Interior Health

BC CHILDREN'S HOSPITAL

PEDIATRIC DIABETIC KETOACIDOSIS PROTOCOL[A]

For Children Ages 1 Month To 19 Years

Patient Name *(last)* _____

(first) _____

DOB *(dd/mm/yyyy)* _____

PHN _____ MRN _____

Account/Visit # _____

IH USE ONLY

Severity of DKA | **DKA vs. HHS** | **Estimate Dehydration** | **Glasgow Coma Scale**

FIRST 60 MIN

0. ABCs, vital signs (with BP), neurovitals signs. Place large-bore IV. Draw labs. Confirm DKA: plasma glucose (PG) greater than 11 mmol/L, moderate to large ketonuria or β-hydroxybutyrate greater than or equal to 3.0 mmol/L, and venous pH less than 7.3 orserum HCO_3– less than 15 mmol/L.[C] Consider possibility of an element of hyperglycemic hyperosmolar state.[B]
1. Measure body weight (BW) in kilograms . . . . . (1) _____ kg
2. Give 0.9% saline (normal saline, NS) resuscitation bolus[D]
   - recommended amount: 10 mL/kg BW over 30 minutes . . . (2) _____ mL
3. Repeat with second bolus of NS if persistent tachycardia, prolonged cap refill (greater than 2 sec), cool extremities:
   - recommended amount: 10 mL/kg BW over 30 minutes . . . (3) 0 mL

   Check box if giving a second 10 mL/kg fluid push ☐

TIME = 60 MIN – 36 HOURS

4. Begin rehydration, calculated for even correction over 36 hours, based on admission BW:[E]
   - 5–10 kg BW: 6.5 mL/kg/H
   - 10–20 kg BW: 6 mL/kg/H
   - 20–40 kg BW: 5 mL/kg/H
   - greater than 40 kg BW: 4 mL/kg/H, maximum 250 mL/H . . . . . (4) _____ mL/kg/H
5. Calculate total hourly fluid rate to be given for 36 hours: multiply (1) and (4) . . . . . (5) _____ mL/H
6. Use NS with KCl 40 mEq/L (Bag A) as initial rehydration fluid, at rate determined in (5), ensuring that patient has voided and has plasma K+ less than 5 mmol/L before adding potassium to the IV fluids.
7. At 60–120 minutes after starting the first fluid bolus, make up and start a piggyback insulin drip at 0.05–0.1 units/kg BW/H (Bag C):[F]
   - 50 units insulin regular (Humulin® R or Novolin® Toronto) in 500 mL NS or D10/NS
   - run at 0.5–1 mL/kg BW/H

   . . . . . (7) _____ mL/H
8. Begin "2-bag method"[G]. Y together (Bag A) NS with 40 mEq/L KCl and (Bag B) D10–D12.5/NS with 40 mEq/L KCl. Decrease replacement fluid rate to adjust for insulin drip rate: subtract (7) from (5) . . . . . (8) _____ mL/H
9. Aim to keep PG 8–12 mmol/L by titrating the rates of these two solutions, keeping the combined rate at (8)[G]. Continue this for the next 6–12 hours, monitoring as below.
10. At 4–6 hours after initial fluids and if corrected plasma Na+ is greater than or equal to 145 mmol/L, stable or increasing, switch Bag A to 0.45% saline with 40 mEq/L KCl and Bag B to D10–D12.5/0.45% saline with 40 mEq/L KCl at the rate as in (8)[H].

Rationale and Notes:

[A] Please note that this protocol is designed as an algorithm for treating the majority of cases of DKA in infants, children and adolescents. It cannot replace careful clinical observation and judgment in treating this potentially very serious condition. If you have questions or problems related to the management of DKA or diabetes, please feel free to contact the BCCH Pediatric Endocrinologist on call.

[B] Hyperglycemic hyperosmolar state (HHS) should be suspected when there is significant hyperglycemia (greater than 33 mmol/L) and hyper-osmolality (greater than 330 mOsm/L) without ketosis or acidosis (bicarbonate greater than 15 mmol/L, venous pH greater than 7.3). A mixed picture of DKA and HHS is possible. Mild hyperglycemia, even with ketones and mild acidosis, can often be managed without IV fluids or IV insulin.

[C] Rapid, deep mouth-breathing (Kussmaul respiration) often dries out the oral mucosa, making the child appear more dehydrated than s/he really is. The hematocrit and other clinical signs (delayed capillary refill) are more accurate measures of dehydration.

[D] Recent research shows that most children with moderate to severe DKA will require a 20 mL/kg resuscitation fluid bolus to restore perfusion, prior to the rehydration phase.

[E] Recent research shows that DKA can be safely corrected over a 24- to 48-H period. This protocol is designed to correct a 10% fluid deficit (100 mL/kg) evenly over 36 H.

[F] IV insulin boluses are always contraindicated. Insulin given in the first 1–2 H of DKA repair is thought to increase mortality. This insulin rate fully inhibits ketogenesis and gluconeogenesis and should be maintained if possible. If unable to keep PG greater than 8 mmol/LG, drop the insulin rate by 25–50%.

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THROUGHOUT

11. Re-evaluate appropriateness of replacement fluid type frequently, anticipating the need to add or increase Na+, K+, dextrose, etc.
    - dextrose[G]: aim to keep the PG 8 – 12 mmol / L range
    - sodium[H]: corrected Na+ less than 145 mmol / L, or falling regardless of level: continue NS corrected Na+ greater than or equal to 145, stable or increasing, switch to ½ NS after 4 – 6 H
    - potassium[I,J]: patient urinating and K+ remains less than 5: continue KCl 40 mmol / L may give 50% of K+ as acetate or phosphate
    - bicarbonate[K]: $NaHCO_3$ is **not** generally recommended
12. Children with DKA have high risk for acute kidney injury (AKI). Use Schwartz formula to calculate expected baseline creatinine (EBC).[L]
13. Close neurological observation and frequent rousing of the child with finger-pokes to detect any changes consistent with cerebral edema. Follow Glasgow Coma Scale. Severe headache, change in sensorium or BP, dilated pupils, bradycardia, irregular breathing, posturing and incontinence are signs of impending deterioration. Rapid intervention is imperative:
    - airway / breathing / circulation
    - elevate head of bed
    - decrease all fluid bags to 5 mL / H pending physician reassessment
    - mannitol 20% (0.5 – 1 g / kg, 2.5 – 5 mL / kg IV over 15 min) or NaCl 3% (2.5 – 5 mL / kg IV over 15 min)[M]
    - consider intubation and mild hyperventilation (keep pCO_2 greater than 22 mg Hg) forimpending respiratory failure
    - arrange CT when stable
14. Follow laboratory parameters (use of a flowsheet is highly recommended):
    - follow PG by meter every 30 – 60 min[G]: does child respond to the poke?
    - follow Na+, K+, Cl−, HCO_3 −, anion gap, urea, creatinine, venous pH every 2 – 4 hours[H, I, K]; Ca2+, Mg2+ and Pi every 2 – 4 hours if giving phosphate[J]
    - follow (preferably) plasma β-hydroxybutyrate every 2 – 4 hours or urine ketones with each void
15. Re-evaluate appropriateness of replacement fluid type frequently, anticipating the need to increase or decrease Na+, K+, dextrose, etc.

Rationale and Notes *(continued)*:

[G] Keeping the PG in the 8 – 12 mmol / L range allows for a buffer against hypoglycemia and a too-rapid fall in plasma osmolality[H]. The "two-bag method" (see our DKA Nursing Protocol) is a handy way to adjust the glucose without altering the Na+ or K+ delivery. It also allows for a faster response to PG changes, and it decreases nursing and pharmacy workload and costs.

[H] The introduction of hypotonic fluids must be considered carefully. The corrected Na+ should be calculated and followed closely: corrected Na+ = [measured Na+ + 0.36×(PG–5.6)]. If corrected Na+ falls or fails to rise as the PG falls, this could indicate excess free-water administration. It is also helpful to monitor the active osmolality [PG + 2 × (Na+ + K+)], which should not fall greater than 0.5 mOsm / kg / H. If the corrected sodium is greater than or equal to 145 mmol / L and stable and the active osmolality has been dropping slowly, switching to ½ NS can be considered after 4–6 H of fluids. An elevated measured Na+ in the face of hyperglycemia indicates severe dehydration and an element of the hyperglycemic hyperosmolar state. Such patients should be rehydrated using fluids with higher osmolar content (e.g. NS) for longer time periods (10 – 12 H).
NOTE: Some IHA sites will not have access to pharmacy after hours to custom mix ½ NS with 40mEq KCL per litre. If this situation arises the commercially available **0.45% NS with 20mEq KCL per litre** solution can be run temporarily until the morning when pharmacy able prepare the correct solution. When this option is used, the insulin rate should also temporarily be reduced to 0.05u/kg/hr.

[I] Serum K+ levels are usually normal at diagnosis and fall precipitously with treatment. An IV fluid containing 20 – 40 mmol / L K+ is usually required to keep the serum K+ greater than 3.0 mmol / L. Begin K+ and insulin together. Oral / nasogastric KCl boluses (0.5 – 1 mmol / kg BW) may also be administered.

[J] While there is no proven benefit to using potassium phosphate or acetate, it does have the theoretical advantage of repleting the severe phosphate deficit of DKA and / or ameliorating the hyperchloremia which inevitably occurs during DKA treatment. If phosphate is given, serum calcium, magnesium and phosphate levels should be monitored closely.

[K] The acidosis of DKA is due to both ketoacids and lactic acid, and these resolve with fluid and insulin replacement. There is no evidence that $NaHCO_3$ is either necessary or safe in DKA, but its use has a number of deleterious effects: paradoxical CNS acidosis, hypokalemia, hyperosmolality, delayed clearance of ketones, and cerebral edema. $NaHCO_3$ in DKA should only be considered if pH less than 6.9 or cardiac failure.

[L] EBC (µmol / L) = 36.5 × height (cm) / 120. Measured creatinine 1.5 – 1.99 × EBC = Stage 1, 2 – 2.99 × EBC = Stage 2, greater than or equal to 3 × EBC = Stage 3 AKI.

[M] Subclinical brain swelling is common in children with DKA. Cerebral edema (CE) accounts for more than half of the 1 – 5% mortality rate of DKA in children. At highest risk are newly diagnosed patients, those aged less than 5 years, and those with initial pH less than 7.1 or pCO_2 less than 18. The exact etiology of CE remains unclear. Resuscitation is successful in only 50% of cases.

Consult Pediatrician On Call, or Pediatric Endocrinologist On Call at BC Children's Hospital (604) 875-2161

Accompanying documents on the BCCH website:
- DKA Flowsheet and DKA Sample Physician Order Sheet
- DKA Glucose, Fluid and Insulin Management
- DKA Nursing Protocol (including the "two-bag" method)
- DKA Recipes for Making Solutions