ENDOCRINOLOGY & DIABETES UNIT
Diabetes Clinic: 604-875-2868
Toll-free Phone: 1-888-300-3088, x2868
Fax: 604-875-3231
http://endodiab.bcchildrens.ca

DIABETIC KETOACIDOSIS PROTOCOL TOOLKIT

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

- the *BCCH DKA Protocol Toolkit* cover document (2016/03/15 version)
- the *BCCH Diabetic Ketoacidosis Medical Protocol* (2015/10/06 version) **PLAIN PDF FORMAT***
- the *BCCH Diabetic Ketoacidosis Nursing Protocol* (2016/03/15 version)
- the *BCCH Diabetic Ketoacidosis Flowsheet* (2015/10/13 version)
- the *BCCH Diabetic Ketoacidosis Sample Physician Order Sheet* (2016/01/16 version)
- the *BCCH Recipes for Making DKA Solutions* (2016/01/19 version)
- the *Glucose, Insulin and Fluid Management in DKA* handout (2016/03/15 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

The BCCH DKA Protocol has been revised to conform to the International Society for Pediatric and Adolescent Diabetes's *2014 Clinical Practice Consensus Guidelines*, the current gold-standard protocol for managing DKA in infants, children and adolescents. This protocol also conforms to the Canadian Diabetes Association's *2013 Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada*.

The major modifications from the previous version (dated 2006/11/03) of the protocol include:

- increased caution in the use of hypotonic fluids in the first 12–24 hours of DKA management
- increased attention to serum sodium levels and the appreciation of the coexistence of hypernatremic dehydration and DKA
- delay in the introduction of insulin infusions for the first 1–2 hours of DKA management
- formalization of the use of the "two-bag" system to facilitate physician and nursing management of IV fluids
- broadening of the safe and effective range of 0.05–0.1 units/kg/h for the insulin infusion

The changes were introduced to reflect an increased understanding in the medical literature of factors leading to complications, particularly cerebral edema, which arise during the treatment of DKA in infants, children and adolescents.

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 UP TO AGE 19 YEARS

THIS PROTOCOL IS ALSO AVAILABLE IN *FILLABLE PDF FORMAT*

BC CHILDREN'S HOSPITAL
An agency of the Provincial Health Services Authority

ON ADMISSION

0. Confirm DKA: plasma glucose (PG) ≥11 mmol/L, ketones, capillary pH ≤7.3, HCO_3^- ≤15 mmol/L.[B]

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

2. Establish extent of dehydration (↓ BP, tears, skin turgor, capillary refill; ↑ hematocrit) in mL/kg:[C]

	infants:	**children:**
• mild:	5% = 50 mL/kg	3% = 30 mL/kg
• moderate:	10% = 100 mL/kg	6% = 60 mL/kg
• severe:	15% = 150 mL/kg	9% = 90 mL/kg .....(2) _____ mL/kg

3. Calculate total fluid deficit: multiply (1) × (2) .....(3) _____ mL

4. Give normal saline (NS) resuscitation bolus **only if patient is orthostatic or shocky**:[D]
   - recommended amount: 5–10 mL/kg BW over 1–2 hours, max <30 mL/kg .(4) _____ mL

TIME = 0–120 MIN

5. Calculate remainder of fluid deficit after fluid bolus: subtract (4) from (3) .....(5) _____ mL

6. Calculate maintenance fluid requirements for the next **48 hours**:[E]
   → 200 mL/kg for the first 10 kg BW
   \+ 100 mL/kg for the next 10 kg BW
   \+ 40 mL/kg for the rest of BW .....(6) _____ mL/**48 h**

7. Calculate total amount of fluid still to be given over 48 hours: add (5) and (6).....(7) _____ mL/**48 h**

8. Calculate hourly rate of fluid replacement: divide (7) by 48 .....(8) _____ mL/h

9. Use **normal saline** (NS) as initial replacement fluid, at rate determined in (8). Add KCl 20–40 mEq/L only if hypokalemic and patient has adequate urine output. Continue this for 1–2 hours.

TIME = 60–120 MIN

10. After 1–2 hours, make up and start a piggyback insulin drip at 0.05–0.1 units/kg BW/h:[F]
    - 50 units insulin regular (Humulin® R or Novolin® Toronto) in 500 mL NS or D10/NS
    - run at 0.5–1.0 mL/kg BW/h .....(10) _____ mL/h

11. Begin "2-bag method" to replace NS[G]. Y together (a) NS with 40 mEq/L KCl and (b) D10–D12.5/NS with 40 mEq/L KCl. Decrease replacement fluid rate to adjust for insulin drip rate: subtract (10) from (8) .....(11) _____ mL/h

12. Aim to keep PG ~10–15 mmol/L by titrating the rates of these two solutions, keeping the combined rate at (11) [G]. Continue this for the next 6–12 hours, monitoring as below in (15) and (16).

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 or diabetes, please feel free to contact the BCCH Pediatric Endocrinologist on call.

[B]Hyperglycemic hyperosmolar syndrome should be suspected when there is significant hyperglycemia (>33 mmol/L) and hyperosmolality (>330 mOsm/L) without ketosis or acidosis (bicarbonate >15 mmol/L). 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 noted are more accurate.

[D]Large fluid boluses are potentially dangerous[L] and should be administered with caution, unless the patient is truly shocky. Only very rarely will a larger (>20 mL/kg BW) fluid bolus will be required to maintain perfusion.

[E]Since most patients develop DKA over days, slow metabolic repair is safest. Overhydration may contribute to cerebral edema.[L] Nonetheless, DKA in children often resolves in less than 48 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 >10 mmol/L[G], drop the insulin rate by 25–50%.

THROUGHOUT

13. 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 ~10–15 mmol/L range
    - sodium[H]: corrected Na^+ <140 mmol/L or falling: continue NS
      corrected Na^+ 140–150, stable: switch to ½NS after 4–6 h
      corrected Na^+ >150, stable: switch to ½NS after 10–12 h
    - potassium[I,J]: patient urinating: continue KCl 20–40 mmol/L
      may give 50% of K^+ as acetate or phosphate
    - bicarbonate[K]: $NaHCO_3$ is **not** generally recommended
14. 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 fluid rate by one-third
    - mannitol (0.5–1 g/kg IV over 20 min) or 3% NaCl (5–10 mL/kg IV over 30 min)[L]
    - consider intubation and mild hyperventilation (keep pCO_2 >22 mg Hg) for impending respiratory failure
    - arrange CT when stable
15. 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, capillary 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
16. Re-evaluate appropriateness of replacement fluid type frequently, anticipating the need to increase or decrease Na^+, K^+, dextrose, etc.

Accompanying documents on our website:
- *DKA Flowsheet*
- *DKA Sample Physician Order Sheet*
- *DKA Nursing Protocol* (including the "two-bag" method)
- *Pharmacy Recipes for Making DKA Solutions*

[G]Keeping the PG in the ~10–15 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 costs and time.

[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 >0.5 mOsm/kg/h. If the corrected sodium is 140–150 mmol/L and stable and the active osmolality has been dropping slowly, switching to ½NS can be considered after 4–6 h. 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 with extreme caution, 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^+ >3.0 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 it does have 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]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 etiology of CE remains unclear, but aggressive hydration has been implicated in several studies. Resuscitation is successful in only 50% of cases. Most experts suggest limiting fluids to <4 L/m^2 body surface area, or to <2.5× maintenance fluid rate in the first 24 h, and to <50 mL/kg in the first 4 h.

ENDOCRINOLOGY & DIABETES UNIT
Diabetes Clinic: 604-875-2868
Toll-free Phone: 1-888-300-3088, x2868
Fax: 604-875-3231
http://endodiab.bcchildrens.ca

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)
- ↑ 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 + 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).

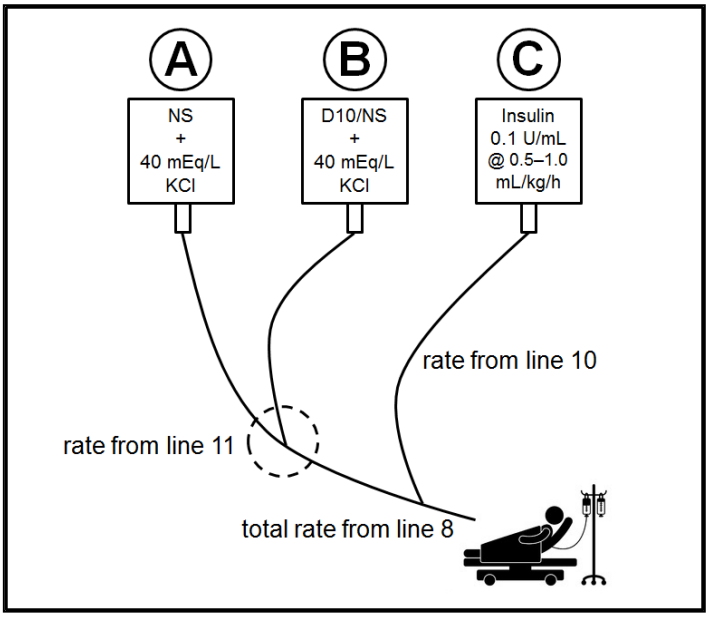
In the "two-bag system", **Bag A** is generally NS + 40 mEq/L KCl, and **Bag B** is usually D12.5/NS + 40 mEq/L KCl (or D10/NS + 40 mEq/L KCl if D12.5/NS is not available). The BCCH Pharmacy has prepared a "recipe book" for preparing these solutions from available IV solutions, which is available from 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 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: IV rate from protocol line 11 = 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 1–2 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 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 0.5–1 mL/kg/hr (which is 0.05–0.1 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 mmol/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. According to BCCH Nursing Policy, the IV bag is changed every 24 hours, and the tubing is changed every 96 hours.

14. 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 96 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.

15. Depending on the patient's progress, the solutions may eventually (e.g. after 6–12 hours) be changed to ½NS + 40 mEq/L KCl and D10–12.5/½NS + 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 hourly until 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®, NovoRapid®, or Apidra®) 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 (Humulin® R or Novolin® Toronto), the insulin injection is given 20–30 minutes before breakfast or dinner, and the insulin infusion is turned off 30–60 minutes after the injection. For rapid-acting insulin (Humalog®, NovoRapid® or Apidra®), the insulin injection is given immediately before breakfast or dinner, and the insulin infusion is turned off 20–30 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

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 Physician Order Sheet
- BCCH Recipes for Making DKA Solutions
- Blood Glucose and Insulin Record
- Glucose, Insulin and Fluid Management in DKA

References

Wolfsdorf JI, Allgrove J, Craig ME, Edge J, Glaser N, Jain V, Lee WWR, Mungai LNW, Rosenbloom AL, Sperling MA, Hanas R. Diabetic ketoacidosis and hyperglycemic hyperosmolar state. International Society for Pediatric and Adolescent Diabetes Clinical Practice Consensus Guidelines 2014 Compendium. *Pediatric Diabetes* 2014:15(Suppl. 20):154–179.

Metzger DL. Diabetic ketoacidosis in children and adolescents: an update and revised treatment protocol. *British Columbia Medical Journal* 2010;52(1):24–31.

Fuloria M, Friedberg MA, DuRant RH, Aschner JL. Effect of flow rate and insulin priming on the recovery of insulin from microbore infusion tubing. *Pediatrics* 1998;102(6):1401–1406.

Furberg H, Jensen AK, Salbu B. Effect of pretreatment with 0.9% sodium chloride or insulin solutions on the delivery of insulin from an infusion system. *American Journal of Hospital Pharmacy* 1986;43(9):2209–2213.

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

BC CHILDREN'S HOSPITAL

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											
Capillary pH											
Bicarbonate: HCO_3^-	Capillary										
	Venous										
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											

BCCH 551

BC CHILDREN'S HOSPITAL
An agency of the Provincial Health Services Authority

CHILDREN'S & WOMEN'S HEALTH CENTRE OF BRITISH COLUMBIA
AN AGENCY OF THE PROVINCIAL HEALTH SERVICES AUTHORITY

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
- ❑ capillary 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 (ONLY AS NECESSARY FOR CARDIOVASCULAR INSTABILITY)
- ❑ 0.9% sodium chloride _____ mL IV over _____ minutes (suggested 5–10 mL/kg over 30–60 minutes; repeat if necessary, maximum <30 mL/kg

Fluid Repair (initial 1–2 hours):
- ❑ 0.9% sodium chloride, run at _____ mL/hour IV (rate determined from DKA protocol, line 8) until _____ o'clock

Fluid Repair (after first 1–2 hours): begin at _____ o'clock
- ❑ discontinue above 0.9% sodium chloride order
- ❑ Bag A: 0.9% sodium chloride + 40 mEq/L potassium chloride at _____ mL/hour IV
- ❑ Bag B: 12.5 % dextrose / 0.9% sodium chloride + 40 mEq/L potassium chloride at _____ mL/hour IV (sum of Bag A rate + Bag B rate determined from DKA protocol, line 11, to keep glucose 10–15 mmol/L)

Insulin Infusion (after first 1–2 hours): begin at _____ o'clock
- ❑ Bag C: 50 units insulin regular (Humulin® R or Novolin® Toronto) in 500 mL 0.9% sodium chloride, flush first 50 mL, then run at _____ mL/hour IV (rate determined from DKA protocol, line 10, where 1 mL/kg/hour = 0.1 units/kg/hour)

Ongoing Monitoring:
- ❑ capillary glucose every _____ minutes (suggested 30–60 minutes)
- ❑ capillary blood gas; whole blood sodium, potassium, chloride, bicarbonate, anion gap, ionized calcium, glucose, beta-hydroxybutyrate; plasma urea, creatinine, phosphorus every _____ hours (suggested 2–4 hours)
- ❑ if patient develops severe headache or alteration in vital signs or Glasgow Coma Scale Score: notify physician STAT, raise head of bed 30°, decrease all IV fluids to 5 mL/hour, and have mannitol ready at bedside for infusion

Signature: _____ Pager # _____

Print Name: _____ College ID#_____

ENDOCRINOLOGY & DIABETES UNIT
Diabetes Clinic: 604-875-2868
Toll-free Phone: 1-888-300-3088, x2868
Fax: 604-875-3231
http://endodiab.bcchildrens.ca

BCCH RECIPES FOR MAKING DKA 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**					

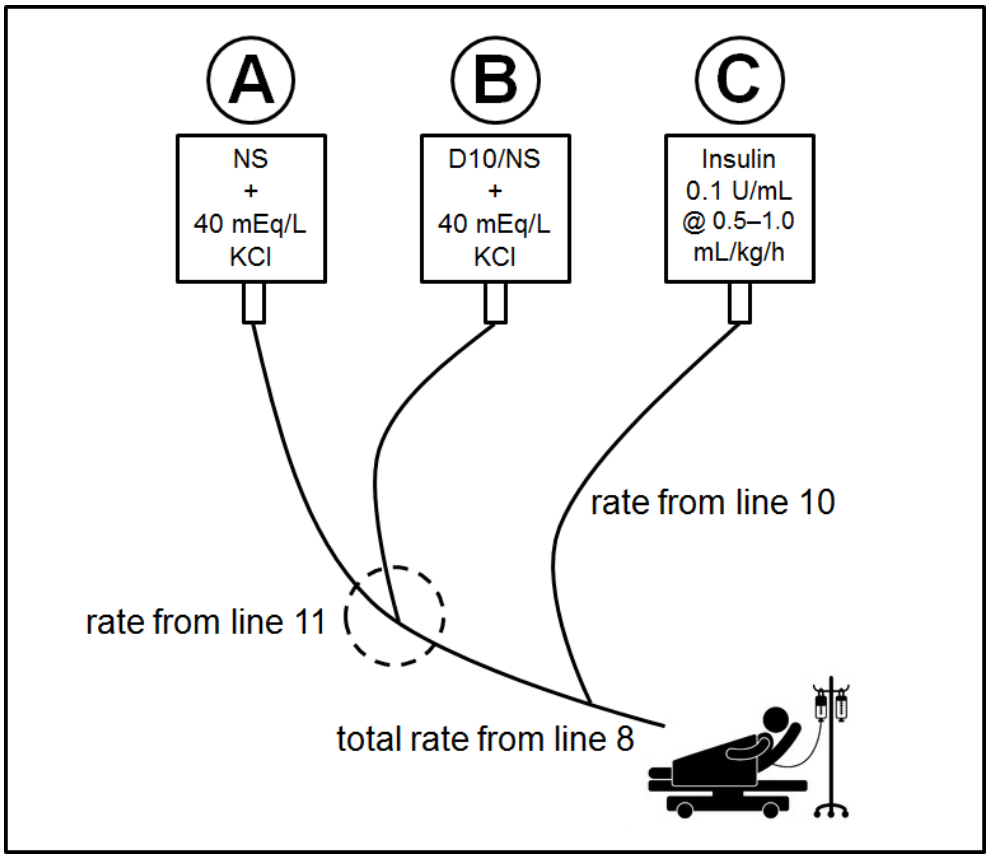
ENDOCRINOLOGY & DIABETES UNIT
Diabetes Clinic: 604-875-2868
Toll-free Phone: 1-888-300-3088, x2868
Fax: 604-875-3231
http://endodiab.bcchildrens.ca

GLUCOSE, INSULIN AND FLUID MANAGEMENT IN DKA

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 DKA Medical Protocol (line 8). 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 C&W Intranet and on BCCH Endocrinology's website (see below).



MANAGING THE FLUIDS AND THE BLOOD GLUCOSE LEVEL

The goal is to keep the blood glucose levels in the 10–15 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–glucose-containing Bag A and the glucose-containing Bag B, while keeping the insulin infusion rate constant (see below).

At the onset, it is recommended having both bags prepared and hung, starting Bag A at nearly the full rate (from line 11 of the 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).

The blood glucose 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 glucose of ~3–5 mmol/L/h.

Assuming that the blood glucose is being monitored every 30–60 minutes, once the blood glucose starts to approach ~20 mmol/L—sooner if the initial blood glucose 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 blood glucose level and the patient's response to these changes.

If the patient's blood glucose level is lower than desired, despite maximal glucose 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 glucose 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 glucose (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. The International Society for Pediatric and Adolescent Diabetes (ISPAD, 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 blood glucose 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 blood glucose 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 serum glucose and hyperosmolality to normalize, which initially requires the use of isotonic fluids, i.e. normal (0.9%) saline. After about 6–8 hours (sometimes sooner, if the corrected sodium and/or osmolality is rising), 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.

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 Physician Order Sheet
- BCCH Recipes for Making DKA Solutions
- Blood Glucose and Insulin Record
- Glucose, Insulin and Fluid Management in DKA

REFERENCES

Wolfsdorf JI, Allgrove J, Craig ME, Edge J, Glaser N, Jain V, Lee WWR, Mungai LNW, Rosenbloom AL, Sperling MA, Hanas R. Diabetic ketoacidosis and hyperglycemic hyperosmolar state. International Society for Pediatric and Adolescent Diabetes Clinical Practice Consensus Guidelines 2014 Compendium. *Pediatric Diabetes* 2014:15(Suppl. 20):154–179.

Metzger DL. Diabetic ketoacidosis in children and adolescents: an update and revised treatment protocol. *British Columbia Medical Journal* 2010;52(1):24–31.

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.