Provincial Clinical Knowledge Topic

Diabetic Ketoacidosis, Pediatric – Emergency & Inpatient

Version 1.0

Revision History

Version	Date of Revision	Description of Revision	Revised By

Important Information Before you Begin

The recommendations contained in this knowledge topic have been provincially adjudicated and are based on best practice and available evidence. Clinicians applying these recommendations should, in consultation with the patient, use independent medical judgment in the context of individual clinical circumstances to direct care. This knowledge topic will be reviewed periodically and updated as best practice evidence and practice change.

The information in this topic strives to adhere to Institute for Safe Medication Practices (ISMP) safety standards and align with Quality and Safety initiatives and accreditation requirements such as the Required Organizational Practices. Some examples of these initiatives or groups are: Health Quality Council Alberta (HQCA), Choosing Wisely campaign, Safer Healthcare Now campaign etc.

Guidelines

This topic is based on the following guideline(s):

- ISPAD Clinical Practice Consensus Guidelines 2014 Compendium: Diabetic Ketoacidosis and Hyperglycemic Hyperosmolar State
- Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2013 Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada. Can J Diabetes 2013;37(suppl 1):S1-S212.
- Alberta Children's Hospital Pediatric (Pediatric Intensive Care Unit) Guidelines for the Management of Type 1 Diabetes Mellitus in Children
- Alberta Children's Hospital Pediatric (Pediatric Intensive Care Unit) Cerebral Edema in Diabetic Ketoacidosis (Guideline)
- Red Deer Regional Hospital Diabetic Ketoacidosis (DKA) Pediatric Protocol
- Stollery Children's Hospital Diabetic Ketoacidosis Guideline + Paper forms
- BC Children's Hospital Diabetic Ketoacidosis Protocol
- Prescriber's Orders for Diabetic Ketoacidosis (DKA) Inpatient and Outpatient
- Bottom Line Recommendations: Diabetic Ketoacidosis (DKA) –Translating Emergency Knowledge for Kids (TREKK)
- Alberta Health Services (Red Deer Regional Hospital) Pediatric Diabetic Ketoacidosis Orders (Up to age 18)
- Alberta Health Services (Stollery Children's Hospital) Diabetic Ketoacidosis (DKA) Admission Orders
- Alberta Health Services (Chinook Regional Hospital) Diabetic Ketoacidosis (DKA) Pediatric Protocol Flowsheet
- Alberta Health Services (Chinook Regional Hospital) Pediatric Diabetic Ketoacidosis (DKA) Protocol *(age less than or equal to 16 years)*

For questions or feedback related to this knowledge topic please contact Clinical Knowledge Topics by emailing clinicalknowledgetopics@ahs.ca

Rationale

Diabetic ketoacidosis (DKA) is the most common cause of premature mortality in children with type 1 diabetes.[1] DKA is a complication of diabetes involving hyperglycemia resulting from a deficiency of insulin. It may occur as a result of: undiagnosed type 1 diabetes, insulin omission or manipulation, insulin pump malfunction or inadequate insulin dosing and monitoring during periods of significantly increased insulin needs, such as illness, infection, major stress or puberty. The hyperglycemia results in a combination of osmotic diuresis, electrolyte abnormalities, and ketone production/acidosis that can lead to significant morbidity and mortality.[2] DKA occurs in up to 40% of children and youth with new onset diabetes.[3,4]

Pediatric DKA must be treated differently than adult DKA. Treatment and management methods used for DKA in adult patients may increase the risk of cerebral edema in pediatric patients. Cerebral edema is a life threatening complication of DKA which occurs in up to 3% of DKA episodes.[4] Cerebral edema is associated with moderate/severe DKA, over hydration, the use of insulin in the first hour of therapy, the use of bolus insulin, bicarbonate use, or too rapid correction of blood glucose.[5]

Pediatric DKA Management Algorithm

KEY POINTS for Pediatric DKA

- **AVOID** overhydration: DO NOT EXCEED 2 x maintenance fluids in the first 24 hours
- **NO** insulin in the first 1-2 hours of treatment
- **NO** insulin boluses
- **NO** bicarbonate

CEREBRAL EDEMA RISK FACTORS

- pH less than 7,
- pCO2 less than 18,
- HCO3 less than 5
- high urea nitrogen

CEREBRAL EDEMA RED FLAGS (often presenting several hours into treatment)

- Decreased LOC
- Headache
- Vomiting
- Incontinence
- Cranial nerve palsies
- Low Oxygen saturations
- Hypertension

Notify physician immediately if red flags are present.

Monitoring
Close nursing observation and frequent assessment. Nursing ratio depends on staffing and individual nursing unit.

Diagnosis of DKA

Initial Management in Emergency Department/Urgent Care (First Hour After Presentation)

Classification of severity

- **Mild**: pH 7.2-7.29 and HCO3 10-14 mmol/L
- **Moderate**: pH 7.1-7.19 and HCO3 5-9 mmol/L
- **Severe**: pH less than 7.1 and HCO3 less than 5 mmol/L

Hemodynamically stable?

- YES → **Initial Fluid Management (volume expansion)**
  0.9% NaCl 10mL/kg IV over 1 hour
- NO → **Resuscitate according to PALS guidelines. Contact PICU to aid in management**

Is child at a site experienced in the care of peds DKA?

Ongoing Management (Hours 1-4 After Presentation)

- YES → **Admit to Hospital**
  Consider ICU admission if required
- NO → **Transfer to site experienced in care of pediatric DKA; continue ongoing management until transfer**

Ongoing DKA Management (1-4 hours)

- **NPO**
- **Rehydrate**: IV rate of 1.5 x maintenance for mild/moderate DKA and 2 x maintenance for severe DKA until detailed fluid calculations are completed
- **Add Potassium**: Change solution to IV 0.9%NaCl with 40 mmol KCl/ L
- **Initiate insulin infusion** 0.1 units/kg/hour after 1-2 hours of IV fluids
- **Recurring labs**; Blood glucose by chemstrip hourly
- **Once glucose reaches 17 mmol/L ADD dextrose** to IV fluid:
  - For patients being transferred to a pediatric DKA site: D5W0.9%NaCl with 40 MEqKCl/L; maintain glucose >10 mmol/L during transfer
  - For pediatric DKA sites- follow algorithm below for TWO Plus ONE Bag system using calculated fluid rates

Next 48 Hours of Admission Until Discharge (Inpatient Unit)

Use TWO Plus ONE Bag System
TWO FLUID Bags: one without Dextrose and one with Dextrose
Maintain calculated total fluid rate; adjust the two bag rates to maintain blood glucose 8-15 mmol/L
ONE INSULIN infusion
Maintain infusion at 0.1 units per kg per hour; do not reduce insulin rate as it is correcting the acidosis

Adjust potassium, sodium in IV fluids based on laboratory monitoring.
Most patients can be maintained on 0.9%NaCl with potassium throughout DKA treatment

Transition to subcutaneous insulin when acidosis corrected and child ready to eat → **Discharge teaching** → **Discharge and Follow Up**

Decision Making

Initial DKA Diagnosis and Decision Making

Children with DKA can present at any age. DKA may be the first presentation of diabetes or occur in a known diabetic patient. The following signs and symptoms may occur at presentation:

Symptoms of hyperglycemia, a consequence of insulin deficiency:
- Polyuria - Increased volume and frequency of urination
- Polydipsia - Thirst is often extreme
- Nocturia and secondary enuresis in a previously continent child
- Weight loss - May be dramatic due to breakdown of protein and fat stores
- Muscle pains and cramps

Symptoms of acidosis and dehydration:
- Abdominal pain - May be severe enough to present as a surgical emergency
- Shortness of breath - May be mistaken for primary respiratory distress
- Confusion and coma in the absence of recognized head injury

Patients with diabetic ketoacidosis may also have the following signs and symptoms:
- Vomiting
- Dehydration
- Signs of intercurrent infection (eg, urinary or respiratory tract infection)
- Weakness and nonspecific malaise that may precede other symptoms of hyperglycemia
- Tachycardia
- Reduced capillary refill
- Kussmaul breathing or deep sighing respiration - A mark of acidosis
- Ketone odor - Patient may have a smell of ketones on his/her breath
- Impaired consciousness or coma
- Abdominal tenderness - Usually nonspecific or epigastric in location

When DKA is suspected: Confirm DKA (diabetic ketoacidosis):[5]
- plasma glucose (PG) greater than 11 mmol/L
- ketonemia (hydroxybutyratemia) or ketonuria
- pH less than or equal to 7.3
- HCO3 less than 15 mmol/L

Clinical Decision Support: Hyperglycemic hyperosmolar syndrome (HHS) should be suspected when there is significant hyperglycemia (greater than 33 mmol/L) and hyperosmolality (greater than 330 mOsm/Kg) without ketosis or acidosis (bicarbonate greater than 15 mmol/L). A mixed picture of DKA and HHS is possible.

If HHS is suspected, management of the patient will differ from management of DKA.
Care by a team experienced in the care of pediatric DKA and HHS is required.
Consult with tertiary care pediatric center endocrinologist and/or PICU for ongoing management and to arrange transfer if not at a tertiary center.

Classifying the Severity of DKA[5]

At initial assessment, children with DKA should be categorized in terms of severity based on initial lab testing. These categories guide rehydration calculations and inform the patient's risk of cerebral edema and requirements for monitoring:

MILD DKA (pH 7.2-7.29 and HCO3 10-14 mmol/L): should be admitted to hospital for intravenous (IV) fluid therapy, IV insulin infusion and close monitoring. The risk of cerebral edema in mild DKA is less than in moderate or severe DKA, however the risk of cerebral edema still exists.

MODERATE DKA (pH 7.1-7.19 and HCO3 5-9 mmol/L): should be admitted to hospital for intravenous (IV) fluid therapy, IV insulin infusion and close monitoring.

SEVERE DKA (pH less than 7.1 and HCO3 less than 5 mmol/L): are at the highest risk for cerebral edema. These patients should be admitted to an area with providers experienced in the care of pediatric DKA, where more frequent observation is available.

DKA Red Flags, Risk Factors, Considerations for PICU Admission

Cerebral Edema is the leading cause of death in children presenting in **diabetic ketoacidosis** and occurs in up to 3% of cases. Cerebral edema may be present at the time of initial assessment or may develop during treatment.

It was previously hypothesized that the brain produces "idiogenic osmoles" in the context of chronic hyperglycemia. During the course of DKA treatment, if fluids – particularly hypotonic fluids – are given too rapidly, water will move from the vascular space into the neurons (water moves from a region of lower osmolality to higher osmolality), and the neurons swell and become injured. However, the main problem with this hypothesis is that confirmatory evidence from clinical studies has been lacking.

Instead, the risk factors for the development of cerebral edema that have been identified seem to indicate more severe DKA – as reflected by lower partial pressure of carbon dioxide, higher BUN, and treatment with bicarbonate. More contemporary data support the hypothesis that acidosis and dehydration lead to diminished blood flow in the brain. This causes the neurons to become injured, and then they swell. In this model, cerebral edema is a *consequence*, rather than a cause, of neuronal injury. The type and the rate of fluid administration *may* subsequently exacerbate neuronal injury.

Detecting cerebral edema: During DKA management, close monitoring for the signs and symptoms of cerebral edema is essential. A list of the red flags for cerebral edema follows; it is not an exhaustive list. **If cerebral edema is suspected, contact PICU** to aid in urgent management and arranging patient transfer. Initial management of cerebral edema is covered later in this topic.

RED FLAGS: Signs of Cerebral Edema

- Altered level of consciousness (restless, irritable, drowsy, obtunded, abnormal motor or verbal response to pain) especially developing after initial improvement
- Headache
- Hypertension (note: may be diastolic hypertension)
- Vomiting
- Incontinence
- Cranial nerve palsies
- Oxygen desaturation

Cerebral Edema Risk Factors

- Greater acidosis, lower CO2 and lower bicarbonate such as in severe DKA: pH less than 7.1, pCO2 less than 18, HCO3 less than 5
- high urea nitrogen[5]

Children at high risk of cerebral edema may require PICU; monitor very carefully; prepare for treatment of cerebral edema if clinical signs occur and contact PICU.

Interventions to Avoid

- **Avoid overhydration:**
  - **AVOID** overhydration: Do not exceed 2 x maintenance fluids in the first 24 hours
  - Avoid fluid bolus unless needed for signs of shock
  - Overhydration may contribute to cerebral edema
- **No insulin within the first 1-2 hours of treatment**

- **No insulin bolus**
- **No administration of bicarbonate: it is NOT indicated** and may be associated with cerebral edema

Considerations for Transfer or Critical Care (ICU) Admission (Contact tertiary care pediatric centre for advice)

Considerations for transfer to Intensive Care Unit/ Critical Care

- Patient needing intubation or already intubated
- Altered Glasgow Coma Scale (many patients are sleepy/ lethargic at presentation but are responsive during exam and interventions)
- Presence of signs of cerebral edema
- Hypokalemia less than 2.5 mmol/L
- Bicarbonate (HCO3) less than 5 mmol/L
- Significant risk of cerebral edema:[5]
    - Younger age (less than 2 years of age)
    - New onset diabetes
    - Severe acidosis (pH less than 7.1)
    - Greater volume of fluid given in the first 4 hours of treatment (greater than 2X maintenance)
    - Significant hypocapnia at presentation (CO2 less than 18)
    - Markedly elevated serum urea at presentation
    - Rapid administration of hypotonic IV fluids
    - IV bolus insulin
    - Administration of bicarbonate
    - Failure of corrected sodium to rise during treatment

Initial DKA Management (First Hour After Presentation)

Diet/Nutrition:
Patients in DKA should be NPO.

Monitoring

- **Vital Signs:** On admission: heart rate, blood pressure, respiratory rate, temperature, oxygen saturation, (then a minimum of every 60 minutes or more frequently as indicated)
- **Cardiac Monitoring**: Continuous Pulse oximetry and cardiac monitors are indicated
- **Neurovitals**: Level of consciousness and Glasgow coma scale (GCS) to detect any changes consistent with cerebral edema. Assess at initial presentation and then a minimum of every 60 minutes in the initial 4 hours; more frequently if clinically indicated (based on DKA severity, initial GCS, presence of cerebral edema risk factors and care setting).
- **Ins and Outs**: Strictly monitor fluid volume intake and output
- **Point of Care Testing:**
    - **Bedside blood glucose by blood glucose monitor** prior to administering IV fluids AND every one hour or more frequently if blood glucose is dropping rapidly.
    - Measure urine ketones 4 to 8 hours at minimum until persistently negative (measure urine ketones OR serum beta-hydroxybutyrate every 4 to 8 hours)

Initial Lab Orders (urgent care: complete labs available at site)

- **Hematology:** Complete Blood Count (CBC)
- **Chemistry:**
    - Sodium (Na), Potassium (K), Chloride (Cl), Glucose, Bicarbonate or CO2, Creatinine, Urea, Anion gap, ionized Calcium, Magnesium, beta-hydroxybutyrate (if available), phosphate, serum osmolality
    - Hemoglobin A1C may be done to establish baseline (if not done in last 30 days)
- **Blood Gases:** Capillary blood gas or venous blood gas with ionized Calcium (if available)
- **Urine Tests:** Urinalysis for ketones

Other Diagnostic Considerations
ECG and CXR are not routinely indicated.
DKA may be precipitated by a concurrent illness. Diagnostic testing, microbiology cultures and appropriate therapy should be based on patient presentation.

Nursing Care
Pediatric DKA patients require frequent monitoring and close observation. If any red flags are noted notify the physician.

Initial Fluid Management FIRST 1 HOUR
In the absence of shock:
Check blood glucose using glucometer at the bedside prior to administering IV fluids. Initiate IV. Provide **initial volume expansion of 10 mL/Kg in the first hour**. Recent literature suggests that initial volume expansion up to 20 ml/kg in the first hour is safe for patients with DKA; based on these newer studies one can consider up to 20 ml/kg for patients with moderate to severe DKA.
DO NOT give initial volume expansion more rapidly than over 1 hour.

AVOID IV BOLUS UNLESS PATIENT IS IN SHOCK. Volume should be expanded to restore peripheral circulation. Most children with severe DKA appear very unwell due to some degree of dehydration and significant acidosis but it is rare for them to be in shock.

IF patient IS in shock as evidenced by signs of poor end organ perfusion or hypotension (late sign):

- Follow the current Heart and Stroke Foundation of Canada Pediatric Advanced Life Support (PALS) guidelines for recommendations regarding acute management of a patient in shock, **and consider an additional diagnosis such as sepsis.**
    - Reassess vital signs and peripheral perfusion following any fluid administration
    - Contact tertiary care center for support

Ongoing DKA Management (1-4 Hours after Presentation)

Disposition
DKA requires admission to a center with pediatric DKA expertise for IV fluid, IV insulin infusion and close monitoring. Transfer should be arranged as soon as possible when patient is stable to enable care to continue in a pediatric DKA center.

Diet/Nutrition
Maintain NPO during the initial hours of management

Monitoring
- **Vital signs**: heart rate, blood pressure, respiratory rate, temperature, oxygen saturation at a minimum of every hour in the initial 1 to 4 hours; more frequently if clinically indicated
- **Neurovitals**: level of consciousness, Glasgow coma scale (GCS) minimum of every hour in the initial 1 to 4 hours; more frequently if indicated
- **Cardiac Monitoring**: Continuous pulse oximetry or cardiac monitor
- **Ins and Outs:** Strictly monitor intake and output hourly
- **Point of Care Testing** :
    - Capillary blood glucose by blood glucose monitoring every hour; more frequently if blood glucose is dropping rapidly**.**
    - **Compare bedside blood glucose monitor result to serum glucose result to ensure correlation and accuracy of blood glucose monitor result.**
    - Frequent blood glucose monitoring will be required while adjusting insulin and fluids in the first 1 to 4 hours.
    - Measure urine ketones every 4 to 8 hours at minimum until persistently negative. Measure urine ketones OR alternatively, serum beta-hydroxybutyrate every 4 to 8 hours

Lab Investigations
Every *2 to 4 hours, minimum of every 4 hours to monitor response to therapy*
- **Chemistry:** Sodium (Na), Potassium (K), Chloride (Cl), Glucose, Bicarbonate
- **Blood Gases:** Capillary blood gas or venous blood gas are acceptable, with Ionized Calcium
- If warranted for more severe DKA, can alternate blood gas collection with chemistry labs to monitor lab values every 2 hours

Every 8 hours
- **Chemistry:** Serum osmolality (if available), Creatinine, Urea, Beta-hydroxybutyrate (if available), Calcium, ionized Calcium if not in blood gases, Phosphate, Magnesium (if available)

Other Diagnostic Considerations
DKA may be precipitated by an intercurrent illness. Diagnostic testing should be based on patient presentation.

Nursing Care
Pediatric DKA patients require frequent monitoring and close observation. If any red flags are noted, notify the physician (refer to Considerations for Transfer or Critical Care (ICU) Admission)

Tracking Management of DKA
Fluid adjustments, lab results and other values may be documented on a tracking tool to aid the physician in following the DKA management. A sample tool: Appendix G: Tracking Tool.

Ongoing DKA Management (1-4 Hours after Presentation) continued: IV Fluids and Potassium

Fluid Choice:

Following initial volume expansion provided in the first one hour, an IV solution containing potassium is recommended. After the first hour of volume expansion, change the iv fluid to **0.9% NaCl with 40 mEq KCl/L if patient is voiding. Continue using this fluid until blood glucose is less than or equal to 17 mmol/L, at which time IV dextrose will be added** (refer to Adding Dextrose to IV Fluids (1-4 Hours After Presentation).

Sodium Decision Support

- **Hypotonic solutions should NOT be used in the initial management of DKA. Most patients can be continued on isotonic solutions for their whole DKA treatment.**
- See "Continued Management until DKA Resolution" section for further decision support for adjusting sodium if required.

Potassium Decision Support

- If patient is hypokalemic ensure potassium replacement is started at the time of initiating maintenance IV fluids and before starting insulin therapy. Otherwise potassium can be added when starting insulin therapy.
- Every patient should receive a minimum of 40 mEq KCl/L via IV fluids. If additional potassium supplementation is required, follow local policy regarding the availability of IV fluids containing higher concentrations of potassium and/or consider oral potassium supplementation.
- Oral Potassium is an OPTION if child requires MORE potassium THAN 40 mEq KCl/L IV to maintain serum potassium levels.
    - potassium chloride 1 mmol/Kg/dose PO every 12 hours for 1 to 3 doses if patient has normal level of consciousness, even if patient NPO. May cause vomiting.

IV infusion rate:

- After the first hour of volume expansion, continue IV fluids at a rate of:
    - 1.5 x maintenance for mild/ moderate DKA OR
    - 2 x maintenance for severe DKA
    - **Continue until detailed fluid calculations are completed**. (See Appendix A: Detailed Fluid Calculations)

Frequent re- assessment of fluid status and neurological status is required.

- **Avoid over hydration; total fluid should not exceed 2 x maintenance in the first 24 hours.**
- **For patients who are transferring to a pediatric DKA center only**:
    - Continue IV fluids at a rate of 1.5 x maintenance for mild/moderate DKA and 2 x maintenance for severe DKA during transfer. Detailed calculations will be completed at the receiving site.
    - Continue DKA management including insulin infusion initiation and adding dextrose if required during transfer (See below). For brief transfers these steps may not be needed until after arrival at the accepting site.
- **Calculate total hourly fluid rate: refer to** Appendix A: Detailed Fluid Calculations. Once detailed fluid calculations are completed, use the calculated total hourly fluid rate.

Ongoing Management (1-4 Hours after Presentation) continued: Insulin Infusion

Start insulin infusion **after child has received 1 to 2 hours of IV fluid** and is hemodynamically stable*:* Insulin regular short-acting **1 unit/mL** in 0.9% NaCl; Dosage 0.1 units/Kg/hr IV.

Calculate insulin infusion rate: 0.1 unit/Kg/hour x _____Kg = _____ unit/hr

- As the insulin concentration is 1 unit/ mL this calculation also provides the rate as unit/hr = mL/hr

If mixed as above, **infusion rate as mL/hr = (0.1 X weight in Kg)/hr**
(e.g. for a 30 Kg child, the initial insulin infusion rate is 3 mL/hr).

For total fluid calculations the insulin fluid rate is insignificant if using an insulin concentration of 1 unit/mL. The insulin rate is NOT included in total fluid intake calculations.

Administration Instructions for INSULIN and considerations for infusion pumps

- Mix fluid continually while injecting, to prevent the insulin from settling in the port. Flush the tubing with the insulin solution to saturate insulin binding sites (5 mL adequate flush for syringe pump set up).
- Use of an IV pump with pediatric drug library including insulin 1 unit/mL profile recommended
- Consider the minimum IV fluid administration rate recommended by each pump vendor when selecting infusion pump to deliver insulin.
- If required, initiate contact with pediatric unit where insulin infusion can be administered via syringe pump

Insulin Clinical Decision Support

- **IV insulin boluses are always contraindicated.** Early IV insulin infusion (within 1st hour of administration of fluids) may increase risk of cerebral edema.
- If metabolic acidosis is not improving after 4 hours, re-evaluate that fluid calculations are correct, insulin infusion is properly mixed, intravenous lines are not occluded, are patent and infusing. Once these have been re-evaluated, if no improvement consider consulting pediatric endocrinology and/or PICU.
- **The purpose of the insulin infusion is to correct the acidosis, not the hyperglycemia**. The goal is to maintain the insulin dosage for as long as possible near 0.1 units/Kg/hr to correct acidosis, while maintaining the blood glucose with dextrose infusion to avoid hypoglycemia.
- Insulin infusion rate should only be reduced if adequate glucose has been provided and acidosis has improved to a serum bicarbonate level of greater than 15 mmol/L.
- Falling blood glucose should be managed by increasing dextrose infusion rate. Decreasing insulin dosage should not be used to address decreasing blood glucose while the patient still has significant acidosis (except when maximal dextrose infusion rates are ineffective).

Ongoing DKA Management (1-4 Hours after Presentation) continued: Adding Dextrose

There are THREE separate patient scenarios for adding dextrose:

1. Patients being transferred to a Pediatric DKA site and dextrose is required during transport.
2. Patients at sites that use Dextrose 10% Solutions for their Two-plus-One dextrose, fluid and insulin delivery system. See below.
3. Patients at sites that use Dextrose 12.5% Solutions for their Two-plus-One dextrose, fluid and insulin delivery system. See below.

Adding Dextrose to IV Fluids: Patients Transferring to a Pediatric DKA center

In some cases dextrose will need to be added during transfer. Expect glucose to drop with fluids and with initiation of insulin infusion (which is started 1 to 2 hours after initiating fluids):

- When blood glucose **reaches 17 mmol/L**, add IV dextrose to IV fluids:
- Use D5W - 0.9% NaCl with 40 mEq KCl/L at the same rates (1.5 x maintenance for mild/moderate DKA and 2 x maintenance for severe DKA).
- Follow blood glucose at least hourly
- Maintain a blood glucose of greater than 10 mmol/L during transfer. This may require a solution change to a D10W - 0.9% NaCl with 40 mEq KCl/L solution to increase the glucose infusion rate.

Adding Dextrose to IV Fluids for Sites Using Dextrose 10% Solution

See Appendix C: Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 10% Solution for more information.

When blood glucose **reaches 17 mmol/L**, add IV dextrose to IV fluids using **Two-plus-One system:**

- Two Solution Bags are Y-ed together and used to titrate dextrose.
- One bag is 0.9% NaCl and 40 mEq KCl/L; The other bag is D10W - 0.9% NaCl and 40 mEq KCl/L.
- Titrating the rates of each bag allows provision of a range of dextrose from 0% to 10%
- In order to maintain a blood glucose of 8 to 15 mmol/L, the concentration of dextrose delivered to the patient is changed by adjusting the proportions of the bags contributing to the total IV rate.

Total hourly fluid rate = Infusion A rate (Saline) + Infusion B rate (Saline and Dextrose)

Start with a combination of Bag A and Bag B that provides a dextrose concentration of **D10W - 0.9% NaCl with 40 mEq KCl/L.** This is accomplished by Bag A (saline) rate = 0% of total hourly fluid rate and Bag B (saline and dextrose) rate= 100% of total hourly fluid rate.

Titrating Dextrose Infusion (to maintain blood glucose 8 to 15 mmol/L)

With each hourly blood glucose level (by chem strip or serum):

- **If blood glucose greater than 15 mmol/L, increase bag A (saline) by 25% of the total hourly fluid rate and decrease bag B (saline and dextrose) by 25% of the total hourly fluid rate.**
- **If blood glucose less than 10 mmol/L, decrease bag A (saline) by 25% of the total hourly fluid rate and increase bag B (saline and dextrose) by 25% of the total hourly fluid rate.**
- Total Hourly Fluid rate remains unchanged
- If blood glucose decreases more than 5 mmol/L per hour, contact physician
- In some clinical circumstances adjusting by more (or less) than 25% of the total hourly fluid rate may be required.

If blood glucose levels cannot be maintained with a maximum of D10W, consider increasing the dextrose concentration to D12.5W; this should be rare.

Table of Rates and Dextrose Concentration based on % of total hourly fluid rate for Bag A and B:

Bag A (saline) 0.9%NaCl with 40 mEq KCl/L	**Bag B (saline and dextrose)** D10W 0.9%NaCl with 40MEq KCl/L	**Final Dextrose Concentration**
0%	100%	D10W
25%	75%	D7.5W
50%	50%	D5W
75%	25%	D2.5W
100%	0%	No Dextrose

Adding Dextrose to IV Fluids for Sites Using Dextrose 12.5% Solution (Only if Pre-Mixed Solutions Available)

See Appendix B Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 12.5% Solution (Only if Pre-Mixed Solutions Available) for more information.

When blood glucose **reaches 17 mmol/L**, add IV dextrose to IV fluids using **Two-plus-One system:**

- Two Solution Bags are Y-ed together and used to titrate dextrose.
- One bag is 0.9% NaCl and 40 mEq KCl/L; The other bag is D12.5W - 0.9% NaCl and 40 mEq KCl/L.
- Titrating the rates of each bag allows provision of a range of dextrose from 0% to 12.5%
- In order to maintain a blood glucose of 8 to 15 mmol/L, the concentration of dextrose delivered to the patient is changed by adjusting the proportions of the bags contributing to the total IV rate.

Total hourly fluid rate = Infusion A rate (Saline) + Infusion B rate (Saline and Dextrose)

Start with a combination of Bag A and Bag B that provides a dextrose concentration of **D10W - 0.9% NaCl with 40 mEq KCl/L.** This is accomplished by Bag A rate = 20% of total hourly fluid rate and Bag B rate= 80% of total hourly fluid rate.

Titrating Dextrose Infusion (to maintain blood glucose 8 to 15 mmol/L)

With each hourly blood glucose level (by chem strip or serum):

- **If blood glucose greater than 15 mmol/L, increase bag A (saline) by 20% of the total hourly fluid rate and decrease bag B (saline and dextrose) by 20% of the total hourly fluid rate.**
- **If blood glucose less than 10 mmol/L, decrease bag A (saline) by 20% of the total hourly fluid rate and increase bag B (saline and dextrose) by 20% of the total hourly fluid rate.**
- Total Hourly Fluid rate remains unchanged
- If blood glucose decreases more than 5 mmol/L per hour, contact physician
- In some clinical circumstances adjusting by more (or less) than 20% of the total hourly fluid rate may be required.

Table of Rates and Dextrose Concentration based on % of total hourly fluid rate for Bag A and B:

Bag A (saline) 0.9%NaCl with 40 mEq KCl/L	**Bag B (saline and dextrose)** D12.5W 0.9%NaCl with 40MEq KCl/L	**Final Dextrose Concentration**
0%	100%	D12.5W
20%	80%	D10W
40%	60%	D7.5W
60%	40%	D5W
80%	20%	D2.5W
100%	0%	No Dextrose

Continued DKA Management until Resolution Greater Than 4 Hours After Presentation

Diet/Nutrition:

- NPO until serum bicarbonate greater than or equal to 18 mmol/L; earlier oral intake may be ordered by physician.
- Oral sugar-free fluids should only be introduced when substantial clinical improvement has occurred [mild acidosis/ketosis may still be present].
- Once taking oral fluids; adjust iv fluid rates to maintain total fluid intake = iv plus po.

Monitoring
While patient is receiving DKA management, i.e. insulin infusion:

- **Vital signs**: pulse, blood pressure, respiratory rate, temperature, O2 saturation at a minimum of every 2 hours or more frequently as indicated
- **Neurovitals:** level of consciousness, Glasgow coma scale (GCS) to detect any changes consistent with cerebral edema at a minimum of every 2 hours or more frequently as indicated
- **Cardiac Monitoring**: Continuous Pulse oximetry and cardiac monitor
- **Ins and Outs**: Monitor fluid volume intake and output every 4 hours or more frequently as indicated
- **Measurements**: Measure and record patient weight daily
- **Point of Care Testing:**
- Capillary blood glucose by finger poke every 2 hours or more frequently
- Measure urine ketones with each at minimum every 4 to 8 hours until persistently negative.
- **Lab Investigations:** Continue labs as described with first 1 to 4 hours of management until the child's bicarbonate level and electrolytes have returned to normal. Labs can then be discontinued.

Intravenous Fluids and Electrolytes (Continued Management until DKA Resolution)
Re-evaluate replacement fluid type frequently, anticipating the need to adjust potassium, dextrose, and other electrolytes based on laboratory monitoring. However, when adjusting solutions allow for adequate time to assess the impact on laboratory results to avoid unnecessary frequent solution changes.

Sodium:

- **For many patients with DKA continuing 0.9% NaCl is appropriate for completing all fluid management. Hypotonic solutions should NOT be used in the initial management of DKA.** There may be rare cases as DKA resolves, i.e. hyperchloremia, or when patient is continuing to receive IV fluids after resolution of acidosis, where using hypotonic fluids such as 0.45% NaCl is appropriate.
- The corrected sodium (as mmol/L) should be calculated and followed closely to ensure that DKA is resolving. The corrected sodium should rise with treatment. If corrected sodium is falling, this is a risk factor for cerebral edema.

  Formula: Corrected Na = [Measured Na + 0.36 x (plasma glucose – 5.6)]

- If the patient is hyperchloremic, one can consider a change to 0.45% NaCl but only in the context of the corrected sodium and hydration status. If the corrected sodium is 140 to 150 and stable, 0.45% NaCl can be considered after 4 to 5 hours of treatment.

Note: There is currently inadequate evidence to support the use of solutions with lower sodium load such as Ringers lactate and Plasmalyte in pediatric DKA.

- If the corrected sodium is greater than 150, then do not consider hypotonic solutions for at least 10 to 12 hours after treatment and only if corrected Na remains stable. An elevated measured Na+ in conjunction with hyperglycemia indicates severe dehydration and an element of hyperglycemic hyperosmolar state. Such patients should be rehydrated with extreme caution, using higher osmolar content fluids (0.9% NaCl) for longer time periods (10 to 12 hours)

Potassium:

- **Most patients should continue to receive a minimum of 40 mEq/L of potassium via IV fluids**. If additional potassium supplementation is required, follow local policy regarding the availability of IV fluids containing 60 mEq/L of potassium, potassium infusions and/or consider oral potassium supplementation.
- **Oral Potassium is an OPTION if child requires MORE potassium THAN 40 mEq KCl/L IV to maintain serum potassium levels.**
- Oral potassium dose: potassium chloride 1 mmol/Kg/dose PO every 12 hours for 1 to 3 doses if patient has normal level of consciousness, even if patient NPO. May cause vomiting.

Phosphate:

- If serum phosphate is less than 0.4 mmol/L, consider administering PO4 in IV fluids
- **While phosphate can be given as sodium phosphate or potassium phosphate, a separate infusion of sodium phosphate is considered a safer alternative** when possible (due to increased risk of mixing error and risk of exceeding potassium rates when using KPO4). Refer and follow local practices for delivery of phosphate including available IV fluids and infusion protocols.
- If phosphate is given, serum Ca, Mg, and phosphate levels should be monitored at a minimum of every 4 hours to avoid hypocalcemia.

Bicarbonate:

- **Sodium bicarbonate (NaHCO3) is NOT recommended**. It should only be considered in exceptional cases in the PICU environment, such as symptomatic hyperkalemia.
- The acidosis of DKA is due to ketoacids and lactic acids and resolves with fluid and insulin replacement.
- NaHCO3 has numerous deleterious effects:
    - Paradoxical CNS acidosis
    - Hypokalemia
    - Hyperosmolality
    - Delayed clearance of ketones

Dextrose Infusion

- Continue to titrate the glucose concentration by adjusting the two solution infusions, Bag A and Bag B, to maintain glucose 8 to 15 mmol/L; the total hourly fluid rate remains unchanged.

Continued DKA Management until Resolution: Insulin Infusion

Insulin Reduction:

- When the bicarbonate level approaches 15 mmol/L, it is acceptable to drop the insulin dosage to 0.05 units/Kg/hour in order to manage decreasing blood glucose. If the bicarbonate level is 8 to 10 insulin should NOT be decreased as the patient is still acidotic[5].
- Falling blood glucose should be managed by increasing dextrose infusion rate. Decreasing insulin dosage should not be used to address decreasing blood glucose while the patient still has significant acidosis (except when maximal dextrose infusion rates are ineffective).

Discontinuation of Insulin Infusion:

- Discontinue insulin infusion once blood pH returns to normal and bicarbonate level is greater than 18 mmol/L, and serum beta-hydroxybutyrate (if measured) is normal.
  Note: Pediatricians may discontinue the insulin infusion before the bicarbonate reaches 18 based on the child's clinical progress and meal timing.
- The blood pH will be normal but ketones may still be present in the urine. This is expected to improve within 24 to 36 hours.
- Insulin discontinuation should occur simultaneously with the provision of subcutaneous insulin.

Subcutaneous insulin

- **Regimen to be determined in conjunction with pediatric diabetes specialist**
- If using insulin aspart (NovoRapid®) or insulin lispro (Humalog®) (rapid-acting) insulin, do not overlap an insulin infusion with subcutaneous insulin. Turn off infusion and administer subcutaneously right away at the time of starting the meal.

Continued DKA Management until Resolution: Disposition Planning

Considerations for discharge

- Resolution of acidosis following treatment; establishment of home regimen of subcutaneous insulin and monitoring
- Consultation with pediatric diabetes specialist

Patient and Family education/discharge instructions

- Education to be provided on admission or prior to discharge

Cerebral Edema Management in DKA

This highlights initial management ONLY.
If cerebral edema is suspected contact PICU immediately for aid in management and transfer to PICU for treatment and monitoring.

Cerebral edema and RED FLAGS for cerebral edema are detailed earlier in the topic.

Elevate HOB 30 degrees

Monitoring

- **Vital signs:**
  - Continuous vital sign monitoring
  - Provide Airway, Breathing, Circulation (Basic Cardiac Life Support) support as required
  - Monitor for blood pressure changes, bradycardia, decreased oxygen saturation, irregular respirations
- Neurovitals**:**
  - Monitor for signs of deterioration frequently: Severe headache, change in sensorium or GCS, restlessness, irritability, drowsiness, dilated pupils, cranial nerve palsies, slurred speech, posturing, and incontinence

Respiratory

- Provide oxygen as required.
- Patients with cerebral edema may develop respiratory failure requiring intubation
- If intubated: target pCO2 between 22 mmHg and 30 mmHg

IV Fluids

- Decrease total IV fluid rate by one-third
- Ensure adequate IV access; second iv optimal

Medications

- **Mannitol**: 0.5 to 1 gram/Kg IV over 20 minutes
  OR
- **Hypertonic Saline:** 3 to 5 mL/Kg over 15 to 30 minutes, repeat as needed based on clinical response, serum sodium and serum osmolality; maximum intermittent infusion rate is 20 mL/Kg/hour

Investigations

- CT scan when stable

Order Set: Diabetic Ketoacidosis Pediatric Emergency Orders for Sites Using D12.5W Solutions

Order Set Components

Restrictions for use of this set of orders: For use in Emergency Department, Urgent Care or for admissions to inpatient units at sites specialized in the care of pediatric DKA
Order Set Requirements: Weight

Initial DKA Management (First Hour of Care) Orders

Patient Care

☑ Goals of Care Designation: utilize appropriate Goal of Care
☑ Notify physician if:
- decreased or changing level of consciousness (restless, irritable, drowsy, obtunded, decreased motor or verbal response to pain) especially after initial improvement
- headache, hypertension, vomiting, incontinence, cranial nerve palsies, oxygen desaturation

Diet

☑ NPO

Monitoring

Vital Signs

☑ On admission: heart rate, blood pressure, respiratory rate, temperature, oxygen saturation
☑ Monitor vital signs every _____minutes (*Minimum of every hour in the initial 1-4 hours, more frequently if required)*
☑ Cardiac Monitoring: Continuous Pulse oximetry and cardiac monitor
☑ Neurovitals: level of consciousness, Glasgow coma scale (GCS) to detect any changes consistent with cerebral edema
  ☑ every _____ minutes (*Indicated at a minimum of every hour in the initial 1-4 hours; more frequently as indicated (based on severity and care setting).*
☑ Intake and Output: Strictly monitor fluid volume intake and output hourly

Point of Care Testing

☑ Blood Glucose Monitoring – POCT, by finger poke hourly ; Check blood glucose using glucometer at the bedside prior to administering any IV fluids
☐ Urine Ketones – POCT every _____ ; monitor at minimum every 4 to 8 hours until persistently negative and an order is received to discontinue; every void if measured on the unit *(measure urine ketones OR serum beta-hydroxybutyrate)*

Initial Lab Orders - STAT

- **Hematology**
  ☐ Complete Blood Count (CBC) with differential

- **Chemistry**
  - ☑ Sodium (Na) LEVEL
  - ☑ Potassium (K) LEVEL
  - ☑ Chloride (Cl) LEVEL
  - ☑ Glucose Random LEVEL
  - ☑ Bicarbonate (CO2 Content)
  - ☑ Creatinine LEVEL
  - ☑ Urea
  - ☑ Osmolality
  - ☐ Calcium (Ca) LEVEL
  - ☐ Beta-hydroxybutyrate – if available (measure urine ketones OR serum beta-hydroxybutyrate)
  - ☐ Phosphate (PO4) LEVEL
  - ☐ Anion gap
  - ☐ Hemoglobin A1C (*if not done in last 30 days*)
  - ☐ Magnesium (Mg) LEVEL
- **Blood Gases**
  - ☐ Blood gas capillary
  - ☐ Blood gas venous mixed
  - ☐ Ionized calcium (iCa) LEVEL *(with gas if available)*
- **Microbiology**
  - ☐ Appropriate cultures as indicated
- **Urine Tests**
  - ☐ Urinalysis Random; for ketones

Diagnostic Investigations

- ☐ Electrocardiogram - 12 Lead
- ☐ Chest X-ray PA and Lateral (GR Chest, 2 Projections)

Fluid Management

Intravenous orders

Volume should be expanded to restore peripheral circulation. Most children with severe DKA appear very unwell due to some degree of dehydration and significant acidosis. It is rare for them to be in shock. Follow the American Heart Association Pediatric Advanced Life Support (PALS) 2015 guidelines for a patient in shock, and ***consider an additional diagnosis such as sepsis****.*
Check blood glucose using glucometer at the bedside prior to administering IV fluids.

In the absence of shock in the first 1-2 hours:

- ☑ 0.9% NaCl 10 millilitres per kilogram (mL/kg) IV over 1 hour to provide initial volume expansion. Do not infuse more rapidly than over 1 hour.

IF patient IS in shock (systolic blood pressure less than [70 + 2x(age in years] mmHg):

- ☐ 0.9% NaCl 10 millilitres per kilogram (mL/kg) IV rapidly
  Dose: Weight in kg _____ x 10 mL/kg = _____ mL IV rapidly
- ☐ Reassess vital signs and peripheral perfusion following any bolus fluid administration.
- ☐ Repeat 0.9% NaCl 10 mL/kg (dose: ____ mL) IV rapidly if no improvement in heart rate or blood pressure, as necessary to restore adequate perfusion.

Ongoing DKA Management (1-4 Hours after Presentation) Orders

Patient Care

☑ Admit to inpatient unit (*in a pediatric DKA site*)
OR Initiate arrangements to transfer patient for subsequent patient care to a center with pediatric DKA expertise.
☑ NPO

Monitoring

☐ Vital signs: heart rate, blood pressure, respiratory rate, temperature, O2 saturation every _____ minutes (*Indicated at a minimum of every hour in the initial 1-4 hours)*
☐ Neurovitals: level of consciousness, Glasgow coma scale (GCS) every_____ minutes (*Indicated at a minimum of every hour in the initial 1-4 hours)OR*
☑ Cardiac Monitoring: Continuous Pulse oximetry or cardiac monitor
☑ Intake and Output: Strictly monitor fluid volume intake and output hourly

Investigations
Point of Care Testing

☑ Blood Glucose Monitoring – POCT, by finger poke hourly and prn. (*Frequent blood glucose measurement at the bedside will be required while adjusting insulin/ IV in first 1-4 hours)*
☐ Urine Ketones – POCT every _____ ; monitor at minimum every 4-8 hours until persistently negative and an order is received to discontinue; every void if measured on the unit (measure urine ketones OR beta-hydroxybutyrate)

Chemistry

- **Every *2-4 hours, minimum of Q4H to monitor response to therapy***
  - ☑ Sodium (Na) LEVEL every _____ hours
  - ☑ Potassium (K) LEVEL every ____ hours
  - ☑ Chloride (Cl) LEVEL every _____hours
  - ☑ Glucose Random LEVEL every _____ hours
  - ☑ Bicarbonate LEVEL every _____ hours
- **Every 8 hours**
  - ☐ Osmolality every 8 hours
  - ☐ Creatinine (Cr) LEVEL every 8 hours
  - ☐ Urea (BUN) every 8 hours
  - ☐ Anion gap every 8 hours
  - ☐ Calcium (Ca) LEVEL every 8 hours
  - ☐ Beta-hydroxybutyrate – if available every 8 hours
  - ☐ Phosphate (PO4) LEVEL every 8 hours
  - ☐ Magnesium (Mg) LEVEL every 8 hours

Blood Gases

Capillary or venous blood gases are acceptable.

- ☐ blood gas capillary every 4 hours;
- ☐ blood gas venous every 4 hours;
- ☐ alternate every 4 hours blood gas with every 4 hours chemistry labs
  (*Optional: if warranted for more severe DKA, can alternate collection with chemistry labs to monitor lab values every 2 hours)*
- ☐ Ionized calcium (iCa) LEVEL *(with gas if available)*

Fluid Management

After initial volume expansion over first 1 hour (0.9% NaCl 10ml/Kg over 1 hour), an IV solution containing potassium is recommended. 0.9% NaCl with 40 mmol KCl/L is recommended if patient is voiding.

Hypotonic solutions should NOT be used in the initial management of DKA. Most patients can be continued on isotonic solutions for their whole DKA treatment.

Avoid over-hydration, total fluid should not exceed 2x maintenance in the first 24 hours.

Refer to Appendix A: Detailed Fluid Calculations

Refer to IV Fluids and Potassium (1-4 Hours after Presentation)

1) 1) IV Fluids without Dextrose (Use when blood glucose greater than 17 mmol/L):

☐ **Mild or moderate DKA:**

0.9% NaCL with 40 mEq KCl/L
IV infusion rate: Hourly rate = 1.5 x maintenance rate
Calculated rate = _____ mL/hr;
discontinue when blood glucose by glucometer reaches 17 mmol/L

OR

☐ **Severe DKA:**

0.9% NaCL with 40 mEq KCl/L
IV infusion rate: Hourly rate = 2 x maintenance rate
Calculated rate = _____ mL/hr;
discontinue when blood glucose by glucometer reaches 17 mmol/L

2) IV Fluids with Dextrose (Use when blood glucose less than or equal to 17 mmol/L)

Add dextrose to IV fluids using Two-plus-One system.

Refer to Appendix A: Detailed Fluid Calculations *for total hourly rate = _____ mL/hr*

Total hourly rate = Infusion A rate (saline) + Infusion B rate (saline and dextrose)

☑ **Titrate dextrose infusion to maintain blood glucose 8-15 mmol/L**

☐ **12.5% Dextrose System**

- Bag A: 0.9% NaCL with 40 mEq KCl/L; Infusion A rate: _____mL/hr
  and
  Bag B: D12.5W/0.9% NaCl with 40 mEq KCl/L; Infusion B rate: _____mL/hr
- Start with a combination of Bag A and Bag B that provides a dextrose concentration of **D10W/0.9% NaCl with 40 mEq KCl/L.** This is accomplished by Bag A rate = 20% of total hourly fluid rate and Bag B rate= 80% of total hourly fluid rate.
- Administration Instructions: Refer to Appendix D: Instructions for Preparing Dextrose 10% and Dextrose 12.5% Solutions; *and* Appendix B: Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 12.5% Solution
- With each hourly blood glucose level (by chem strip or serum):
- If blood glucose greater than 15 mmol/L, increase bag A (saline) by 20% of total hourly fluid rate and decrease bag B (dextrose) by 20% of the total hourly fluid rate
- If blood glucose less than 10 mmol/L, decrease bag A (saline) by 20% of the total hourly fluid rate and increase bag B (dextrose) by 20% of the total hourly fluid rate
- Infuse **Bag A** and **Bag B** at rates indicated. Total Hourly Fluid rate remains unchanged
- If blood glucose decreases more than 5 mmol/L per hour, contact physician.
- In some clinical circumstances adjusting by more (or less) than 20% of the total hourly fluid rate may be required. Use clinical judgment.

3) **Fluids for patients being transferred to a pediatric site or where a Two Plus One bag System is not available and glucose level is reaching 17 mmol/L such that glucose must be added. Continue previous IV rate.**
   - ☐ D5W/0.9% NaCl with 40 mEq KCl/L _____ mL/hr

4) **Additional Fluids Orders if Required**
   - ☐ _____
   - ☐ _____
   - ☐ _____
   - ☐ _____

Medications

Insulin Infusion *(after receiving 1-2 hours of IV fluids)*

Start insulin infusion after patient has received initial volume expansion over 1-2 hours and is hemodynamically stable.

IV insulin boluses are always contraindicated. *Early IV insulin infusion (within 1st hour of administration of fluids) may increase risk of cerebral edema.*

If metabolic acidosis is not improving after 4 hours, re-evaluate that rehydration calculations are correct, insulin infusion is properly mixed, intravenous lines are not occluded, are patent and infusing.

Once these have been re-evaluated, if no improvement consider consulting pediatric endocrinology and/or PICU.

- ☐ insulin infusion; Humulin R 1 unit/mL in 0.9% NaCl; _____units/ hour (0.1 units/Kg/hr) = ml/hr IV continuously

Potassium

Begin 40 mEq/L potassium in IV fluids when insulin infusion is initiated. If additional potassium supplementation is required, follow local policy regarding the availability of IV fluids containing 60 mEq/L of potassium, or consider oral potassium supplementation (may cause vomiting)

- ☐ potassium chloride ____ mmol (1 mmol/Kg/dose) PO q12 hours for ____ doses (*if patient has normal level of consciousness, even if patient NPO. 1-3 doses recommended)*

Order Set: Diabetic Ketoacidosis Pediatric Emergency Orders for Sites Using D10W Solutions

Order Set Components

Restrictions for use of this set of orders: For use in Emergency Department, Urgent Care or for admissions to inpatient units at sites specialized in the care of pediatric DKA
Order Set Requirements: Weight

Initial DKA Management (First Hour of Care) Orders

Patient Care

☑ Goals of Care Designation: utilize appropriate Goal of Care
☑ Notify physician if:
- decreased or changing level of consciousness (restless, irritable, drowsy, obtunded, decreased motor or verbal response to pain) especially after initial improvement
- headache, hypertension, vomiting, incontinence, cranial nerve palsies, oxygen desaturation

Diet

☑ NPO

Monitoring

Vital Signs

☑ On admission: heart rate, blood pressure, respiratory rate, temperature, oxygen saturation
☑ Monitor vital signs every _____minutes. (*Minimum of every hour in the initial 1-4 hours, more frequently if required)*
☑ Cardiac Monitoring: Continuous Pulse oximetry and cardiac monitor
☑ Neurovitals: level of consciousness, Glasgow coma scale (GCS) to detect any changes consistent with cerebral edema
  ☑ every _____ minutes (*Indicated at a minimum of every hour in the initial 1-4 hours; more frequently as indicated (based on severity and care setting).*
☑ Intake and Output: Strictly monitor fluid volume intake and output hourly

Point of Care Testing

☑ Blood Glucose Monitoring – POCT, by finger poke hourly ; Check blood glucose using glucometer at the bedside prior to administering any IV fluids
☐ Urine Ketones – POCT every _____ ; monitor at minimum every 4-8 hours until persistently negative and an order is received to discontinue; every void if measured on the unit (*measure urine ketones OR serum beta-hydroxybutyrate)*

Initial Lab Orders - STAT

- **Hematology**
  ☐ Complete Blood Count (CBC) with differential
- **Chemistry**
  ☑ Sodium (Na) LEVEL
  ☑ Potassium (K) LEVEL

- ☑ Chloride (Cl) LEVEL
- ☑ Glucose Random LEVEL
- ☑ Bicarbonate (CO2 Content)
- ☑ Creatinine LEVEL
- ☑ Urea
- ☑ Osmolality
- ☐ Calcium (Ca) LEVEL
- ☐ Beta-hydroxybutyrate – if available (measure urine ketones OR serum beta-hydroxybutyrate)
- ☐ Phosphate (PO4) LEVEL
- ☐ Anion gap
- ☐ Hemoglobin A1C (*if not done in last 30 days*)
- ☐ Magnesium (Mg) LEVEL

- **Blood Gases**
  - ☐ Blood gas capillary
  - ☐ Blood gas venous mixed
  - ☐ Ionized calcium (iCa) LEVEL *(with gas if available)*
- **Microbiology**
  - ☐ Appropriate cultures as indicated
- **Urine Tests**
  - ☐ Urinalysis Random; for ketones

Diagnostic Investigations

- ☐ Electrocardiogram - 12 Lead
- ☐ Chest X-ray PA and Lateral (GR Chest, 2 Projections)

Fluid Management

Intravenous orders

Volume should be expanded to restore peripheral circulation. Most children with severe DKA appear very unwell due to some degree of dehydration and significant acidosis. It is rare for them to be in shock. Follow the American Heart Association Pediatric Advanced Life Support (PALS) 2015 guidelines for a patient in shock, and ***consider an additional diagnosis such as sepsis****.*
Check blood glucose using glucometer at the bedside prior to administering IV fluids.

In the absence of shock in the first 1-2 hours:

- ☑ 0.9% NaCl 10 millilitres per kilogram (mL/kg) IV over 1 hour to provide initial volume expansion. Do not infuse more rapidly than over 1 hour.

IF patient IS in shock (systolic blood pressure less than [70 + 2x(age in years] mmHg):

- ☐ 0.9% NaCl 10 millilitres per kilogram (mL/kg) IV rapidly
  Dose: Weight in kg _____ x 10 mL/kg = _____ mL IV rapidly
- ☐ Reassess vital signs and peripheral perfusion following any bolus fluid administration.
- ☐ Repeat 0.9% NaCl 10 mL/kg (dose: ____ mL) IV rapidly if no improvement in heart rate or blood pressure, as necessary to restore adequate perfusion.

Ongoing DKA Management (1-4 Hours after Presentation) Orders

Patient Care

☑ Admit to inpatient unit (*in a pediatric DKA site*)
OR Initiate arrangements to transfer patient for subsequent patient care to a center with pediatric DKA expertise.
☑ NPO

Monitoring

☐ Vital signs: heart rate, blood pressure, respiratory rate, temperature, 02 saturation every _____ minutes (*Indicated at a minimum of every hour in the initial 1-4 hours)*
☐ Neurovitals: level of consciousness, Glasgow coma scale (GCS) every ____ minutes (*Indicated at a minimum of every hour in the initial 1-4 hours)*
☑ Cardiac Monitoring: Continuous Pulse oximetry or cardiac monitor
☑ Intake and Output: Strictly monitor fluid volume intake and output hourly

Investigations
Point of Care Testing

☑ Blood Glucose Monitoring – POCT, by finger poke hourly and prn. (*Frequent blood glucose measurement at the bedside will be required while adjusting insulin/ IV in first 1-4 hours)*
☑ Urine Ketones – POCT every _____ ; monitor at minimum every 4-8 hours until persistently negative and an order is received to discontinue; every void if measured on the unit (*measure urine ketones OR serum beta-hydroxybutyrate)*

Chemistry

- **Every *2-4 hours, minimum of Q4H to monitor response to therapy***
  - ☑ Sodium (Na) LEVEL every _____ hours
  - ☑ Potassium (K) LEVEL every ____ hours
  - ☑ Chloride (Cl) LEVEL every _____hours
  - ☑ Glucose Random LEVEL every _____ hours
  - ☑ Bicarbonate LEVEL every _____ hours
- **Every 8 hours**
  - ☐ Osmolality every 8 hours
  - ☐ Creatinine (Cr) LEVEL every 8 hours
  - ☐ Urea (BUN) every 8 hours
  - ☐ Anion gap every 8 hours
  - ☐ Calcium (Ca) LEVEL every 8 hours
  - ☐ Beta-hydroxybutyrate – if available every 8 hours
  - ☐ Phosphate (PO4) LEVEL every 8 hours
  - ☐ Magnesium (Mg) LEVEL every 8 hours

Blood Gases

Capillary or venous blood gases are acceptable.

- ☐ blood gas capillary every 4 hours;
- ☐ blood gas venous every 4 hours;
- ☐ alternate every 4 hours blood gas with every 4 hours chemistry labs (*Optional: if warranted for more severe DKA, can alternate collection with chemistry labs to monitor lab values every 2 hours)*
- ☐ Ionized calcium (iCa) LEVEL *(with gas if available)*

Fluid Management

After initial volume expansion over first 1 hour (0.9% NaCl 10mL/Kg over 1 hour), an IV solution containing potassium is recommended. 0.9% NaCl with 40 mEql KCl/L is recommended if patient is voiding.

Hypotonic solutions should NOT be used in the initial management of DKA. Most patients can be continued on isotonic solutions for their whole DKA treatment.

Avoid over-hydration, total fluid should not exceed 2x maintenance in the first 24 hours.

Refer to Appendix A: Detailed Fluid Calculations

Refer to IV Fluids and Potassium (1-4 Hours after Presentation)

1) IV Fluids without Dextrose (Use when blood glucose greater than 17 mmol/L):

☐ **Mild or moderate DKA:**

0.9% NaCl with 40 mEqKCl/L
IV infusion rate: Hourly rate = 1.5 x maintenance rate
Calculated rate = _____ mL/hr;
discontinue when blood glucose by glucometer reaches 17 mmol/L

OR

☐ **Severe DKA:**

0.9% NaCl with 40 mEq KCl/L;
IV infusion rate: Hourly rate = 2 x maintenance rate
Calculated rate = _____ mL/hr;
discontinue when blood glucose by glucometer reaches 17 mmol/L

2) IV Fluids with Dextrose (Start when blood glucose falls to less than or equal to 17 mmol/L)

Add dextrose to IV fluids using Two-plus-One system.

Refer to Appendix A: Detailed Fluid Calculations *for total hourly rate = _____ mL/hr*

Total hourly rate = Infusion A rate (saline) + Infusion B rate (saline and dextrose)

☑ **Titrate dextrose infusion to maintain blood glucose 8-15 mmol/L**

☐ ***10% Dextrose System***

- Bag A: 0.9 % NaCl with 40 mEq KCl/L; Infusion A rate: _____mL/hr
  And
  Bag B: D10W - 0.9% NaCl with 40 mEq KCl/L**;** Infusion B rate: _____ mL/hr; Start with a combination of Bag A and Bag B that provides a dextrose concentration of **D10W - 0.9% NaCl with 40 mEq KCl/L.** This is accomplished by Bag A rate = 0% of total hourly fluid rate and Bag B rate= 100% of total hourly fluid rate.
- Administration Instructions:
  Refer to Appendix D: Instructions for Preparing Dextrose 10% and Dextrose 12.5% Solutions; **and** Appendix C: Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 10% Solution

With each hourly blood glucose level (by chem strip or serum):

- If blood glucose greater than 15 mmol/L, increase bag A (saline) by 25% of the total hourly fluid rate and decrease bag B (dextrose) by 25% of the total hourly fluid rate
- If blood glucose less than 10 mmol/L, decrease bag A (saline) by 25% of the total hourly fluid rate and increase bag B (dextrose) by 25% of the total hourly fluid rate
- Infuse **Bag A** and **Bag B** at rates indicated. Total Hourly Fluid rate remains unchanged.
- If blood glucose decreases more than 5 mmol/L per hour, contact physician
- In some clinical circumstances adjusting by more (or less) than 25% of the total fluid hourly rate may be required. Use clinical judgement.

3) **Fluids for patients being transferred to a pediatric site or where a Two Plus One bag System is not available and glucose level is reaching 17 mmol/L such that glucose must be added.** Continue rate as before: 1.5 x maintenance for mild to moderate DKA and 2 x maintenance for severe DKA.
   - ☐ D5W 0.9% NaCl with 40 mEq/L KCl _____ mL/hr

4) **Additional Fluids Orders if Required**
   - ☐ _____
   - ☐ _____
   - ☐ _____
   - ☐ _____

Medications

Insulin Infusion *(after receiving 1-2 hours of IV fluids)*

Start insulin infusion after patient has received initial volume expansion over 1-2 hours and is hemodynamically stable.

IV insulin boluses are always contraindicated. *Early IV insulin infusion (within 1st hour of administration of fluids) may increase risk of cerebral edema.*

If metabolic acidosis is not improving after 4 hours, re-evaluate that rehydration calculations are correct, insulin infusion is properly mixed, intravenous lines are not occluded, are patent and infusing.

Once these have been re-evaluated, if no improvement consider consulting pediatric endocrinology and/or PICU.

- ☐ insulin infusion; Humulin R 1 unit/mL in 0.9% NaCl; _____units/ hour (0.1 units/kg/hr)= mL/hr IV continuously

Potassium

Begin 40 mEq/L potassium in IV fluids when insulin infusion is initiated. If additional potassium supplementation is required, follow local policy regarding the availability of IV fluids containing 60 mEq/L of potassium, or consider oral potassium supplementation (may cause vomiting)

- ☐ potassium chloride ____ mmol (1 mmol/Kg/dose) PO q12 hours for ____ doses (*if patient has normal level of consciousness, even if patient NPO. 1-3 doses recommended)*

Order Set: Diabetic Ketoacidosis Pediatric Inpatient Orders for Sites Using D12.5W Solutions

Order Set Components

Restrictions for use of this set of orders: For use in inpatient units
Order Set Requirements: Weight

Admission/Discharge/Transfer

- ☐ Admit to inpatient unit
- ☐ Transfer patient for subsequent patient care to a center with pediatric DKA expertise. (*Transfer should be arranged as soon as possible when patient is stable to enable care to continue in a site with providers experienced in the care of pediatric DKA.)*

Patient Care

- ☑ Goals of Care Designation: utilize appropriate Goal of Care
- ☑ Weigh patient, daily
- ☑ Notify physician if:
    - decreased or changing level of consciousness (restless, irritable, drowsy, obtunded) especially after initial improvement
    - headache, hypertension, vomiting, incontinence, cranial nerve palsies, oxygen desaturation

Diet:

- ☑ NPO

Ongoing DKA Management (1-4 Hours after Presentation) Orders

Monitoring

Vital signs and neurovitals are indicated at a minimum of every hour in the initial 1-4 hours; more frequently as indicated (based on severity and care setting)

- ☑ Vital signs: heart rate, blood pressure, respiratory rate, temperature, 02 saturation; every_____ minutes
- ☑ Neurovitals: level of consciousness, Glasgow coma scale (GCS) every ____ minutes
- ☑ Cardiac Monitoring: Continuous Pulse oximetry or cardiac monitor
- ☑ Intake and Output: Strictly monitor intake and output hourly

Point of Care Testing

Frequent blood glucose point of care testing is required while adjusting insulin/IV in first 1-4 hours.

- ☑ Blood Glucose Monitoring – POCT, by finger poke hourly
- ☑ Urine Ketones – POCT every _____ ; monitor at minimum every 4-8 hours until persistently negative and an order is received to discontinue; every void if measured on the unit (*measure urine ketones OR serum beta-hydroxybutyrate)*

Laboratory Investigations

ECG and CXR are not routinely indicated. DKA may be precipitated by a concurrent illness. Diagnostic testing should be based on patient presentation.

Continue monitoring chemistry and blood gases until the child's serum bicarbonate level and serum electrolytes have returned to normal.

Chemistry

- **Once**
  - ☐ Hemoglobin A1C (if not done in emergency/ last 30 days)
- **Every *2-4 hours, minimum of Q4H to monitor response to therapy***
  - ☑ Sodium (Na) LEVEL every _____ hours
  - ☑ Potassium (K) LEVEL every ____ hours
  - ☑ Chloride (Cl) LEVEL every _____ hours
  - ☑ Glucose Random LEVEL every _____ hours
  - ☑ Bicarbonate LEVEL every ____ hours
- **Every 8 hours**
  - ☐ Serum osmolality every 8 hours
  - ☐ Creatinine LEVEL every 8 hours
  - ☐ Urea every 8 hours
  - ☐ Anion gap every 8 hours
  - ☐ Calcium LEVEL every 8 hours
  - ☐ Beta-hydroxybutyrate – if available every 8 hours
  - ☐ Phosphate LEVEL every 8 hours
  - ☐ Magnesium LEVEL every 8 hours

Blood Gases

Capillary or venous blood gases are acceptable.

- ☐ blood gas capillary every 4 hours;
- ☐ blood gas venous every 4 hours;
- ☐ alternate every 4 hours blood gas with every 4 hours chemistry labs (*Optional: if warranted for more severe DKA, can alternate collection with chemistry labs to monitor lab values every 2 hours)*
- ☐ Ionized calcium (iCa) LEVEL *(with gas if available)*

Fluid Management

Proceed to detailed rehydration calculations after the first hour of initial fluid management orders. Continue initial IV infusion rate (1.5 x maintenance for mild/ moderate DKA and 2 x maintenance for severe DKA) until detailed fluid calculations are completed.

Avoid over-hydration, total fluid should not exceed 2x maintenance in the first 24 hours.

Determine based on initial assessment and lab results if the child is in mild, moderate, or severe DKA. This will be required for detailed fluid calculations. **Refer to** Appendix A: Detailed Fluid Calculations

Refer to IV Fluids and Potassium (1-4 Hours after Presentation)
Refer to Intravenous Fluids and Electrolytes (Continued Management until DKA Resolution

After initial fluid management over first 1 hour (0.9% NaCl 10ml/kg over 1 hour), every patient should receive minimum of 40 mEq/L of potassium via IV fluids. *If additional potassium supplementation is required, follow local policy regarding the IV fluids containing 60 mEq/L of potassium, or consider oral potassium supplementation (may cause vomiting).*

1) Initial Intravenous Fluids (Use when blood glucose greater than 17 mmol/L)

a. **0.9% NaCl with 40 mEq KCl/L**
IV infusion rate: Calculated hourly rate = _____mL/ hr; prescriber to discontinue when blood glucose by glucometer reaches 17 mmol/L

2) IV Fluids with Dextrose (Use when blood glucose less than or equal to 17 mmol/L)

Add dextrose to IV fluids using Two-plus-One system.
Refer to Appendix A: Detailed Fluid Calculations for total hourly fluid rate = _____ ml/hr
Total hourly rate = Infusion A rate (saline) + Infusion B rate (saline and dextrose)

☐ **12.5% Dextrose System**

- Bag A: 0.9% NaCl with 40 mEq KCl/L; Infusion A rate: _____mL/hr
  and
  Bag B: D12.5W - 0.9% NaCl with 40 mEq KCl/L; Infusion B rate: _____mL/hr; Start with a combination of Bag A and Bag B that provides a dextrose concentration of D10W - 0.9 NaCl with 40 mEq KCl/L. This is accomplished by Bag A rate = 20% of total hourly fluid rate and Bag B rate= 80% of total hourly fluid rate.
- Administration Instructions:
  Refer to Appendix D: Instructions for Preparing Dextrose 10% and Dextrose 12.5% Solutions; and Appendix B: Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 12.5% Solution

With each hourly blood glucose level (by chem strip or serum):

- If blood glucose greater than 15 mmol/L, increase bag A (saline) by 20% of the total hourly fluid rate and decrease bag B (saline and dextrose) by 20% of the total hourly fluid rate
- If blood glucose less than 10 mmol/L, decrease bag A (saline) by 20% of the total hourly fluid rate and increase bag B (saline and dextrose) by 20% of the total hourly fluid rate.
- Infuse **Bag A** and **Bag B** at rates indicated. Total Hourly Fluid rate remains unchanged
- If blood glucose decreases more than 5 mmol/L per hour, contact physician.
- In some clinical circumstances adjusting by more (or less) than 20% of the total hourly fluid rate may be required. Use clinical judgement.

3) Additional Fluids Orders if Required

☐ _____
☐ _____
☐ _____
☐ _____

Medications

- **Insulin Infusion *(after receiving 1-2 hours of IV fluids and hemodynamically stable)***

IV insulin boluses are always contraindicated. *Early IV insulin infusion (within 1st hour of administration of fluids) may increase risk of cerebral edema.*
If metabolic acidosis is not improving after 4 hours, re-evaluate that rehydration calculations are correct, insulin infusion is properly mixed, intravenous lines are not occluded, are patent and infusing.
Once these are re-evaluated, if no improvement consider consulting pediatric endocrinology and/or PICU.

Refer to Insulin Infusion (1-4 Hours after Presentation)

☐ insulin secondary infusion; Humulin R 1 unit/mL in 0.9% NaCl; _____units/ hour (0.1 units/kg of body weight/hr) = mL/hr IV continuously

- **Potassium**
  Begin 40 mEq/L potassium in IV fluids when insulin infusion is initiated. If additional potassium

supplementation is required, follow local policy regarding the availability of IV fluids containing 60 mEq/L of potassium, or consider oral potassium supplementation (may cause vomiting)

☐ potassium chloride_____ mmol (1 mmol/Kg/dose) PO every 12 hours for_____doses (*if patient has normal level of consciousness, even if patient NPO. 1-3 doses recommended)*

Continued Management until DKA Resolution Orders

Order Set Components:

Patient Care

Diet:

☐ Sugar-free oral fluids when serum bicarbonate greater than or equal to 18 mmol/L *(mild acidosis/ketosis may still be present). Note: Earlier PO intake may be ordered by physician.*

Monitoring

☐ Vital signs: heart rate, blood pressure, respiratory rate, temperature, O2 saturation; every _____ hours; Reduce to q 4 hour vital signs when insulin infusion is discontinued. *(Indicated at a minimum of every 2 hours while receiving insulin infusion)*

☐ Neurovitals: level of consciousness, Glasgow coma scale (GCS) every _____hours Discontinue neurovitals once insulin infusion is discontinued and child is neurologically normal.(*Indicated at a minimum of every 2 hours while receiving insulin infusion)*

☐ Cardiac Monitoring: Continuous Pulse oximetry and cardiac monitor, discontinue when insulin infusion discontinued

☐ Intake and Output: Monitor fluid volume intake and output every 4 hours. Reduce to every 8 hours once infusions are discontinued.

Point of Care Testing

☑ Blood Glucose Monitoring – POCT, every_____hours and prn; (*Indicated every 2 hours or more frequently while patient is receiving DKA management (i.e. insulin infusion)*

☐ Urine Ketones – POCT; every 4-8 hours until persistently negative and an order is received to discontinue (measure urine ketones or serum betahydroxybutyrate)

☐ Discontinue urine ketones once negative x _____ or insulin infusion is discontinued.

Lab Investigations

☐ Discontinue routine lab investigations (once the child's bicarbonate level and electrolytes have returned to normal)

Intravenous Orders

Re-evaluate replacement fluid type frequently, anticipating the need to adjust sodium, potassium, dextrose, etc based on laboratory monitoring.

Continue the IV fluids for additional 12 - 24 hours to complete rehydration if required. Most patients are able to rehydrate themselves orally and do not require continued IV.

- **Dextrose**:

  Continue IV dextrose as ordered in 1-4 hours to maintain blood glucose 8-15 mmol/L. Keeping blood

glucose in this range allows for buffer against hypoglycemia and a too-rapid fall in plasma osmolality. Corrected sodium should be calculated and followed. The corrected sodium should rise with treatment. If corrected sodium is falling, this is a risk factor for cerebral edema.

Formula for Corrected Sodium Calculation

Corrected Na = [Measured Na + 0.36 x (plasma glucose – 5.6)]

Most patients can be maintained on a 0.9% NaCl containing solution throughout their DKA treatment*. There may be rare cases as DKA resolves, i.e. hyperchloremia, or when patient is continuing to receive IV fluids after resolution of acidosis, where using hypotonic fluids such as 0.45% NaCl is appropriate.*

Use of 0.45% NaCl should only be considered if *corrected sodium is 140-150 mmol/L and stable, and patient has received 4-5 hours of treatment;*

☐ **12.5% Dextrose System**

- Bag A: 0.45% N*aCl* with 40 mEq KCl/L; Infusion A rate: _____mL/hr

and

- Bag B: D12.5W - 0.45% NaCl with 40 mEq KCl/L; Infusion B rate:_____mL/hr
- Administration Instructions:
  Refer to Appendix D: Instructions for Preparing Dextrose 10% and Dextrose 12.5% Solutions; **and** Appendix B: Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 12.5% Solution

With each hourly blood glucose level (by chem strip or serum):

- If blood glucose greater than 15 mmol/L, increase bag A (saline) by 20% of the total hourly fluid rate and decrease bag B (saline and dextrose) by 20% of the total hourly fluid rate
- If blood glucose less than 10 mmol/L, decrease bag A (saline) by 20% of the total hourly fluid rate and increase bag B (saline and dextrose) by 20% of the total hourly fluid rate
- Infuse **Bag A** and **Bag B** at rates indicated. Total Hourly Fluid rate remains unchanged.
- If blood glucose decreases more than 5 mmol/L per hour, contact physician
- In some clinical circumstances adjusting by more (or less) than 20% of the total hourly fluid rate may be required. Use clinical judgment.

Medications: **Insulin Infusion**

Insulin Reduction:

Falling blood glucose should be managed by increasing dextrose infusion rate. Decreasing insulin dosage should not be used to address decreasing blood glucose while the patient still has significant acidosis (except when maximal dextrose infusion rates are ineffective).

☐ Reduce insulin infusion rate to _____units/hr (0.05 units/kg/hour)
(reduce to 0.05 units/ kg/ hr when blood bicarbonate level is greater than 15 mmol/L)

Insulin Discontinuation:

☐ Discontinue insulin infusion once blood pH returns to normal and serum bicarbonate level is greater than 18 mmol/L, and serum beta-hydroxybutyrate (if available) is normal; simultaneously with the provision of subcutaneous insulin *(The blood pH will be normal but ketones may still be present in the urine. This is expected to occur within 24 - 36 hours)*

Medications: Subcutaneous insulin (add insulin orders)

For rapid-acting insulin, the insulin injection is given immediately before breakfast or dinner, and the insulin infusion is turned off at the same time.

☐ _____
☐ _____
☐ _____

- **Potassium**

  Every patient should receive minimum of 40 mEq/L of potassium via IV fluids.
  If additional potassium supplementation is required, follow local policy regarding the availability of IV fluids containing 60 mEq/L of potassium, or consider oral potassium supplementation (may cause vomiting)

  ☐ potassium chloride _____mmol (1 mmol/kg/dose) PO every 12 hours for ____doses (*if patient has normal level of consciousness, even if patient NPO. 1-3 doses recommended)*

- **Phosphate**

  If serum phosphate is less than 0.4 mmol/L, considering administering PO4 in IV fluids. While phosphate can be given as sodium phosphate or potassium phosphate, sodium phosphate IV is considered a safer alternative when possible.
  If phosphate is given, monitor serum Ca, Mg, and phosphate levels minimum every 4 hours to avoid hypocalcemia.

  ☐ Refer to local order and policy for sodium phosphate IV, including available IV fluids and infusion protocols

Order Set: Diabetic Ketoacidosis Pediatric Inpatient Orders for Sites Using D10W Solutions

Order Set Components

Restrictions for use of this set of orders: For use in inpatient units
Order Set Requirements: Weight

Admission/Discharge/Transfer

- ☐ Admit to inpatient unit
- ☐ Transfer patient for subsequent patient care to a center with pediatric DKA expertise.(*Transfer should be arranged as soon as possible when patient is stable to enable care to continue in a site with providers experienced in the care of pediatric DKA)*

Patient Care

- ☑ Goals of Care Designation: utilize appropriate Goal of Care
- ☑ Weigh patient, daily
- ☑ Notify physician if:
    - decreased or changing level of consciousness (restless, irritable, drowsy, obtunded) especially after initial improvement
    - headache, hypertension, vomiting, incontinence, cranial nerve palsies, oxygen desaturation

Diet:

- ☑ NPO

Ongoing DKA Management (1-4 Hours after Presentation) Orders

Monitoring

Vital signs and neurovitals are indicated at a minimum of every hour in the initial 1-4 hours; more frequently as indicated (based on severity and care setting)

- ☑ Vital signs: heart rate, blood pressure, respiratory rate, temperature, O2 saturation; every_____ minutes
- ☑ Neurovitals: level of consciousness, Glasgow coma scale (GCS) every ____ minutes
- ☑ Cardiac Monitoring: Continuous Pulse oximetry or cardiac monitor
- ☑ Intake and Output: Strictly monitor intake and output hourly

Point of Care Testing

Frequent blood glucose point of care testing is required while adjusting insulin/IV in first 1-4 hours.

- ☑ Blood Glucose Monitoring – POCT, by finger poke hourly
- ☑ Urine Ketones – POCT every _____ ; monitor at minimum every 4-8 hours until persistently negative and an order is received to discontinue; every void if measured on the unit (*measure urine ketones OR serum beta-hydroxybutyrate)*.

Laboratory Investigations

ECG and CXR are not routinely indicated. DKA may be precipitated by a concurrent illness. Diagnostic testing should be based on patient presentation.

Continue monitoring chemistry and blood gases until the child's serum bicarbonate level and serum electrolytes have returned to normal.

Chemistry

- **Once**
  - ☐ Hemoglobin A1C (if not done in emergency/ last 30 days)
- **Every *2-4 hours, minimum of Q4H to monitor response to therapy***
  - ☑ Sodium (Na) LEVEL every _____ hours
  - ☑ Potassium (K) LEVEL every ____ hours
  - ☑ Chloride (Cl) LEVEL every _____ hours
  - ☑ Glucose Random LEVEL every _____ hours
  - ☑ Bicarbonate LEVEL every ____ hours
- **Every 8 hours**
  - ☐ Serum osmolality every 8 hours
  - ☐ Creatinine LEVEL every 8 hours
  - ☐ Urea every 8 hours
  - ☐ Anion gap every 8 hours
  - ☐ Calcium LEVEL every 8 hours
  - ☐ Beta-hydroxybutyrate – if available every 8 hours
  - ☐ Phosphate LEVEL every 8 hours
  - ☐ Magnesium LEVEL every 8 hours

Blood Gases

Capillary or venous blood gases are acceptable.

- ☐ blood gas capillary every 4 hours;
- ☐ blood gas venous every 4 hours;
- ☐ alternate every 4 hours blood gas with every 4 hours chemistry labs
  (*Optional: if warranted for more severe DKA, can alternate collection with chemistry labs to monitor lab values every 2 hours)*
- ☐ Ionized calcium (iCa) LEVEL *(with gas if available)*

Fluid Management

Proceed to detailed rehydration calculations after the first hour of initial fluid management orders. Continue initial IV infusion rate (1.5 X maintenance for mild/ moderate DKA and 2 x maintenance for severe DKA) until detailed fluid calculations are completed.

Avoid over-hydration, total fluid should not exceed 2x maintenance in the first 24 hours.

Determine based on initial assessment and lab results if the child is in mild, moderate, or severe DKA. This will be required for detailed fluid calculations. **Refer to** Appendix A: Detailed Fluid Calculations

Refer to IV Fluids and Potassium (1-4 Hours after Presentation)
Refer to Intravenous Fluids and Electrolytes (Continued Management until DKA Resolution

After initial fluid management over first 1 hour (0.9% NaCl 10mL/kg over 1 hour), every patient should receive minimum of 40 mEq/L of potassium via IV fluids. *If additional potassium supplementation is required, follow local policy regarding the IV fluids containing 60 mEq/L of potassium, or consider oral potassium supplementation (may cause vomiting).*

1) **Initial Intravenous Fluids (Use when blood glucose greater than 17 mmol/L)**
   a. **0.9% NaCl with 40 mEq KCl/L**
   IV infusion rate: Calculated hourly rate = _____mL/ hr; prescriber to discontinue when blood glucose by glucometer reaches 17 mmol/L

2) **IV Fluids with Dextrose (Use when blood glucose less than or equal to 17 mmol/L)**
Add dextrose to IV fluids using Two-plus-One system.
Refer to Appendix A: Detailed Fluid Calculations *for total hourly fluid rate = _____ mL/hr*
Total hourly rate = Infusion A rate (saline) + Infusion B rate (saline and dextrose)
☐ **10% *Dextrose System***
- Bag A: 0.9% NaCl with 40 mEq KCl/L; Infusion A rate: _____mL/hr
and
Bag B: D10W - 0.9% NaCl with 40 mEq KCl/L**;** Infusion B rate: _____mL/hr; Start with a combination of Bag A and Bag B that provides a dextrose concentration of **D10W - 0.9% NaCl with 40 mEq KCl/L.** This is accomplished by Bag A rate = 0% of total hourly fluid rate and Bag B rate= 100% of total hourly fluid rate.
- Administration Instructions:
Refer to Appendix D: Instructions for Preparing Dextrose 10% and Dextrose 12.5% Solutions; and Appendix C: Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 10% Solution

With each hourly blood glucose level (by chem strip or serum):
- If blood glucose greater than 15 mmol/L, increase bag A (saline) by 25% of the total hourly fluid rate and decrease bag B (saline and dextrose) by 25% of the total hourly fluid rate
- If blood glucose less than 10 mmol/L, decrease bag A (saline) by 25% of the total hourly fluid rate and increase bag B (saline and dextrose) by 25%
- If blood glucose decreases more than 5 mmol/L per hour, contact physician
- Infuse **Bag A** and **Bag B** at rates indicated. Total Hourly Fluid rate rins unchanged.
- In some clinical circumstances adjusting by more (or less) than 25% of the total hourly fluid rate may be required. Use clinical judgement.

3) **Additional Fluids Orders if Required**
☐ _____
☐ _____
☐ _____
☐ _____

Medications

- **Insulin Infusion *(after receiving 1-2 hours of IV fluids and hemodynamically stable)***

IV insulin boluses are always contraindicated. *Early IV insulin infusion (within 1st hour of administration of fluids) may increase risk of cerebral edema.*
If metabolic acidosis is not improving after 4 hours, re-evaluate that rehydration calculations are correct, insulin infusion is properly mixed, intravenous lines are not occluded, are patent and infusing.
Once these are re-evaluated, if no improvement consider consulting pediatric endocrinology and/or PICU.

Refer to Insulin Infusion (1-4 Hours after Presentation)

☐ insulin secondary infusion; Humulin R 1 unit/mL in 0.9% NaCl; _____units/ hour (0.1 units/kg/hr) = ml/hr IV continuously

- **Potassium**
  Begin 40 mEq/ L potassium in IV fluids when insulin infusion is initiated. If additional potassium supplementation is required, follow local policy regarding the availability of IV fluids containing 60 mEq/L of potassium, or consider oral potassium supplementation (may cause vomiting)

☐ potassium chloride_____ mmol (1 mmol/kg/dose) PO every 12 hours for_____doses (*if patient has normal level of consciousness, even if patient NPO. 1-3 doses recommended)*

Continued Management until DKA Resolution Orders

Order Set Components:

Patient Care

Diet:

☐ Sugar-free oral fluids when serum bicarbonate greater than or equal to 18 mmol/L *(mild acidosis/ketosis may still be present). Note: Earlier po intake may be ordered by physician. Once on po fluids, reduce total iv rates accordingly.*

Monitoring

☐ Vital signs: heart rate, blood pressure, respiratory rate, temperature, O2 saturation; every _____ hours; Reduce to every 4 hours vital signs when insulin infusion is discontinued. (*Indicated at a minimum of every 2 hours while receiving insulin infusion)*

☐ Neurovitals: level of consciousness, Glasgow coma scale (GCS) every _____hours Discontinue neurovitals once insulin infusion is discontinued and child is neurologically normal (*Indicated at a minimum of every 2 hours while receiving insulin infusion)*

☐ Cardiac Monitoring: Continuous Pulse oximetry and cardiac monitor, discontinue when insulin infusion discontinued

☐ Intake and Output: Monitor fluid volume intake and output every 4 hours. Reduce to every 8 hours once infusions are discontinued.

Point of Care Testing

☑ Blood Glucose Monitoring – POCT, every_____hours and prn; (*Indicated every 2 hours or more frequently while patient is receiving DKA management (i.e. insulin infusion)*

☐ Urine Ketones – POCT every _____ ; monitor at minimum every 4-8 hours until persistently negative and an order is received to discontinue; every void if measured on the unit (*measure urine ketones OR serum beta-hydroxybutyrate)*

☐ Discontinue urine ketones once negative x _____ or insulin infusion is discontinued.

Lab Investigations

☐ Discontinue routine lab investigations (once the child's bicarbonate level and electrolytes have returned to normal)

Intravenous Orders

Re-evaluate replacement fluid type frequently, anticipating the need to adjust sodium, potassium, dextrose, etc based on laboratory monitoring.

Continue the IV fluids for additional 12 - 24 hours to complete rehydration if required. Most patients are able to

rehydrate themselves orally and do not require continued iv.

- **Dextrose**:

  Continue IV dextrose as ordered in 1-4 hours to maintain blood glucose 8-15 mmol/L. Keeping blood glucose in this range allows for buffer against hypoglycemia and a too-rapid fall in plasma osmolality. Corrected sodium should be calculated and followed. The corrected sodium should rise with treatment. If corrected sodium is falling, this is a risk factor for cerebral edema.

  Formula for Corrected Sodium Calculation
  Corrected Na = [Measured Na + 0.36 x (plasma glucose – 5.6)] (ISPAD)

  ***Most patients can be maintained on a 0.9% NaCl containing solution throughout their DKA treatment**. There may be rare cases as DKA resolves, i.e. hyperchloremia, or when patient is continuing to receive IV fluids after resolution of acidosis, where using hypotonic fluids such as 0.45% NaCl is appropriate.*

  Use of 0.45% NaCl should only be considered if *corrected sodium is 140-150 mmol/L and stable, and patient has received 4-5 hours of treatment;*

  ☐ ***10% Dextrose System***
  - Bag A: 0.45% NaCl with 40 mEq KCl/L; Infusion A rate: _____mL/hr

  and
  - Bag B: D10W - 0.45% NaCl with 40 mEq KCl/L**;** Infusion B rate: _____mL/hr
  - Start with a combination of Bag A and Bag B that provides a dextrose concentration of **D10W - 0.9% NaCl with 40 mEq KCl/L.**
  - Administration Instructions:
    Refer to Appendix D Instructions for Preparing Dextrose 10% and Dextrose 12.5% Solutions**; and**
    Appendix C: Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 10% Solution

  With each hourly blood glucose level (by chem strip or serum):
  - If blood glucose greater than 15 mmol/L, increase bag A (saline) by 25% of the total hourly fluid rate and decrease bag B (saline and dextrose) by 25% of the total hourly fluid rate
  - If blood glucose less than 10 mmol/L, decrease bag A (saline) by 25% of the total hourly fluid rate and increase bag B (saline and dextrose) by 25% of the total hourly fluid rate
  - Infuse **Bag A** and **Bag B** at rates indicated.
  - If blood glucose decreases more than 5 mmol/L per hour, contact physician
  - Infuse **Bag A** and **Bag B** at rates indicated. Total Hourly Fluid rate remains unchanged.
  - In some clinical circumstances adjusting by more (or less) than 25% of the total hourly fluid rate may be required. Use clinical judgement.

  - If blood glucose levels cannot be maintained with a maximum of D10W, consider increasing the dextrose concentration to D12.5W; this should be rare.

Medications: **Insulin Infusion**

Insulin Reduction:
Falling blood glucose should be managed by increasing dextrose infusion rate. Decreasing insulin dosage should not be used to address decreasing blood glucose while the patient still has significant acidosis (except when maximal dextrose infusion rates are ineffective).

☐ Reduce insulin infusion rate to _____units/hr (0.05 units/kg/hour)

(reduce to 0.05 units/ Kg/ hr when blood bicarbonate level is greater than 15 mmol/L)

Insulin Discontinuation:

☐ Discontinue insulin infusion once blood pH returns to normal and serum bicarbonate level is greater than 18 mmol/L, and serum beta-hydroxybutyrate (if available) is normal; simultaneously with the provision of subcutaneous insulin *(The blood pH will be normal but ketones may still be present in the urine. This is expected to occur within 24 - 36 hours)*

Medications: Subcutaneous insulin (add insulin orders)

For rapid-acting insulin, the insulin injection is given immediately before breakfast or dinner, and the insulin infusion is turned off at the same time.

☐ _____
☐ _____
☐ _____

- **Potassium**

  Every patient should receive minimum of 40 mEq/L of potassium via IV fluids.
  If additional potassium supplementation is required, follow local policy regarding the availability of IV fluids containing 60 mEq/L of potassium, or consider oral potassium supplementation (may cause vomiting)

  ☐ potassium chloride _____mmol (1 mmol/Kg/dose) PO every 12 hours for ____ doses (*if patient has normal level of consciousness, even if patient NPO. 1-3 doses recommended)*

- **Phosphate**

  If serum phosphate is less than 0.4 mmol/L, considering administering PO4 in IV fluids. While phosphate can be given as sodium phosphate or potassium phosphate, sodium phosphate IV is considered a safer alternative when possible.
  If phosphate is given, monitor serum Ca, Mg, and phosphate levels minimum every 4 hours to avoid hypocalcemia.

  ☐ Refer to local order and policy for sodium phosphate IV, including available IV fluids and infusion protocols

Order Set: Cerebral Edema Pediatric Orders

Order Set Requirements: Weight

Admission/Discharge/Transfer:
- ☐ Call Rapid Response team (if applicable) for early warning signs or symptoms, or Code Blue for ominous signs
- ☐ Admit to tertiary site PICU for treatment and monitoring
- ☐ Initiate transfer to site for care by providers experienced with cerebral edema in pediatric DKA

Patient Care
- ☐ Goals of Care Designation: utilize appropriate Goal of Care
- ☐ Activity: Elevate HOB 30^0

Monitoring
- ☐ **Vital signs:**
  - Continuous monitoring: heart rate, blood pressure, respiratory rate, temperature, oxygen saturation. *Provide Airway, Breathing and Circulation support as required.*
  - Monitor for blood pressure changes, bradycardia, decreased oxygen saturation, irregular respirations
- ☐ **Neurovitals:**
  - **Monitor for signs of deterioration every _____ minutes:** *Severe headache, change in sensorium or GCS, restlessness, irritability, drowsiness dilated pupils, cranial nerve palsies, slurred speech, posturing, and incontinence*

Respiratory
- ☐ **Oxygen**
  - Administer high-flow oxygen _____ L by rebreather mask

Intravenous Orders
- ☐ Intravenous cannula, insert (*Establish large bore to decrease risk of extravasation)*
- ☐ Decrease IV fluid rate by one-third

Mannitol:

_____ gram/Kg IV over 20 minutes (dose range 0.5-1 gram/kg)

OR

Hypertonic Saline
- ☐ _____ml 3% NaCl IV over 15 to 30 minutes, (dose range 3 to 5 mL/kg); repeat as needed based on clinical response, serum sodium and serum osmolality;

Investigations Non-Lab
- ☐ CT scan when stable

Appendices

Appendix A - Detailed Fluid Calculations

Challenges in assessing dehydration in DKA:

Patients with DKA have a deficit in extracellular fluid volume that usually is in the range of 5–10%. Shock with hemodynamic compromise is rare in pediatric DKA. Clinical estimates of the volume deficit are subjective and inaccurate. [5] Therefore, in mild DKA one can assume 3% dehydration, in moderate DKA, 6% and in severe DKA 9% dehydration. Koves 2004 recommends "given that clinical hydration assessment appears to be unreliable when compared with absolute measures of dehydration, a conservative approach may be advocated" and "an initial assumption of 7-9% dehydration seems a reasonable figure upon which to base rehydration in most patients." [7]

Recommended estimation:

To avoid inadequate rehydration and in the context of challenging hydration assessment in DKA:

- **For mild and moderate DKA estimate 6% dehydration;**
- **For severe DKA estimate 9% dehydration**.

Table 1. Detailed Fluid Calculations

Body Weight in kilograms: _____ kg (a)

Step	Clinical Decision Support	Calculation
1. Identify percentage dehydration based on severity of DKA	***Severity of DKA*** / ***% Dehydration*** / ***Extent of Dehydration (mL/kg)*** Mild to Moderate DKA / *6%* / *60ml/kg* Severe DKA / *9%* / *90ml/kg*	**Extent of dehydration =** _____mL/kg (b)
2. Calculate total fluid deficit	Multiply: **(body weight in kg)** x **(extent of dehydration in mL/kg)**	Body weight (a) X dehydration ml/kg (b) **=Total fluid deficit** _____mL (i)
3. Calculate the remainder of the fluid deficit (ii) after the initial 1-2 hours of fluid management	Amount of IV fluid received in first 1-2 hours: _____ mL (c) Subtract: **[Total fluid deficit (i)] - [amount NS given first 1-2 hours (c)**	(i) – (c) =_____mL (ii) **=Remainder of fluid deficit (ii) to be given over the next 48 hours** in addition to maintenance fluids.
4. Calculate maintenance fluid requirements for the next 48 hours	***24-hour maintenance requirements:*** **based on body weight:** **10 kg or less** = 100 mL/kg/24 h **11–20 kg** = 1000mL+50 mL/kg/24 h for each kg greater than 10 **Greater than 20 kg** = 1500mL+20 mL/kg/24 h for each kg greater than 20 = _____ *mL maintenance for 24 hours* *Multiply by 2* = _____ **(iii)**	24 hour maintenance requirements X 2 =_____mL (iii) **=Maintenance fluid requirements for the next 48 hours**
5. Calculate the total amount of fluid still to be given over 48 hours	***Total Fluid to be given over 48 hours*** **Add:** FLUID DEFICIT **(ii) +** MAINTENANCE FLUIDS **(iii)** *Note: Additional Losses (ie vomiting/ diarrhea) are NOT included; If added losses are occurring, measure losses and replace in addition.*	(ii) + (iii) = _____ml (iv) **= Total Amount of Fluid to be given in next 48 hours (v)**
6. Calculate hourly fluid rate for the next 48 hours.	Total amount of fluid to be given in 48 hours) mL (v) /48 hours = hourly rate of fluid replacement (in mLs/hr) ***Note: If calculated fluid deficit replacement rate PLUS maintenance is greater than 2X maintenance (ie in severe DKA in a larger child) use a maximum rate of 2 X maintenance.***	(iv) mL 48 hours =_____**mL/hr** **= Total Hourly Fluid Rate (**maximum rate is 2x maintenance)**

Adapted from: BC Children's Hospital Endocrinology and Diabetes Unit. BC Children's Hospital Diabetic Ketoacidosis Protocol for children up to age 19 years.

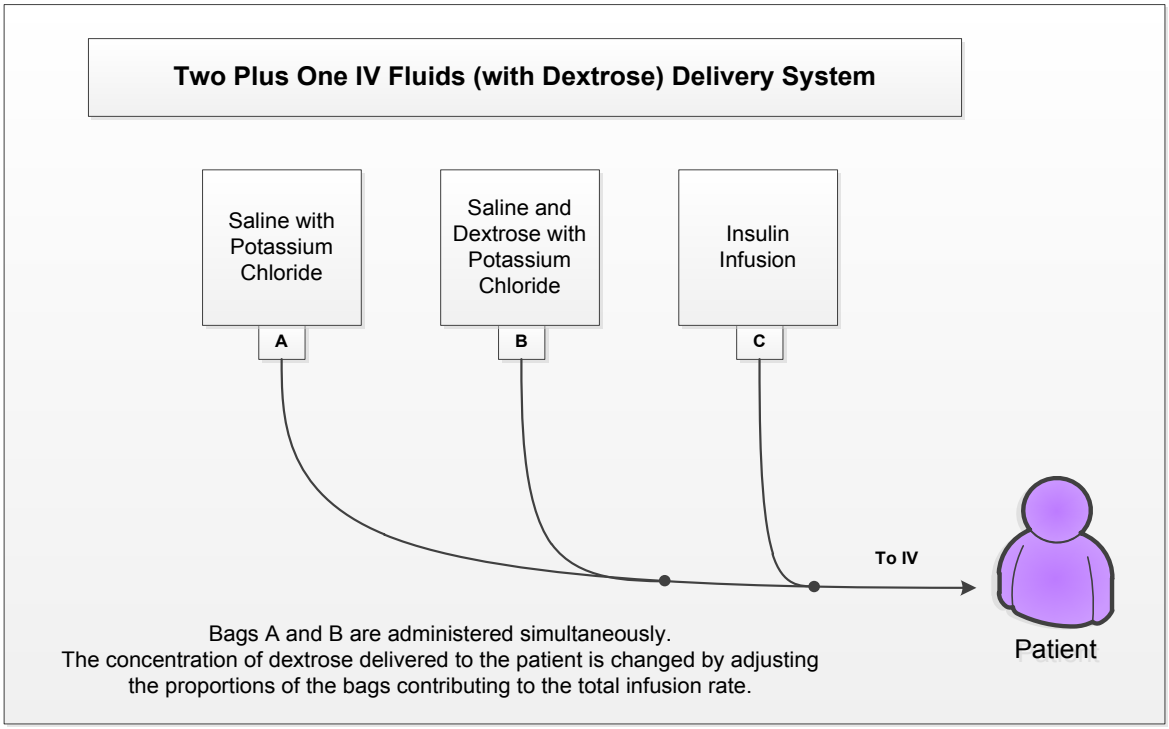
Appendix B - Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 12.5% Solution

When blood glucose **reaches 17 mmol/L**, add IV dextrose to IV fluids using **Two-plus-One system:**

- Two Solution Bags are Y-ed together and used to titrate dextrose.
- Both bags have 0.9% NaCl and 40 mEq KCl/L; one bag has no dextrose and one has D12.5W.
- Titrating the rates of each bag allows provision of a range of dextrose from 0% to 12.5%
- In order to maintain a blood glucose of 8-15 mmol/L, the concentration of dextrose delivered to the patient is changed by adjusting the proportions of the bags contributing to the total IV rate.

Set Up:

Bag A: 0.9% NaCl with 40 mEq KCl/L
Bag B: D12.5W - 0.9% NaCl with 40 mEq KCl/L
Insulin infusion also infused through the Y site at the IV catheter



Start with a combination of Bag A and Bag B that provides a dextrose concentration of **D10W - 0.9% NaCl with 40 mEq KCl/L. To achieve this initial dextrose concentration using D12.5W, use:**

Table 2. Achieving Final Dextrose Concentrations using Two Plus One IV System

Final Dextrose Concentration Delivered to Patient	**Rate of Bag A** Saline Solution (0.9% NaCl + potassium)	**Rate of Bag B** Saline and Dextrose Solution (**D12.5W -** 0.9% NaCl + potassium)
D10W	20% of total hourly fluid rate	80% of total hourly fluid rate

The total hourly fluid rate adding Bag A and Bag B should ALWAYS equal the total hourly IV infusion rate calculated for the patient; proportions of the hourly rate contributed by the two bags is adjusted as below**.** If blood glucose decreases more than 5 mmol/L per hour, contact physician.

More information:

Appendix C: Adding Dextrose to IV Fluids Using Dextrose 10% Solution
Appendix D: Instructions for preparing Dextrose 10% and Dextrose 12.5% Solution

Table 3. Titration of Dextrose

Hourly Blood Glucose Result (serum/ chemstrip)	**Rate of Bag A** Saline Solution (0.9% NaCl + potassium)	**Rate of Bag B** Saline and Dextrose Solution (**D12.5W -** 0.9% NaCl + potassium)
Greater than 15 mmol/L	Increase Bag A (saline) by 20% of the total hourly fluid rate	Decrease bag B (saline and dextrose) by 20% of the total hourly fluid rate
Less than 10 mmol/L	Decrease Bag A (saline) by 20% of the total hourly fluid rate	Increase bag B (saline and dextrose) by 20% of the total hourly fluid rate
10-15 mmol/L	No changes to rates of Bag A or Bag B	

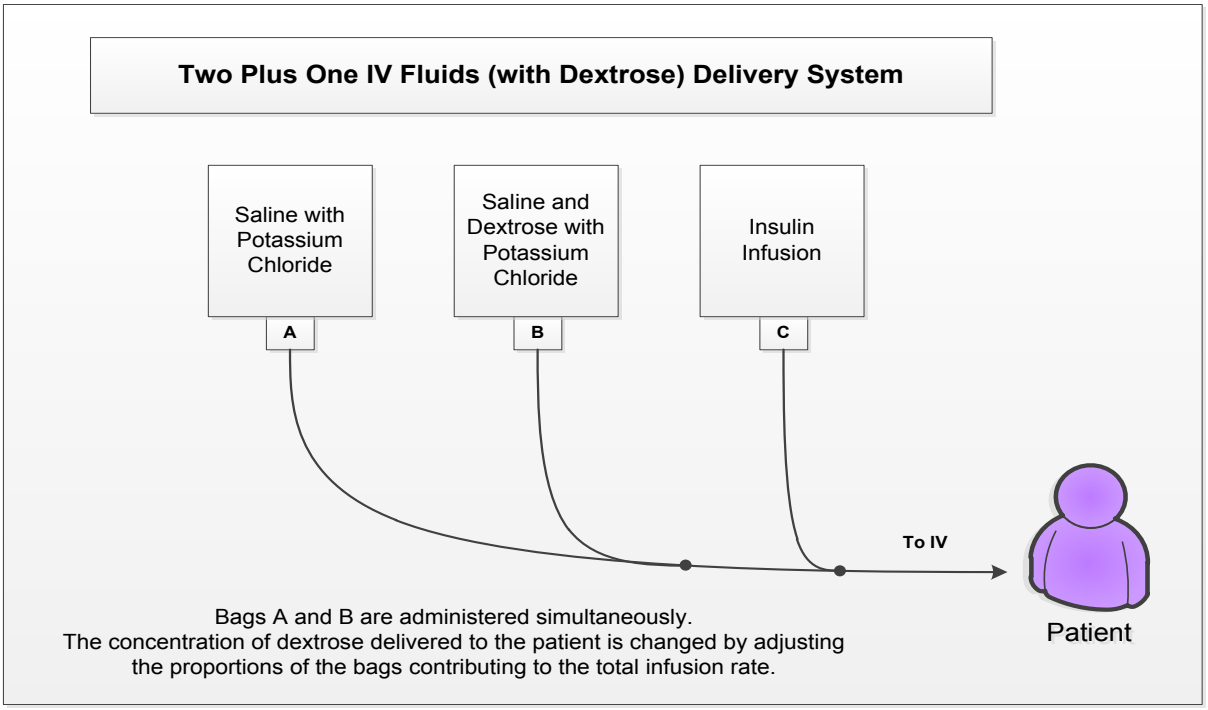
Appendix C - Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 10% Solution

When blood glucose **reaches 17 mmol/L**, add IV dextrose to IV fluids using **Two-plus-One system:**

- Two Solution Bags are Y-ed together and used to titrate dextrose.
- Both bags have 0.9% NaCl and 40 mEq KCl/L; one bag has no dextrose and one has D10W.
- Titrating the rates of each bag allows provision of a range of dextrose from 0% to 10%
- In order to maintain a blood glucose of 8-15 mmol/L, the concentration of dextrose delivered to the patient is changed by adjusting the proportions of the bags contributing to the total IV rate.

Set Up:

Bag A: 0.9% NaCl with 40 mEq KCl/L
Bag B: D10W - 0.9% NaCl with 40 mEq KCl/L
Insulin infusion also infused through the Y site at the IV catheter



Start with a combination of Bag A and Bag B that provides a dextrose concentration of **D10W - 0.9% NaCl with 40 mEq KCl/L. To achieve this initial dextrose concentration using D10W, use:**

Table 4. Achieving Final Dextrose Concentrations using Two Plus One IV System

Final Dextrose Concentration Delivered to Patient	Rate of Bag A Saline Solution (e.g. 0.9% NaCl + potassium)	Rate of bag B Saline and Dextrose Solution (D10W - 0.9% NaCl + potassium)
Dextrose 10%	0% of total hourly fluid rate	100% of total hourly fluid rate

The total hourly fluid rate adding Bag A and Bag B should ALWAYS equal the total hourly IV infusion rate calculated for the patient; proportions of the hourly rate contributed by the two bags is adjusted as below**.** If blood glucose decreases more than 5 mmol/L per hour, contact physician.

More information:

Appendix B: Adding Dextrose to IV Fluids (1-4 Hours after Presentation) Using Dextrose 12.5% Solution

Appendix D: Instructions for preparing Dextrose 10% and Dextrose 12.5% Solution

Table 5. Titration of Dextrose

Hourly Blood Glucose Result (serum/ chemstrip)	**Rate of Bag A** Saline Solution (0.9% NaCl + potassium)	**Rate of Bag B** Dextrose Saline Solution (**D10W -** 0.9% NaCl + potassium)
Greater than 15 mmol/L	Increase Bag A (saline) by 25% of the total hourly fluid rate	Decrease bag B (saline and dextrose) by 25% of the total hourly fluid rate
Less than 10 mmol/L	Decrease Bag A (saline) by 25% of the total hourly fluid rate	Increase bag B (saline and dextrose) by 25% of the total hourly fluid rate
10-15 mmol/L	No changes to rates of Bag A or Bag B	

Appendix D - Instructions for Preparing Dextrose 10% and 12.5% IV Solutions

No dextrose is required until the patient's blood glucose reaches 17 mmol/L or less.

Considerations for selecting IV dextrose concentration:

- Availability of ready-to-administer IV fluids
- Commercially available/ ready-to-administer fluids speed up time to administration
- Using higher dextrose concentration allows for maximizing IV dextrose concentration without requirement of mixing a new solution.

Preparing Dextrose IV Solutions:

- The resulting final dextrose concentrations based on these formulas are approximated. For 500 mL bag, amount of fluid to remove and D50W to add can both be decreased by half.
- For D10W or D12.5W solutions ordered containing potassium, use a commercially available solution that contains potassium as the base solution (e.g. D5W - 0.9% NaCl with 20 or 40 mmEq KCl/L). A base solution without potassium can be used if needed.
- Patients in DKA generally require 40 mEq KCl/L.
- Note: Follow CARNA and local pharmacy regulations regarding preparation of bags requiring 150 ml of the solution removed.

Table 6. Preparing Dextrose 10% and Dextrose 12.5% IV Solutions

Desired/ Final Solution	Base Solution (Start with) 1000mL	Remove	Add
D10W - 0.45% NaCl with 20 mEq KCl/L	D5W - 0.45% NaCl with 20 mEq KCl/L	100 mL	100 mL of D50W
D10W - 0.9% NaCl with 20 mEq KCl/L	D5W - 0.9% NaCl with 20 mEq KCl/L	100 mL	100 mL of D50W
D12.5W - 0.45% NaCl with 20 mEq KCl/L	D5W - 0.45% NaCl with 20 mEq KCl/L	150 mL	150 mL of D50W
D12.5W - 0.9% NaCl with 20 mEq KCl/L	D5W - 0.9% NaCl with 20 mEq KCl/L	150 mL	150 mL of D50W
D10W - 0.45% NaCl with 40 mEq KCl/L	D5W - 0.45% NaCl with 40 mEq KCl/L	100 mL	100 mL of D50W
D10W - 0.9% NaCl with 40 mEq KCl/L	**D5W - 0.9% NaCl with 40 mEq KCl/L**	**100 mL**	**100 mL of D50W**
D12.5W - 0.45% NaCl with 40 mEq KCl/L	D5W - 0.45% NaCl with 40 mEq KCl/L	150 mL	150 mL of D50W
D12.5W - 0.9% NaCl with 40 mEq KCl/L	**D5W - 0.9% NaCl with 40 mEq KCl/L**	**150 mL**	**150 mL of D50W**

Adjust the concentration of dextrose delivered by adjusting the proportions of the bags contributing to the total IV fluid infusion hourly rate. ***Total hourly IV fluid volume remains the same.***
Using "Titration Calculations," maintain blood glucose between 8-15 mmol/L.

Appendix E – Analytics

Baseline Analytics

Outcome Measure 1

Name of Measure	Order set Usage for topic: Diabetic Ketoacidosis Pediatric Emergency Orders for Sites Using D12.5W Solutions
Definition	For all pediatric patients seen in emergency department with DKA, number of times order set is being used. Overall, by region, by sites, and by units
Rationale	Intended to measure if the order set cited in the knowledge topic is being used and what % of time. May indicate areas with adoption issues or gaps in topic
Notes for Interpretation	Site capacity, rural considerations, roll out of provincial CIS

Outcome Measure 2

Name of Measure	Order set Usage for: Diabetic Ketoacidosis Pediatric Emergency Orders for Sites Using D10W Solutions
Definition	For all pediatric patients seen admitted to inpatient units with DKA, number of times order set is being used. Overall, by region, by sites, and by units
Rationale	Intended to measure if the order set cited in the knowledge topic is being used and what % of time. May indicate areas with adoption issues or gaps in topic
Notes for Interpretation	Site capacity, rural considerations, roll out of provincial CIS

Outcome Measure 3

Name of Measure	Order set Usage for topic: Diabetic Ketoacidosis Pediatric Inpatient Orders for Sites Using D12.5W Solutions
Definition	For all pediatric patients admitted to inpatient units with DKA, number of times order set is being used. Overall, by region, by sites, and by units
Rationale	Intended to measure if the order set cited in the knowledge topic is being used and what % of time. May indicate areas with adoption issues or gaps in topic
Notes for Interpretation	Site capacity, rural considerations, roll out of provincial CIS

Outcome Measure 4

Name of Measure	Order set Usage for topic: Diabetic Ketoacidosis Pediatric Inpatient Orders for Sites Using D10W Solutions
Definition	For all pediatric patients admitted to inpatient units with DKA, number of times order set is being used. Overall, by region, by sites, and by units
Rationale	Intended to measure if the order set cited in the knowledge topic is being used and what % of time. May indicate areas with adoption issues or gaps in topic
Notes for Interpretation	Site capacity, rural considerations, roll out of provincial CIS

Outcome Measure 5

Name of Measure	Order set Usage for: Cerebral Edema Pediatric Orders
Definition	For all pediatric patients seen admitted to inpatient units with DKA, number of times order set is being used. Overall, by region, by sites, and by units
Rationale	Intended to measure if the order set cited in the knowledge topic is being used and what % of time. May indicate areas with adoption issues or gaps in topic
Notes for Interpretation	Site capacity, rural considerations, roll out of provincial CIS

Clinical Analytics

Outcome Measure 1

Name of Measure	DKA inpatient length of stay in the emergency department
Definition	Of the total number of patients presenting to the emergency department for DKA management, how many were treated and admitted to hospital or transferred within [time frame – define]
Rationale	Does availability of a provincial DKA clinical guidance tool kit decrease LOS in the emergency department?
Cited References	*See knowledge topic reference list*

Outcome Measure 2

Name of Measure	DKA inpatient repeated presentation to ED
Definition	Of the total number of patients presenting to the ED for DKA management, how many presented to the ED again for DKA management within 2 weeks
Rationale	Does availability of a provincial DKA clinical guidance tool kit decrease re-admissions and resource utilization?
Notes for Interpretation	Variation in complexity of patients, site capacity limitations. As well, access to primary care options (urgent care centers, family physicians, walk-in clinics) in a community vary and can contribute to significant variation in outpatient management and subsequent presentation to the ED, ultimately resulting in inpatient admissions.
Cited References	*See knowledge topic reference list*

Outcome Measure 3

Name of Measure	Number of patients admitted for DKA experiencing hypernatremia
Definition	Of the total number of patients admitted for DKA management, how many patients experienced hypernatremia as evidenced by [lab value – sodium level – define]
Rationale	Corrected sodium should rise with treatment of DKA. Is the usage of 0.9% NaCl for rehydration in DKA as recommended associated with hypernatremia?
Notes for Interpretation	Variation in access to lab information by region or site. Use formula to calculate corrected sodium level based on serum glucose.
Cited References	*See knowledge topic reference list*

Outcome Measure 4

Name of Measure	Number of patients admitted for DKA experiencing hyponatremia
Definition	Of the total number of patients admitted for DKA management, how many patients experienced hyponatremia as evidenced by [lab value – sodium level – defined
Rationale	The corrected sodium should be calculated and followed closely to ensure that DKA is resolving. The corrected sodium should rise with treatment. If corrected sodium is falling, this is a risk factor for cerebral edema.
Notes for Interpretation	Variation in access to lab information by region or site Most patients have pseudohyponatremia at presentation- Use formula to calculate corrected sodium level based on serum glucose.
Cited References	*See knowledge topic reference list*

Outcome Measure 5

Name of Measure	Number of patients admitted for DKA where solutions with 0.45%NS are ordered.
Definition	Of the total number of patients admitted for DKA management, how many patients required a switch from 0.9%NS to 0.45%NS and for those where 0.45% NS are ordered is there evidence of hyperchloridemia?
Rationale	Most DKA patients should not require a a switch from 0.9% NS solutions. Hyperchloremia is one potential reason for such a switch.
Cited References	*See knowledge topic reference list*

Outcome Measure 6

Name of Measure	Number of patients admitted for DKA receiving insulin infusion at a dose of 0.05 units/kg/hour
Definition	For patients admitted for DKA management: a) How many patients, of all patients admitted for DKA management, received an insulin dosage of 0.05 units/kg/hr? b) What is the timing of reduction of insulin infusion to 0.05 u/kg/ hr – how many hours after initial insulin order is initiated does the insulin infusion dose get reduced? c) What is the length of time patients receive the 0.05 unit/kg per dose insulin infusion? d) What is the patient's most recent bicarbonate level lab result result at the time of reduction of insulin infusion?
Rationale	Falling blood glucose should be managed by increasing dextrose infusion rate. Decreasing insulin dosage should not be used to address decreasing blood glucose while the patient still has significant acidosis (except when maximal dextrose infusion rates are ineffective). Insulin infusion rate should only be reduced to 0.05 units/kg/hour when acidosis improves to a blood bicarbonate level of greater than 15 mmol/L[5]
Cited References	*See knowledge topic reference list*

Outcome Measure 7

Name of Measure	DKA inpatient length of stay (LOS)
Definition	Of the total number of patients admitted for DKA management: a) What is the total length of stay of DKA admission? b) LOS while receiving insulin infusion c) LOS after discontinuation of insulin infusion
Rationale	Does availability of a provincial DKA clinical guidance tool kit decrease LOS in inpatient units?
Cited References	*See knowledge topic reference list*

Outcome Measure 8

Name of Measure	DKA inpatient repeated admissions
Definition	Of the total number of patients admitted for DKA management, how many were admitted again for DKA management: A) within 2 weeks (same DKA episode)? B) beyond 2 weeks (new DKA episode)?
Rationale	A) Does availability of a provincial DKA clinical guidance tool kit decrease re-admissions for the same DKA episodes and resource utilization? B) Does chronic diabetes management as outpatient contribute to prevention of DKA re-admissions?
Notes for Interpretation	Variation in complexity of patients, site capacity limitations. As well, access to primary care options (urgent care centers, family physicians, walk-in clinics) in a community vary and can contribute to significant variation in outpatient management and subsequent presentation to the ED, ultimately resulting in inpatient admissions.
Cited References	*See knowledge topic reference list*

Outcome Measure 9

Name of Measure	DKA Severity
Definition	Of the total number of patients admitted for DKA management, how many patients are diagnosed with each of the following levels of severity: Mild Moderate Severe
Rationale	Determine the severity of DKA at presentation as a measure of timely accessing of acute care services for DKA management.
Notes for Interpretation	IV fluid dosing calculations for each patient will be based on assessed severity of mild/moderate (6% dehydration), or severe (9% dehydration)
Cited References	*See knowledge topic reference list*

Outcome Measure 10

Name of Measure	Time to serum bicarbonate greater than 18 mmol/L
Definition	By sub-group based on degree of dehydration at presentation: mild, moderate, severe: Of the total number of patients admitted for DKA management in each of these severity categories, how many patients serum bicarbonate returned to greater than 18 mmol/L: In 12 hours In 24 hours In 36 hours In 48 hours
Rationale	Does availability of guidance tool kit and recommended management decrease length of time required to resolve DKA?
Cited References	*See knowledge topic reference list*

Outcome Measure 11

Name of Measure	Frequency of Hypophosphatemia and use of PO4 containing iv solutions in DKA
Definition	Of the total patients with DKA % with serum PO4 less than 0.4 mmol/L; for those with PO4 less than 0.4 mmol/L; length of time in this range; % receiving PO4 replacement % with an IV solution with NaPO4 ordered; Length of infusion % with an IV solution with KPO4 ordered (not recommended); length of infusion
Rationale	How many patients are receiving PO4 and is the safest solution being used? Is more guideance and support for hypophosphatemia diagnosis and management needed?
Cited References	*See knowledge topic reference list*

Outcome Measure 12

Name of Measure	Diagnosis of Cerebral Edema
Definition	Of the total number of patients admitted for DKA management, how many patients are diagnosed with cerebral edema? by sub-group based on degree of dehydration at presentation: mild, moderate, severe
Rationale	Are the current recommendations effective at decreasing the risk and incidence of cerebral edema?
Cited References	*See knowledge topic reference list*

Documentation Required for Clinical Analytics

- *Diagnosis of mild, moderate or severe DKA*
- *Cerebral edema suspected and factors contributing*
- *Cerebral edema diagnosis and rationale for diagnosis*
- *Rationale for reducing insulin infusion to 0.05 units/kg/hour*
- *Rationale for changing IV fluids from 0.9% NaCl to 0.45% NaCl*
- *Rationale for use of IV phosphate in infusions*

Appendix F - References

1. Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2013 Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada. Can J Diabetes 2013;37(suppl 1):S1-S212.

2. Alberta Health Services. Provincial Clinical Knowledge Topic: Diabetic Ketoacidosis, Adult – Emergency Department. 2016.

3. Klingensmith GJ, Tamborlan WV, Haller MJ, Silverstein J, Cenqiz E, Shanmugham S et al. Diabetic ketoacidosis at diabetes onset: still an all too common threat in youth. J Pediatr. 2013. 162(2):330-4.

4. ISPAD Clinical Practice Consensus Guidelines 2014 Compendium: Diabetic ketoacidosis and hyperglycemic hyperosmolar state. Pediatr Diabetes. 2014. 15(20): 154-179

5. Edge JA, Jakes RW, Hawkins M, Winter D, Ford-Adams ME, Murphy NP et al. The UK case- control study of cerebral oedema complicating diabetic ketoacidosis in children. Diabetologia (2006) 49: 2002-2009. doi:10.1007/s00125-006-0363-8

6. Glaser N. Cerebral injury and cerebral edema in children with diabetic ketoacidosis: could cerebral ischemia and reperfusion injury be involved? *Pediatr Diabetes* 2009;10(8):534-41.

7. Koves IH, Neutze J, Donath S, Lee W, Werther G, Barnett P et al. The Accuracy of Clinical Assessment of Dehydration During Diabetic Ketoacidosis in Childhood. Diabetes Care. 2004. 27(10): 2485-2487

Additional References and General Reading

8. Wolfsdorf J, Glaser N, and Sperling . Consensus Statement: DKA in Infants, Children and Adolescents. Diabetes Care. 2006. 29(5):1150-1159.

9. Deeter KH, Roberts JS, Bradford H, Richards T, Shaw D, Marro K et al. Hypertension despite dehydration during severe pediatric diabetic ketoacidosis. Pediatr Diabetes. 2011: 12: 295–301.

10. BC Children's Hospital. BCCH Diabetic Ketoacidosis Nursing Protocol. March 15, 2016. www.bcchildrens.ca/endocrinology-diabetes-site/documents/dkaprtrn.pdf

Appendix G – Tracking Tool

Figure 1. Sample Diabetic Ketoacidosis Tracking Tool

Month/Day									
Time									
Sample Type (Venous/Cap)									
Na^+									
Na^+ Corrected[1]									
K^+									
Cl^-									
CO_2									
Anion Gap[2]									
pH									
pCO^2									
HCO_3									
BE									
CA^{++}									
Mg^{++}									
Phosphate									
Glucose/Chemstrip									
Urine Ketone									
Urine Output									
Insulin (Units/Kg/hour)									
Insulin IV Rate (mL/hour)									
Dextrose Solution[3]									
NS Solution[4]									
KPhos (mmol/L)									
KCl (mmol/L)									
Fluid IV Rate									
Total IV Rate (ins + IV)									

[1]: corrected Na = measured sodium + (0.3 x [glucose – 6])

[2]: Anion Gap = Na – (Cl_HCO_3)

[3]: D5W, D10W, …

[4]: NS, ½ NS, …

Appendix H – Tables

Table 5. Correlation of Blood and Urine Ketones		
	Urine Ketones	Blood Ketones (B-hydroxybutyrate)
Negative	Less than 0.5 mmol/L	Less than or equal to 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	Greater than or equal to 3.0 mmol / L

Adapted from: BC Childrens Hospital BCCH Diabetic Ketoacidosis Nursing Protocol. March 15, 2016. www.bcchildrens.ca/endocrinology-diabetes-site/documents/dkaprtrn.pdf

Acknowledgements

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Thank you to all clinicians who participated in the colleague review process. Your time spent reviewing the knowledge topics and providing valuable feedback is appreciated.