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BCCH DIABETIC KETOACIDOSIS NURSING PROTOCOL

Diabetic ketoacidosis (DKA) involves a combination of hyperglycemia, acidosis, and ketones. It is diagnosed when (1) the blood glucose is ≥11 mmol/L; (2) capillary pH is ≤7.3 and/or capillary bicarbonate is ≤15 mmol/L; and (3) ketones are present in the blood and/or urine (see below). It usually takes days to develop DKA, but it can take hours in children with acute illness, insulin omission, or insulin pump failure.

Causes of DKA Include:

- undiagnosed type 1 diabetes
- insulin omission or manipulation
- inadequate insulin dosing and monitoring during periods that significantly increase insulin needs: (illness, infection, major stress, puberty, pregnancy)
- insulin pump or infusion site malfunction or misuse

Signs and Symptoms of DKA Include:

- polyuria
- polydipsia
- dehydration
- weight loss
- lethargy
- nausea, vomiting and abdominal pain
- fruity or acetone-smelling breath
- flushed face
- confusion
- hyperventilation and Kussmaul breathing (rapid, deep, sighing mouth-breathing)
- ↑ heart rate and ↑ respirations, and possibly ↓ blood pressure

Acute dehydration must be treated with IV fluid replacement. Overhydration, correcting the hyperglycemia too quickly, the use of insulin in the first 1–2 hours of fluid therapy, and the use of bicarbonate have been implicated in causing cerebral edema in DKA, which can be fatal. Hydration should be cautious, according to the DKA Protocol, and the blood glucose should not fall below 15 mmol/L for the first 12–24 hours.

NURSING MANAGEMENT OF DKA IN THE EMERGENCY ROOM

1. Patient should be kept NPO.

2. Weight is needed for rehydration calculations. The ER physician will estimate the degree of dehydration and the fluids required, using the DKA Protocol.

3. Baseline neurovital signs.

4. Apply pulse oximetry and cardiac monitor; O_2 via mask if saturation is low.

5. Initial bloodwork: glucose, sodium, potassium, chloride, bicarbonate, osmolality, urea, creatinine, calcium, phosphorus, capillary blood gas and serum ketones/β-hydroxybutyrate (where available); and urine for ketones and glucose. Bloodwork can be done with the IV start. If IV start is difficult, call the Lab to do a stat finger sample rather than waiting for the IV line to be initiated.

6. Measure blood glucose with hospital meter. If labwork is done at the same time, a drop from the lab sample may be used to do this. If the meter reads "HI", the blood glucose is ≥27.8 mmol/L, and the physician may request that labwork be drawn to obtain the actual blood glucose level.

7. Start one large-bore IV line. Three infusions will be **Y**'d into this line.

8. At the physician's discretion, moderately to severely dehydrated patients may receive a 5–10 mL/kg normal saline (NS, 0.9% NaCl) bolus over 30–60 minutes. This may be repeated, but should total <30 mL/kg.

9. In the first 1–2 hours of DKA management, the desired fluid is NS (NS with 40 mmol KCl/L may be used if the serum potassium level is initially low and the patient is urinating). The ER physician will calculate the rate of this from the DKA Protocol.

10. NOTE THAT INSULIN IS NO LONGER GIVEN IN THE FIRST 1–2 HOURS OF DKA MANAGEMENT.

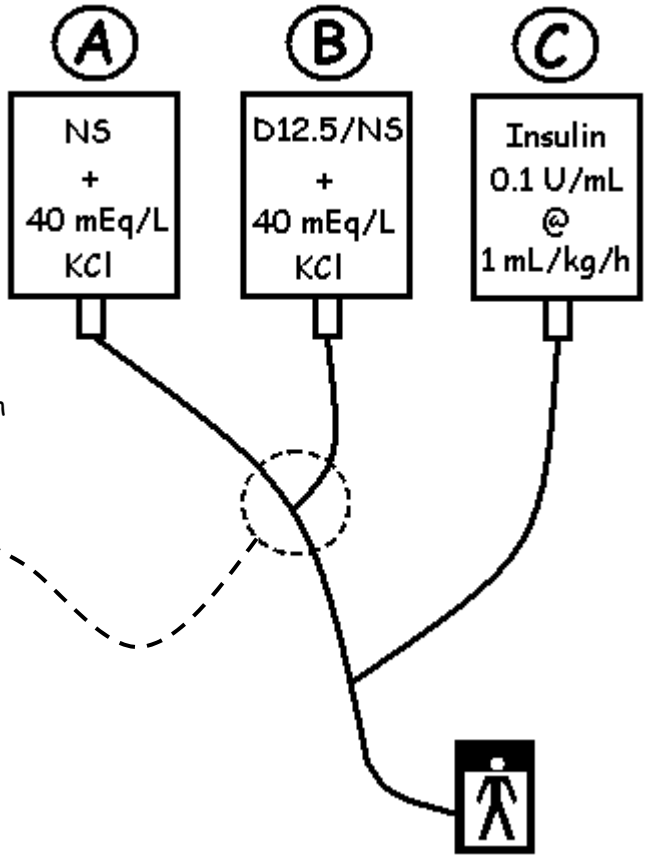
11. Set up the "two-bag system". This consists of two IV bags (**A** and **B**) with equal electrolyte concentration, one containing no dextrose, the other 10–12.5% dextrose. They are administered simultaneously. The concentration of dextrose is easily changed by adjusting the proportions of the two bags contributing to the

total rate. The total rate is determined by the child's degree of dehydration, according to the DKA Protocol. The insulin infusion (**Bag C**) will eventually be **Y**'d into these bags (see below).

In the "two-bag system", **Bag A** is generally NS with 40 mEq/L KCl, and **Bag B** is usually D12.5/NS with 40 mEq/L KCl (or D10/NS with 40 mEq/L KCl if D12.5/NS is not available). The BCCH Pharmacy has prepared a "recipe book" for preparing these solutions from available IV solutions, which is available from the *Parenteral Drug Manual* on the C&W Intranet and on Endocrinology's website (see below). The following solutions should also be available pre-made in the Emergency Room and on 3F for after-hours use:

- NS + 40 mEq/L KCl
- D12.5/NS + 40 mEq/L KCl
- ½NS + 40 mEq/L KCl
- D12.5/½NS + 40 mEq/L KCl

EXAMPLE OF THE "TWO-BAG SYSTEM"



example for a child with total IV rate = 100 mL/h
(this does not include insulin infusion rate)
total rate = (rate Bag A + rate Bag B) = 100 mL/h

rate Bag A no dextrose (mL/h)	rate Bag B D12.5 (mL/h)	final dextrose concentration (%)
100	0	D0
60	40	D5
40	60	D7.5
20	80	D10
0	100	D12.5

after: Grinberg A et al, *Journal of Pediatrics* 1999;134(3):376–378.

12. Insulin is started 1–2 hours after initial DKA fluid management is begun. To prepare the insulin infusion, 50 units (0.5 mL) of Regular, short-acting insulin (Humulin R or Novolin Toronto) is added to a 500-mL bag of NS (or to D10/NS, if ordered). This is a concentration of 0.1 units/mL. The insulin is drawn up in a tuberculin syringe with a 1½-inch needle so that the insulin is injected past the plastic port of the IV bag. Mix fluid continually while injecting, to prevent the insulin from settling in the port. Flush the tubing with 50 mL of the insulin solution to saturate insulin binding sites. **This procedure requires a double-check.** The insulin infusion (**Bag C**) is Y'd into the lowest port on the IV, closest to the patient and is usually run at 1 mL/kg/hr (which is 0.1 units/kg/hr). An insulin bolus is never given. This dose of insulin is required to reverse the ketosis. As the blood glucose approaches 15 mEq/L, or if it is dropping too rapidly, the total rate of the insulin infusion will remain the same, but the rate of the no-dextrose IV will be decreased, and the rate of the high-dextrose IV will increased by the same amount.

13. The insulin infusion is discontinued once the blood pH returns to normal and the patient is ready to switch to SQ insulin. This is usually within 24–36 hours. Pharmacy prepares a new insulin infusion bag every 24 hours. The tubing is replaced every 72 hours, as per BCCH Nursing Policy and Procedure Manual PT-004 (*Parenteral and Infusion Therapy: Initiating or Changing an Infusion*), available on the C&W Intranet.

14. Depending on the patient's progress, the solutions may eventually (e.g. after 6–12 hours) be changed to ½NS with 40 mEq/L KCl and D12.5/½NS with 40 mEq/L KCl.

NURSING CARE

- blood glucose by meter and/or lab every 30–60 minutes
- electrolytes, lab glucose, blood ketones, capillary gas every 2–4 hours as ordered
- record nursing results on DKA flowsheet
- neurovital signs every 15 minutes until stable, then every hour until order is discontinued
- close neurological observation and frequent rousing
- monitor for headache, abnormal respirations or behavioral changes
- NPO until rehydrated and glucose is stabilized
- ice chips may be allowed, at physician's discretion
- check urine for ketones with each void
- strict intake and output

Monitor for Cerebral Edema

Cerebral edema occurs in ~0.5% of children presenting in DKA, and it has a mortality of ~25%. At highest risk are (1) children newly diagnosed with diabetes, (2) younger children, and (3) children with the greatest degree of dehydration and acidosis. Symptoms include:

- headache
- inappropriate lowering of heart rate
- recurrence of vomiting
- changes in neurological status (restlessness, irritability, drowsiness, incontinence, cranial nerve palsies, altered pupillary reactivity, etc.)
- rising blood pressure
- oxygen desaturation

If you suspect cerebral edema, notify the physician immediately. Elevate the head of the bed. Be prepared to call the code team, and ensure that IV mannitol and/or 3% saline is ready at hand.

Transfer to ward

This may happen any time after the child is stabilized. An order should be sent to Pharmacy for intermediate-acting (Humulin N or Novolin NPH) and short-acting (Humulin R or Novolin Toronto) or rapid-acting (Humalog® or NovoRapid®) insulin vials to be sent to the ward, in preparation for a switchover to SQ insulin. Nursing care continues as above until the insulin infusion is discontinued.

Subcutaneous insulin is started when acidosis is corrected and the child is ready to eat. The blood pH will be normal, and serum ketones (see below) will have normalized, but ketones will likely still be present in the urine. For short-acting insulin (Regular or Toronto), the insulin injection is given 20–30 minutes before breakfast or dinner, and the insulin infusion is turned off 30 minutes after the injection. For rapid-acting insulin (Humalog® or NovoRapid®), the insulin injection is given immediately before breakfast or dinner, and the insulin infusion is turned off 10–15 minutes after the injection. The physician may choose to continue the IV fluids for another 12–24 h to complete rehydration. Labwork will be discontinued once the child's pH and electrolytes have returned to normal.

For newly diagnosed children, diabetes education is initiated with the family as soon as possible. Children who are not newly diagnosed will need a reassessment of their diabetes management.

Internet Links

BCCH DKA Homepage: endodiab.bcchildrens.ca/ForProfessionals/DKAProtocol.htm
BCCH DKA Protocol Toolkit: endodiab.bcchildrens.ca/pdf/dkatoolkit.htm
BCCH DKA Medical Protocol: endodiab.bcchildrens.ca/pdf/dkaprt.htm PLAIN PDF FORMAT
BCCH DKA Medical Protocol: endodiab.bcchildrens.ca/pdf/dkaprtfill.htm FILLABLE PDF FORMAT
BCCH DKA Nursing Protocol: endodiab.bcchildrens.ca/pdf/dkaprtrn.htm
BCCH DKA Flowsheet: endodiab.bcchildrens.ca/pdf/dkaflow.htm
BCCH DKA Sample Physician Order Sheet: endodiab.bcchildrens.ca/pdf/dkaorders.htm
BCCH Recipes for Making DKA Solutions: endodiab.bcchildrens.ca/pdf/dkarecipes.htm
BCCH Blood Glucose and Insulin Record: endodiab.bcchildrens.ca/pdf/gluinsflow.htm

References

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Grimberg A, Cerri RW, Satin-Smith M, Cohen P. The "two bag system" for variable intravenous dextrose and fluid administration: Benefits in diabetic ketoacidosis management. *Journal of Pediatrics* 1999;134(3):376–378.

Correlation of Blood and Urine Ketones

Urine ketones		Blood ketones (β-hydroxybutyrate)
negative	<0.5 mmol/L	≤0.5 mmol/L
trace	0.5 mmol/L	0.6–0.9 mmol/L
small	1.5 mmol/L	1.0–1.4 mmol/L
moderate	4 mmol/L	1.5–2.4 mmol/L
large	8 mmol/L	2.5–2.9 mmol/L
very large	16 mmol/L	≥3.0 mmol/L