) is greater than or equal to (≥) 18 mmol/L, the patient can transition to subcutaneous insulin.
    - If bicarb remains less than (< 18 but acidosis has resolved, obtain a BOHB and readiness to transition to subcutaneous insulin with the on-call diabetes physician.
    - Obtain a serum lipase if patient has persistent nausea, vomiting or abdominal pain.
  - The diabetes physician may recommend giving long-acting subcutaneous insulin (e.g. Lantus®, glargine) to patients while they are STILL on the insulin drip; ask the diabetes physician about the timing of the first dose of long-acting SQ insulin during the day when possible.
    - Recommendations will be documented in chart notes for reference.
  - If the patient has already received long-acting insulin while on the insulin drip:
    - You may turn off the insulin drip once ketoacidosis has resolved (serum bicarb greater than or equal to (≥) 18 mEq/L.
    - Remain on the dextrose IVF for no more than 15 minutes after the insulin drip has been turned off, then turn off dextrose IVF.
    - Continue non-dextrose containing fluids to run at maintenance overnight.
  - If patient has not yet received long-acting insulin, keep patient on insulin drip until the first meal has arrived.
    - Order the carbohydrate counting diet and allow patient to order a meal.
    - Once food has arrived, but PRIOR to eating, check pre-prandial glucose and give the subcutaneous long-acting and short-acting insulin (pre-prandial glucose correction and carbohydrate coverage) and turn off the insulin drip at this time.
    - If glucose is less than (> 100, keep dextrose-containing IVF on for an additional 15 minutes, otherwise turn IVF off as well.
    - Allow the patient to eat.
    - If there is any concern for nausea/vomiting or patient’s ability to eat (especially in a child less than 5 years of age), then consider a PO trial prior to discharge and possibly prior to administration of subcutaneous insulin.

- New onset patients are typically discharged in the morning to go directly to the Barbara Davis Center (BDC), while known patients with diabetes are usually discharged to home.
  - Clarify the plan with the on call diabetes physician.
  - Breakfast is NOT available at the BDC and, therefore, if the patient is discharged to the BDC, please have the patient bring breakfast to the BDC.
  - Insulin can be given at the BDC.

- **For NEW ONSET patients**, provide printed instructions, including a map to the BDC http://www.barbaradaviscenter.org/
Types of insulin (NOTE: insulin in BOLD is available on the formulary)

<table>
<thead>
<tr>
<th>Type</th>
<th>Insulin Name</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-acting (provides basal coverage)</td>
<td>Lantus® (insulin glargine)</td>
<td>1-2 hours</td>
<td>No peak</td>
<td>22-24 hours</td>
</tr>
<tr>
<td>Long-acting (provides basal coverage)</td>
<td>Levemir® (insulin detemir)</td>
<td>1-2 hours</td>
<td>No peak</td>
<td>Less than 24 hours</td>
</tr>
<tr>
<td>Long-acting (provides basal coverage)</td>
<td>Tresiba® (insulin degludec)</td>
<td>1 hour</td>
<td>No peak</td>
<td>Up to 42 hours</td>
</tr>
<tr>
<td>Intermediate-acting</td>
<td>NPH</td>
<td>1 hour</td>
<td>4-6 hours</td>
<td>8-16 hours</td>
</tr>
<tr>
<td>Rapid-acting</td>
<td>Humalog® (insulin lispro)</td>
<td>15-30 minutes</td>
<td>1-1.5 hours</td>
<td>3-4 hours</td>
</tr>
<tr>
<td>Rapid-acting</td>
<td>Novolog® (insulin aspart) &amp; Apidra® (insulin glulisine)</td>
<td>15-30 minutes</td>
<td>1-1.5 hours</td>
<td>3-4 hours</td>
</tr>
</tbody>
</table>

NOTE: the concentration of all of the types of insulin listed above is 100 units/mL

General principles regarding SQ insulin regimens

- Carbohydrate counting + blood glucose correction
  - Give rapid-acting (Humalog/lispro) insulin to cover the amount of carbohydrates the child is about to eat + additional rapid-acting insulin to bring the blood glucose down.
  - Example
    1. Carbohydrate counting: If a child is on a 1:15 gram carbohydrate coverage (1 unit of rapid-acting insulin for every 15g of carbohydrates consumed) and eats a 60g pancake breakfast, s/he needs 4 units of rapid-acting insulin before breakfast (60g/15g = 4 units).
    2. Correction factor: If the child has a correction factor of “1 for every 100 starting at 150,” that means if the child’s blood glucose is 130 before a meal s/he does not need any additional rapid-acting insulin on top of the insulin given to cover carbohydrates. However, if the blood glucose is 151-250 prior to their meal, s/he needs 1 unit of rapid-acting insulin in addition to the insulin given to cover the carbohydrates. If her/his blood glucose is 251-350, s/he needs 2 units of rapid-acting insulin in addition to the insulin to cover carbohydrates, etc.
  - Ideally, rapid-acting insulin should be given 20-30 minutes before eating (to match onset of action), but for young children (especially younger than 3 years of age), children with newly diagnosed diabetes, or children who may not finish their meal or vomit, it is acceptable to give insulin immediately after the meal and within 20-30 minutes of STARTING to eat.
  - Do NOT give rapid-acting insulin injections for blood sugar correction more often than every 4 hours unless specified by endocrinology as this can cause “insulin stacking” and puts the child at risk for hypoglycemia (think about the duration of rapid-acting insulins).

- Sliding scale
  - This is essentially carbohydrate counting + correction factor but written together to simplify calculations.
  - This is rarely used in the inpatient setting
  - This works best for children who eat a fixed amount of carbohydrates at every meal (a “consistent carb” diet) and is often used for families who have a child with new onset diabetes or otherwise have not learned carbohydrate counting yet.
For patients on an insulin pump

- Order insulin pump orders using the “INSULIN SUBQ *PUMP* + HYPOGLYCEMIA” order set, which includes orders for HYPOGLYCEMIA.
- Pumps use only rapid-acting insulin that is delivered continuously (basal rate) and as boluses that cover elevated glucose and carbohydrates.
- A family member must be present who knows how to use the pump in order to restart the child on her/his pump. The family must bring their own set of new pump supplies (e.g. infusion set, reservoir, and inserter) and must use a completely new set. The patient cannot use the pump set that may have failed prior to coming to the hospital. When the patient is medically ready to restart the insulin pump, have the family member connect and restart the pump as the nurse discontinues the IVF and insulin drip.
- If there is no family member present to reconnect the pump or pump supplies are not available, the child will need to be started on subcutaneous insulin injections.
- **Note:** There may be reasons not to restart the pump (i.e. psychosocial issues, family/patient knowledge deficit on pump use or site insertion, etc.) and a plan for subcutaneous insulin injections will need to be made.

**PARENT | CAREGIVER EDUCATION**

- The Barbara Davis Center (BDC) for Diabetes - [http://www.barbaradaviscenter.org/](http://www.barbaradaviscenter.org/)
REFERENCES

Consensus Guidelines


DKA


Cerebral Edema


Insulin Treatment

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