
BCCH DKA GLUCOSE, INSULIN AND FLUID MANAGEMENT

2019 REVISIONS TO BCCH DKA PROTOCOL

The 2019 revisions to the BCCH DKA Protocol are based on the results of recent research findings on rehydration protocols. These revisions bring the BCCH DKA Protocol into alignment with the *Clinical Practice Consensus Guidelines 2018* from the International Society for Pediatric and Adolescent Diabetes (ISPAD) and with the 2018 DKA resources from TREKK Canada (references below).

INITIAL FLUID REPLACEMENT

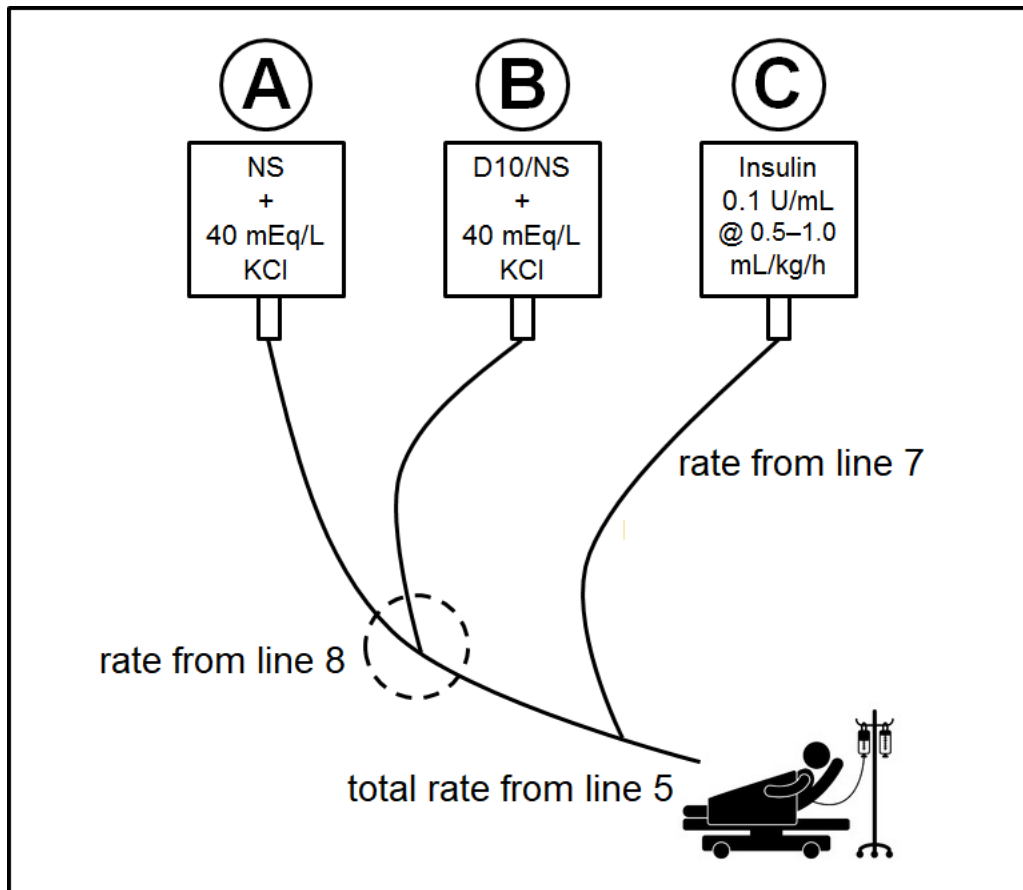
Results from the PECARN DKA FLUID Study (reference below) have demonstrated that fluid replacement can safely be achieved using more-aggressive regimens than have been in place over the past two decades. It is now recommended that all patients in moderate-to-severe DKA receive a 10-mL/kg bolus of 0.9% sodium chloride (normal saline, NS) over 30 minutes. Those patients with persistent tachycardia, prolonged capillary refill (>2 sec), and cool extremities should receive a second 10-mL/kg fluid push as well. Once the fluid push(es) have been delivered, and assuming the patient has adequate urine output and a normal serum potassium, fluid replacement is continued using NS + 40 mEq/L KCl (Bag A, see next section), until the patient has been receiving fluids for 2 hours; at that point, intravenous insulin is started. Fluid replacement rates are now calculated for a 36-hour period of rehydration, compared to the 48-h period used in the past.

THE "TWO-BAG SYSTEM"

The "two-bag system" (reference below) 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 total rate is determined by the child's degree of dehydration, according to the BCCH DKA Medical Protocol (line 5). 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 D10/NS + 40 mEq/L KCl (or D12.5/NS + 40 mEq/L KCl, if your institution can make this). The BCCH Pharmacy has prepared a "recipe book" for preparing these solutions from

commercially available IV solutions, which is available from the Parenteral Drug Manual on the BCCH ePOPS website and on BCCH Endocrinology's website (references below).



MANAGING THE BLOOD GLUCOSE (BG) LEVEL

The goal is to keep the BG levels in the 8-12 mmol/L range, both to minimize glycosuria and to allow for a buffer against hypoglycemia. This is most easily achieved by alternately adjusting the rates of the non-dextrose-containing Bag A and the dextrose-containing Bag B, while keeping the insulin infusion rate constant (see example below).

At the onset, it is recommended having both bags prepared and hung, starting Bag A at nearly the full rate (from line 8 of the BCCH DKA Medical Protocol), and starting Bag B at a "to-keep-open" rate (2-5 mL/h). The insulin infusion rate of 0.05-0.1 U/kg/h (0.5-1.0 mL/kg/h) should not be adjusted until the pH is close to normal (see below).

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

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 ~3-5 mmol/L/h.

Assuming that the BG is being monitored every 30-60 minutes, once it starts to approach ~20 mmol/L—sooner if the initial BG drop is >5 mmol/L/h—the rate of Bag A is decreased, and the rate of Bag B is increased by an equivalent amount. A general rule is to make changes of approximately 10-20% of the total every hour. This will depend on the rate of fall of the BG level and the patient's response to these changes.

If the patient's BG level is lower than desired, despite maximal dextrose infusion from Bag B, you may (in order of safety):

1. cut the insulin infusion rate by ~25%, provided the acidosis is correcting
2. give the patient a small amount (1-2 mL/kg) of juice or 2-4 dextrose tablets (being mindful of the overall fluid balance)
3. change the insulin bag to D10/NS
4. in institutions with intensive-care capabilities, consider placing a central line and using a higher concentration of dextrose (e.g. D20) in Bag B.

THE INSULIN INFUSION

The optimal initial insulin infusion rate is not known, but an increasing number of experts are suggesting a starting rate of 0.05 U/kg/h, i.e. 50% of the rate of previous protocols. ISPAD 2018 (reference below) supports the use of either starting rate, until more conclusive information is available. We would suggest that this lower rate be considered especially when (1) patients have already had a significant drop in their BG prior to starting insulin; (2) when the patient's acidosis is less severe; (3) or when it is expected that the patient will be quite insulin-sensitive (some young children with DKA, patients with hyperglycemic hyperosmolar state, and some older children with established diabetes and insulin pump-site failure or acute insulin omission).

The half-life of IV insulin is quite short (minutes), so the insulin infusion should never be discontinued, until the patient has been established on subcutaneous insulin. If the patient's BG level is difficult to maintain >8-10 mmol/L despite the measures suggested above, one can cut the insulin infusion rate by ~25%, provided that the metabolic acidosis is resolving. It is unusual for a child in DKA to need <0.025 U/kg/h.

POTASSIUM

Nearly all children in DKA will require large amounts of potassium for repletion, and 40 mEq/L KCl in the IV will generally suffice. Some children will require extra oral or nasogastric potassium chloride (0.5-1.0 mEq/kg) to keep their serum potassium level >3.5 mmol/L. Rarely, children will require less potassium, in which case one could use 20 mEq/L.

SWITCHING TO HALF-NORMAL SALINE

The goal of treating DKA is to slowly allow the BG and hyperosmolality to normalize, which initially requires the use of isotonic fluids, i.e. normal (0.9%) saline. After about 4-6 hours, once the corrected Na⁺ is ≥145 mmol/L, the patient may require some free water in the form of hypotonic fluids to continue to have a drop in serum osmolality. At this point, Bags A and/or B can be switched to their half-normal (0.45%) saline equivalents.

HELP IN REAL TIME

If you have questions or problems related to the management of DKA or diabetes (for patients in BC and the Yukon), please feel free to contact the BC Children's Hospital Pediatric Endocrinologist on call at 604-875-2161.

ONLINE LINKS

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

- [BCCH DKA Protocol Toolkit](#)
- [BCCH DKA Medical Protocol \(PLAIN PDF FORMAT\)](#)
- [BCCH DKA Medical Protocol \(FILLABLE PDF FORMAT\)](#)
- [BCCH DKA Nursing Protocol](#)
- [BCCH DKA Flowsheet](#)
- [BCCH DKA Sample Prescriber Order Sheet](#)
- [BCCH DKA Glucose, Insulin and Fluid Management](#)
- [BCCH DKA Recipes for Making Solutions](#)
- [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 3rd, 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.

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.

Translating Emergency Knowledge for Kids (TREKK Canada) [2018 diabetic ketoacidosis resources](#).

Glaser N, Kuppermann N. Fluid treatment for children with diabetic ketoacidosis: how do the results of the PECARN FLUID Trial change our perspective? *Pediatric Diabetes* 2019;20(1):10-14.

BC Children's Hospital ePOPS (Electronic Policies, Order Sets, Procedures and Standards): policyandorders.cw.bc.ca.