ENDOCRINOLOGY & DIABETES UNIT
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BCCH DIABETIC KETOACIDOSIS PROTOCOL TOOLKIT

The *BCCH DKA Protocol Toolkit* contains the following documents:

- the *BCCH DKA Protocol Toolkit* cover document (2024/12/10 version)
- the *BCCH DKA Medical Protocol* (2024/12/10 version) **plain PDF format***
- the *BCCH DKA Nursing Protocol* (2024/12/10 version)
- the *BCCH DKA Sample Prescriber Order Sheet* (2024/05/14 version)
- the *BCCH DKA Flowsheet* (2024/05/14 version)
- the *BCCH DKA Recipes for Making Solutions* handout (2024/05/14 version)
- the *BCCH DKA Glucose, Insulin and Fluid Management* handout (2024/12/10 version)

Each of these documents is also available individually for download from our website:
www.bcchildrens.ca/health-professionals/clinical-resources/endocrinology-diabetes/dka-protocol

*The BCCH DKA Medical Protocol can also be downloaded in **fillable PDF format** from our website:
www.bcchildrens.ca/endocrinology-diabetes-site/documents/dkaprtfill.pdf

Following the publication of the PEKARN DKA FLUID Trial [*New Engl J Med* 2018;378(24):2275-2287], which demonstrated the safety of more-aggressive fluid replacement regimens than are used in current DKA protocols, the Division of Pediatric Endocrinology & Diabetes has updated the BCCH DKA Protocol. Our 2024 revision aligns closely with the protocol developed by TREKK (Translating Emergency Knowledge for Kids), which is designed for the initial management of pediatric DKA in most Canadian emergency departments, as well as with the DKA algorithm developed by the Canadian Pediatric Endocrine Group, which is designed for ongoing inpatient management of DKA. The 2024 revision is also aligned with the *Clinical Practice Consensus Guidelines 2022* of the International Society for Pediatric and Adolescent Diabetes (ISPAD).

The major modifications from the previous version (dated 2019/10/08) of the protocol include:

- DKA is now defined as blood glucose ≥11.1 mmol/L, moderate–large ketonuria (≥2+) or plasma β-hydroxybutyrate ≥3.0 mmol/L, and venous pH <7.3 or plasma bicarbonate <18 mmol/L (previously 15 mmol/L).
- More-aggressive fluid boluses are suggested at the start of therapy: most patients with DKA should receive a 20-mL/kg bolus of normal saline at the beginning, those with poor cardiovascular function will require additional fluid boluses until stable.

We hope that you will find these materials to be helpful in managing pediatric cases of diabetic ketoacidosis. Please do not hesitate to contact the Endocrinology & Diabetes Unit at BCCH for any help in implementing this protocol at your health-care centre in British Columbia. We also welcome any suggestions to make this material more useful to your practice.

BC CHILDREN'S HOSPITAL DIABETIC KETOACIDOSIS PROTOCOL[A]

FOR CHILDREN AGES 1 MONTH TO 19 YEARS

THIS PROTOCOL IS ALSO AVAILABLE IN FILLABLE PDF FORMAT

FIRST 30 MIN

0. ABCs, vital signs (with BP), neurovital signs. Place large-bore IV. Draw labs. Confirm DKA: blood glucose ≥11.1 mmol/L, moderate–large ketonuria (≥2+) or plasma β-hydroxybutyrate ≥3.0 mmol/L, and venous pH <7.3 or plasma HCO_3^- <18 mmol/L.[C] Consider possibility of an element of hyperglycemic hyperosmolar state.[B]

1. Measure body weight in kilograms .....(1) _____ kg

2. Give 0.9% saline (normal saline, NS) resuscitation bolus[D]
   - recommended amount: 20 mL/kg over 30 min, max 1000 mL .....(2) _____ mL

3. Give rapid repeated boluses of NS if persistent tachycardia, prolonged cap refill (>2 sec), cool extremities:
   - 20 mL/kg boluses, repeated until stable; total **extra** given: .....(3) _____ mL

TIME = 30 MIN–36 HOURS

4. Begin rehydration, calculated for even correction over 36 hours, based on admission body weight:[E]
   - 5–10 kg: 6.5 mL/kg/h
   - 10–20 kg: 6 mL/kg/h
   - 20–40 kg: 5 mL/kg/h
   - >40 kg: 4 mL/kg/h, maximum 500 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 a plasma K^+ ≤5.5 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/h (Bag C). Ensure plasma K^+ ≥3.5 mmol/L first. Consider 0.5 mL/kg/h if pH >7.15.[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 ≥140 mmol/L, stable or increasing, switch Bag A to 0.45% saline w/ 40 mEq/L KCl and Bag B to D10–D12.5/0.45% saline w/ 40 mEq/L KCl at the rate as in (8)[H].

Rationale & 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, please feel free to contact the BCCH Pediatric Endocrinologist on call.

[B]Hyperglycemic hyperosmolar state (HHS) should be suspected when there is significant hyperglycemia (>33.3 mmol/L) and hyperosmolality (>320 mOsm/L) without ketosis or acidosis (bicarbonate >15 mmol/L, venous pH >7.25). 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 they really are. The hematocrit and other clinical signs (decreased capillary refill) are more accurate measures of dehydration.

[D]Recent research shows that most children with moderate–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 >8 mmol/L[G], drop the insulin rate by 25–50%. Consider 0.05 U/kg/h for pH >7.15. Ensure plasma K^+ ≥3.5 mmol/L before starting insulin.

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^+ <140 mmol/L, or falling regardless of level: continue NS
      corrected Na^+ ≥140, stable or increasing, switch to ½NS after 4–6 h
    - potassium[I,J]: patient urinating and K^+ remains ≤5.5: continue KCl 40 mmol/L
      may give 50% of K^+ as 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 (avoid hypocapnia) for impending 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]; Ca^{2+}, Mg^{2+} and P_i 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.

[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]At some point, the patient will require a switch to the use of hypotonic fluids. The corrected Na^+ should be calculated and followed closely: corrected Na^+ = [measured Na^+ + 0.36×(PG–5.6)]. It is also helpful to monitor the active osmolality [PG + 2×(Na^+ + K^+)], which should not fall >0.5 mOsm/kg/h. If the corrected sodium is ≥140 mmol/L and stable or rising and the active osmolality has been dropping slowly, switching to ½NS should 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).

[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^+ ≥3.5 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, it does have the theoretical advantage of repleting the severe phosphate deficit of DKA and/or ameliorating hyperchloremia which inevitably occurs during DKA treatment. A phosphate <0.32 mmol/L should be treated. 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 <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, ≥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 <5 years, and those with initial pH <7.1 or pCO_2 <18. The exact etiology of CE remains unclear. Resuscitation is successful in only 50% of cases.

Accompanying documents on our 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*

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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 <18 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)
- ↑ 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 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 Medical 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 Medical Protocol*.
3. Baseline and then vital signs and neurovital signs every 30–60 minutes.
4. Administer oxygen to patient based on their SpO_2 needs.
5. Measure blood glucose with hospital glucose 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 blood 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 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. Most patients will receive a 20 mL/kg normal saline (NS, sodium chloride 0.9%) bolus, maximum 1000 mL, over 30 minutes once the IV is in. For rare patients with circulatory failure, rapid repeated NS boluses of 20 mL/kg may be required.
9. After the initial NS fluid boluses, the desired fluid is NS + 40 mmol KCl/L, ensuring plasma potassium level is ≤5.5 mmol/L and the patient is urinating. The ER physician will calculate the rate of this from the *BCCH Medical 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 Medical Protocol*. The insulin infusion (**Bag *C***) will eventually be **Y**'d into these bags (see below).

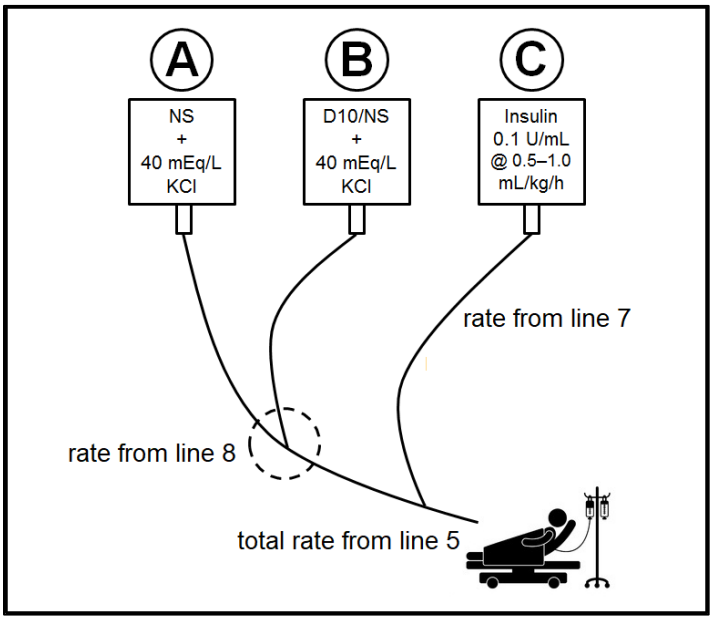
In the "two-bag system", **Bag A** is generally NS + 40 mEq/L KCl, and **Bag B** is usually D12.5/NS + 40 mEq/L KCl (or D10/NS + 40 mEq/L KCl if D12.5/NS is not available). The BCCH Pharmacy has prepared a "recipe book" for preparing these solutions from available IV solutions, which is available from 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, ensuring plasma K^+ is ≥3.5 mmol/L. 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 *Administration Set Priming and Loading and Initiating or Changing the Infusion*, available on the C&W SHOP website.
14. Depending on the patient's progress, the solutions may eventually (e.g. after 6 to 12 hours) be changed to ½NS + 40 mEq/L KCl and D10–12.5/½NS + 40 mEq/L KCl.

Nursing Care

- Blood glucose by glucose 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 in EMR or on paper 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
- Send urine sample to lab to check 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
- Unexplained bradycardia
- 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 available if needed for STAT administration at the physician's order.

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. Basal (Basaglar® and Levemir®) and rapid-acting (Humalog®/Admelog® and NovoRapid®/Tresiba®) 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 blood 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*

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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.

Translating Emergency Knowledge for Kids (TREKK Canada): www.trekk.ca.

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

PRESCRIBER'S ORDERS FOR DIABETIC KETOACIDOSIS (DKA) INPATIENT AND OUTPATIENT

DATE ___/___/_____ **TIME** ___:___ **HOURS**
DD MM YYYY **HH MM**

WEIGHT_____ kilograms	HEIGHT_____ centimetres	❑ ALLERGY CAUTION sheet reviewed

Pharmacy Use Only	WRITE FIRMLY WITH A BALLPOINT PEN WITH BLUE OR BLACK INK	Noted by RN/UC

On Admission STAT:

- ❑ vital signs and neurovital signs on admission and then hourly
- ❑ weigh patient
- ❑ strictly monitor input and output
- ❑ nothing by mouth
- ❑ pulse oximetry and cardiac monitor
- ❑ insert large-bore intravenous cannula
- ❑ capillary blood glucose by fingerpoke
- ❑ urine for ketones
- ❑ venous blood gas; whole blood sodium, potassium, chloride, bicarbonate, anion gap, ionized calcium, glucose, beta-hydroxybutyrate
- ❑ urea, creatinine, phosphorus, complete blood-cell count/differential, HbA1C
- ❑ other labs: _____

Fluid Resuscitation Bolus(es) (initial 30–60 minutes):

- ❑ 1st: sodium chloride 0.9% _____ mL IV over 30 minutes (20 mL/kg)
- ❑ 2nd (PRN): sodium chloride 0.9% _____ mL IV over 30 minutes (20 mL/kg)

Fluid Repair (after initial 30–60 minutes): begin at _____ h

- ❑ **Bag A:** sodium chloride 0.9% + 40 mEq/L potassium chloride at _____ mL/hour IV (rate determined from DKA protocol, line 5). Ensure serum potassium is ≤5.5 mmol/L.

Fluid Repair and Insulin Infusion (after initial 1–2 hours): begin at _____ h

- ❑ reduce **Bag A** to _____ mL/hour
- ❑ **Bag B:** dextrose 12.5% / sodium chloride 0.9% + 40 mEq/L potassium chloride at _____ mL/hour IV (sum of Bag A rate + Bag B rate determined from DKA protocol, line 8, to keep glucose 8–12 mmol/L)
- ❑ **Bag C:** 50 units insulin regular (Humulin® R or Novolin® Toronto) in 500 mL sodium chloride 0.9% at _____ mL/hour IV (rate determined from DKA protocol, line 7, where 1 mL/kg/hour = 0.1 units/kg/hour). Saturate insulin binding sites by priming and flushing with 50 mL of prepared insulin infusion to run through tubing and discard. Ensure serum potassium is ≥3.5 mmol/L.

Ongoing Monitoring:

- ❑ capillary glucose every _____ minutes (suggested 30–60 minutes)
- ❑ venous blood gas; whole blood sodium, potassium, chloride, bicarbonate, anion gap, ionized calcium, glucose, β-hydroxybutyrate; plasma urea, creatinine, and phosphorus every _____ hours (suggested 2–4 hours)
- ❑ if patient develops severe headache or alteration in vital signs or Glasgow Coma Scale Score: notify MD STAT, raise head of bed 30°, decrease all IV fluids to 5 mL/hour pending MD review
- ❑ mannitol 20% _____ g IV STAT over 15 minutes (0.5–1 g/kg, 2.5–5 mL/kg)
- ❑ sodium chloride 3% _____ mL IV STAT over 15 minutes (2.5–5 mL/kg)

Signature: _____ Pager # _____

Print Name: _____ License #_____

BCCH ENDOCRINOLOGY & DIABETES UNIT
DIABETIC KETOACIDOSIS FLOWSHEET

Date: Time:											
Heart Rate											
Respiratory Rate											
Blood Pressure											
Glasgow Coma Scale											
Neuro ✓ Done?											
Blood Glucose	Meter										
	Lab										
Urine Ketones											
Nurse's Initials											
Venous pH											
Bicarbonate: HCO_3^-	Venous										
	Serum										
Base Deficit											
Sodium: Na^+											
Potassium: K^+											
Chloride: Cl^-											
Anion Gap: $[Na^+ + K^+ - Cl^- - HCO_3^-]$											
β-Hydroxybutyrate											
"Corrected" Sodium: $Na^+ + 0.36 \times [Glucose - 5.6]$											
"Active" Osmolality: $Glucose + 2 \times [Na^+ + K^+]$											
Urea											
Creatinine											
Calcium											
Phosphate											
Physician's Initials											

ENDOCRINOLOGY & DIABETES UNIT
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BCCH DKA RECIPES FOR MAKING SOLUTIONS

Item #		Dextrose solution to prepare:	1 Dextrose solution and size of IV bag to use:	2 Withdraw & discard from bag:	3 Add to bag:
1	commercially available	**D5W**-NaCl 0.9% with 40 mmol KCl /L			
2		**D10W**-NaCl 0.9% with 40 mmol KCl /L	1000 mL D5W-NaCl 0.9% with 40 mmol KCl /L	100 mL	100 mL **D50W**
3		**D12.5W**-NaCl 0.9% with 40 mmol KCl /L	1000 mL D5W-NaCl 0.9% with 40 mmol KCl /L	100 mL	150 mL **D50W**
4	commercially available	**D5W**-NaCl 0.45% with 40 mmol KCl /L			
5		**D10W**-NaCl 0.45% with 40 mmol KCl /L	1000 mL D5W-NaCl 0.45% with 40 mmol KCl /L	100 mL	100 mL **D50W**
6		**D12.5W**-NaCl 0.45% with 40 mmol KCl /L	1000 mL D5W-NaCl 0.45% with 40 mmol KCl /L	100 mL	150 mL **D50W**
Note: this results in approximate concentrations and is to be used only when Pharmacy mixing is not available					
Prepared by **C&W Pharmacy Department; contact 604-875-2059 for questions**					

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BCCH DKA GLUCOSE, INSULIN AND FLUID MANAGEMENT

2024 Revisions to the BCCH DKA Protocol

The 2024 revisions to the *BCCH DKA Medical Protocol* are based on the results of recent research findings on rehydration protocols. These revisions bring the *BCCH DKA Medical Protocol* into alignment with the *Clinical Practice Consensus Guidelines 2022* from the International Society for Pediatric and Adolescent Diabetes (ISPAD) and with the 2023 DKA resources from TREKK Canada (references below).

Initial Fluid Replacement

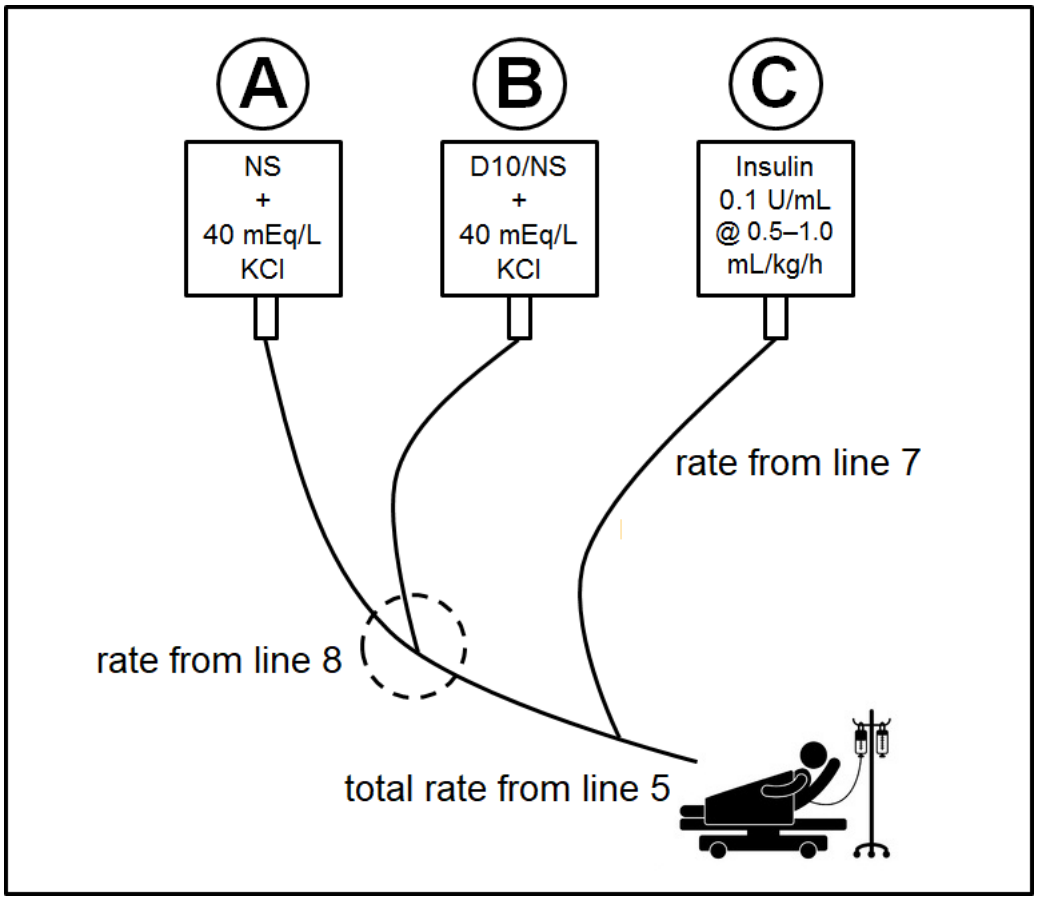
Results from the PECARN DKA FLUID Study (reference below) have demonstrated that fluid replacement can safely be achieved using more-aggressive regimens than have been in place over the past two decades. It is now recommended that most patients in moderate-to-severe DKA receive a 20–mL/kg bolus of 0.9% sodium chloride (normal saline, NS), maximum 1000 mL, over 30 minutes. Those patients with persistent tachycardia, prolonged capillary refill (>2 sec), and cool extremities should receive rapid repeated 20-mL/kg fluid pushes to restore peripheral circulation. Once the fluid push(es) have been delivered, and having ensured that the patient has adequate urine output and a plasma potassium ≤5.5 mmol/L, fluid replacement is continued using NS + 40 mEq/L KCl (Bag A, see next section), until the patient has been receiving fluids for 1–2 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 fluid replacement rate calculated includes both the fluid deficit and maintenance fluids; ongoing urinary losses are generally not replaced.

For obese children, adult fluid rates are used: 1000 mL for a resuscitation bolus and a rate of 500 mL/h for ongoing fluid infusions.

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 ~2–5 mmol/L/h.

Assuming that the BG is being monitored every 30–60 minutes, once it starts to approach ~14–17 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 2022 (reference below) supports the use of either starting rate (0.05 or 0.1 U/kg/h), until more conclusive information is available. ISPAD does suggest 0.05 U/kg/h when pH >7.15. 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).

It is important to ensure a plasma potassium ≥3.5 mmol/L before starting insulin.

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 plasma potassium level ≥3.5 mmol/L. Rarely, children will require less potassium, in which case one could use 20 mEq/L. Potassium should be deferred if a patient is not urinating or if plasma K^+ >5.5.

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 ≥140 mmol/L and is stable or rising, the patient should receive some free water in the form of hypotonic fluids to continue to have a drop in plasma osmolality. At this point, Bags A and/or B can be switched to their half-normal (0.45%) saline equivalents.

Treating the Acidosis

At presentation, DKA-associated acidosis can be combination of lactic and ketoacidosis. Lactic acidosis will resolve with restoration of peripheral circulation. The ketoacidosis

will resolve with fluids and insulin; the β-hydroxybutyrate should drop ~0.5 mmol/L/h. There is a general contraindication to the use of bicarbonate in DKA. Later in the course of DKA, a patient can develop a hyperchloremic acidosis from the large amounts of NaCl and KCl they are receiving. This can be distinguished from ketoacidosis by measuring β-hydroxybutyrate. Hyperchloremia can be treated or prevented using 0.45% normal saline or a combination of KCl and KPhos (see next section).

Monitoring Phosphate Levels

Phosphate levels frequently drop during DKA treatment. There is little evidence supporting the routine use of phosphate-containing fluids in DKA. However, severe phosphate deficiency (<0.32 mmol/L ± symptoms) should be treated. This can be done by replacing 50% of the KCl in the infusion as KPhos (20 mEq/L each KCl and KPhos). If this is done, one needs to pay attention to the possibility that this can cause hypocalcemia and hypomagnesemia.

Calculations

Anion gap: $Na^+ + K^+ - Cl^- - HCO_3^-$: normal 16 ± 2 mmol/L
Corrected Na^+ = measured Na^+ + [0.36 × (plasma glucose – 5.6)]
Effective osmolality = plasma glucose + [2 × ($Na^+ + K^+$)]: normal 275–295 mOsm/kg

Treatment of Suspected Cerebral Injury

1. airway / breathing / circulation
2. elevate head of bed
3. reduce fluid rate by ⅓, but avoid hypotension
4. administer hyperosmolar agent:
   - mannitol 20% 0.5–1 g/kg (2.5–5 mL/kg) IV over 15 min
   - NaCl 3% 2.5–5 mL/kg IV over 15 min
5. intubate if pending respiratory failure
6. mild hyperventilation, avoid hypocapnia

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 Glucose, Insulin and Fluid Management*
- *BCCH DKA Recipes for Making Solutions*

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