

## 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 site problems.

### Causes of DKA Include:

- undiagnosed type 1 diabetes
- insulin omission or manipulation
- inadequate insulin dosing and monitoring during periods of increased insulin needs: (illness, infection, major stress, puberty, pregnancy)
- insulin pump misuse or infusion site disconnection, kinking or failure

### 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)
- $\uparrow$  heart rate and  $\uparrow$  respirations, and possibly  $\downarrow$  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 to 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 BCCH DKA Protocol.

### NURSING MANAGEMENT OF DKA IN THE EMERGENCY ROOM

1. Patient should be kept NPO.
2. A measured weight is essential for rehydration calculations. The ER physician will estimate the degree of dehydration and the fluids required, using the BCCH DKA Protocol.
3. Baseline and then 1-hourly vital signs and neurovital signs.
4. Apply pulse oximetry and cardiac monitor; O<sub>2</sub> via mask if saturation is low.
5. Measure blood glucose with hospital meter. If bloodwork 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 ~30 mmol/L or greater, and the physician may request that labwork be drawn to obtain the actual blood glucose level.
6. Initial bloodwork: CBC, glucose, sodium, potassium, chloride, bicarbonate, osmolality, urea, creatinine, ionized calcium, phosphorus, venous blood gas and serum ketones/ $\beta$ -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.
7. Start one large-bore IV line. Three infusions will be Y'd into this line.
8. All patients will receive a 10 mL/kg normal saline (NS, sodium chloride 0.9%) bolus over 30 minutes once the IV is in. At the physician's discretion, moderately to severely dehydrated patients may receive a second 10 mL/kg NS bolus over 30 to 60 minutes. Very rarely, patients may require a third NS bolus.
9. After the initial NS fluid boluses, the desired fluid is NS + 40 mmol KCl/L, assuming serum potassium level is not elevated and the patient is urinating. The ER physician will calculate the rate of this from the BCCH DKA Protocol.
10. NOTE THAT INSULIN IS NOT GIVEN IN THE FIRST 1 to 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 or 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 BCCH DKA Protocol. The insulin infusion (**Bag C**) will eventually be Y'd into these bags (see below).

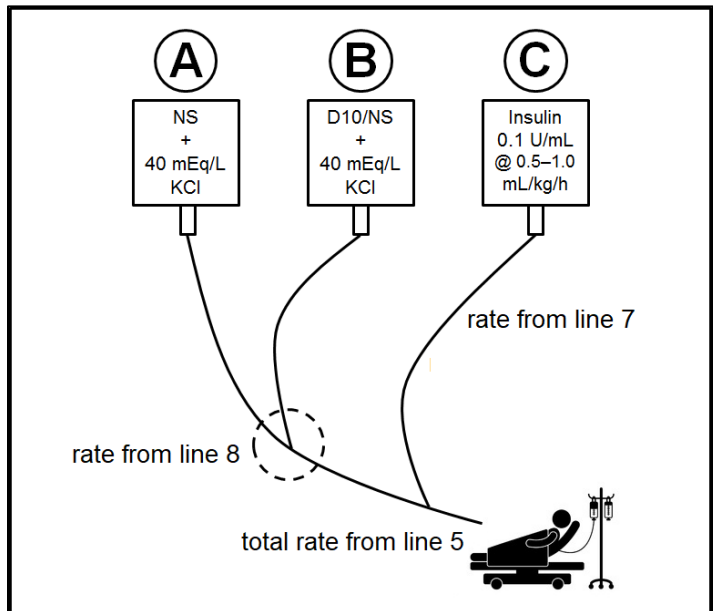
In the "two-bag system", **Bag A** is generally NS + 40 mEq/L KCl, and **Bag B** is usually D12.5/NS + 40 mEq/L KCl (or D10/NS + 40 mEq/L KCl if D12.5/NS is not available). The BCCH Pharmacy has prepared a "recipe book" for preparing these solutions from available IV solutions, which is available from 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 T7 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: IV rate from protocol line 8 = 100 mL/h  
 (this does not include insulin infusion rate)  
 rate Bag A + rate Bag B = 100 mL/h

rate Bag A no dextrose (mL/h)	rate Bag B D10 (mL/h)	final dextrose concentration (%)
100	0	D0
80	20	D2
60	40	D4
40	60	D6
20	80	D8
0	100	D10



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

12. Insulin is started 1 to 2 hours after initial DKA fluid management is begun. To prepare the insulin infusion, 50 units (0.5 mL) of short-acting insulin regular (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. **Do not use an insulin syringe.** 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 preparation of the insulin bag requires a double-check if not performed in the Pharmacy.** The insulin infusion (**Bag C**) is Y'd into the lowest port on the IV, closest to the patient, and is usually run at 0.5 to 1 mL/kg/h (which is 0.05 to 0.1 units/kg/h). An

insulin bolus is never given. This high dose of insulin is required to reverse the ketosis. The BG level will fall quite rapidly in the first hour or two with the initial fluid management, even before insulin is started, secondary to improved renal clearance and hemodilution. Thereafter, one should aim for a fall in BG of ~3 to 5 mmol/L/h. As the blood glucose approaches 15 mmol/L, or if it is dropping >5 mmol/L/h, the total rate of the insulin infusion will remain the same, but the rate of the no-dextrose **Bag A** will be decreased, and the rate of the high-dextrose **Bag B** will be increased by the same amount. The target is to have the BG in the 8 to 12 mmol/L range, both to minimize glycosuria, and to allow for a buffer against hypoglycemia.

13. The insulin infusion is discontinued once the blood pH returns to normal and the patient is ready to switch to subcutaneous insulin. This is usually within 24 to 36 hours. Pharmacy prepares a new insulin infusion bag every 24 hours. The tubing is replaced every 96 hours, as per BCCH Nursing Policy and Procedure Manual CV.01.05 [Administration Set Priming and Loading and Initiating or Changing the Infusion](#), available on the C&W ePOPS website.
14. Depending on the patient's progress, the solutions may eventually (e.g. after 6 to 12 hours) be changed to  $\frac{1}{2}$ NS + 40 mEq/L KCl and D10-12.5/ $\frac{1}{2}$ NS + 40 mEq/L KCl.

#### NURSING CARE

- blood glucose by meter and/or lab every 30 to 60 minutes
- electrolytes, lab glucose, blood ketones, venous gas every 2 to 4 hours as ordered
- record nursing results on DKA flowsheet
- vital and neurovital signs on admission and then hourly
- 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

**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

**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. Decrease all IV bags to 5 mL/h pending physician reassessment. Be prepared to call the code team, and ensure that IV mannitol (available on the BCCH wards) and/or 3% saline is ready at hand.

**TRANSFER TO WARD**

This may happen any time after the child is stabilized. This generally means that the patient's cardiovascular and CNS status is stable, and the patient has **Bags A, B** and **C** hanging. Disposable insulin pens with basal (Basaglar® and Levemir®), intermediate-acting (Humulin® N and Novolin® NPH) and rapid-acting (Humalog® and NovoRapid®) insulin will be available on the wards, 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 rapid-acting insulin (Humalog® or NovoRapid®), the injection is generally given immediately before breakfast or dinner, and the insulin infusion is turned off 20 to 30 minutes after the injection. An injection of basal insulin (Basaglar® or Levemir®) is generally given at the same time. The physician may choose to continue the IV fluids for another 12 to 24 hours 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

The following resources are all available from our [DKA Protocol webpage](#):

- [DKA Protocol Toolkit](#)
- [DKA Medical Protocol \(PLAIN PDF FORMAT\)](#)
- [DKA Medical Protocol \(FILLABLE PDF FORMAT\)](#)
- [DKA Nursing Protocol](#)
- [DKA Flowsheet](#)
- [DKA Sample Prescriber Order Sheet](#)
- [DKA Recipes for Making Solutions](#)
- [DKA Glucose, Insulin and Fluid Management](#)
- [Blood Glucose and Insulin Record for Conventional Insulin Regimens](#)
- [Blood Glucose and Insulin Record for MDI](#)

### REFERENCES

Wherrett DK, Ho J, Huot C, Legault L, Nakhla N, Rosolowsky E. *Diabetes Canada Clinical Practice Guidelines Expert Committee. Diabetes Canada 2018 Clinical practice guidelines for the prevention and management of diabetes in Canada: Type 1 diabetes in children and adolescents. Can J Diabetes 2018;42(Suppl 1):S234-S246.*

Wolfsdorf JI, Glaser N, Agus M, Fritsch M, Hanas R, Rewers A, Sperling MA, Codner E. *ISPAD Clinical Practice Consensus Guidelines 2018: Diabetic ketoacidosis and the hyperglycemic hyperosmolar state. Pediatric Diabetes 2018;19(Suppl 27):155-177.*

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 3<sup>rd</sup>, Olsen CS, Casper TC, Dean JM, Glaser NS; PECARN DKA FLUID Study Group. *Clinical trial of fluid infusion rates for pediatric diabetic ketoacidosis. New England Journal of Medicine 2018;378(24):2275-2287.*

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Translating Emergency Knowledge for Kids (TREKK Canada): [www.trekk.ca](http://www.trekk.ca).

BC Children's Hospital SHOP (Shared Health Organizations Portal): [shop.healthcarebc.ca/phsa/bc-cnw-hospitals](http://shop.healthcarebc.ca/phsa/bc-cnw-hospitals).