NETS
Part of the Sydney Children's Hospitals Network

DIABETIC KETOACIDOSIS

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

- Young children requiring rehydration and metabolic correction for DKA are at significant risk of cerebral oedema

CHANGE SUMMARY

- Infusion concentration is now standardised and no longer weight–based. This has been changed to align with the SCHN Practice Guideline
- There are now 2 infusion concentrations: for patients 10 kg and over and for patients under 10 kg

READ ACKNOWLEDGEMENT

- All NETS clinical staff are to read and acknowledge they understand the contents of this guideline.

Approved by:	SCHN Policy, Procedure and Guideline Committee	
Date Effective:	1st February 2019	**Review Period**: 3 years
Team Leader:	Deputy Director	**Area/Dept**: NETS

Rationale

- To initiate the process of correcting dehydration, metabolic derangements and electrolyte imbalance

Principles of Retrieval Management

- Assess and manage life-threatening airway, breathing and circulation deficits
- Assess level of consciousness (GCS) and then 15 minutely during transfer
- Assess level of dehydration (Appendix 1) – conservative estimate recommended
- Consider need for oxygen e.g. if altered level of consciousness (if necessary 6-10L/min via Hudson mask)
- Check blood glucose if more than 15 minutes since last check and at least hourly thereafter
- Commence rehydration (see fluids and electrolytes) avoiding rapid rehydration
- Commence insulin infusion, if required (see insulin therapy). Do not reduce or cease the insulin infusion if glucose is falling <15mmol/L – instead increase the glucose concentration
- Collect venous blood gas for measurement of pH, electrolytes, and osmolality 2 hourly during retrieval
- Record all blood sampling results on observation chart
- Measure urine output and maintain strict fluid balance
- Consider an indwelling urinary catheter (IDC) (indications include pH < 7, excessive urinary output and transport)
- Check urinalysis results for ketones and glucose
- NBM, except ice to suck until metabolically stable i.e. pH > 7.30, HCO_3 > 15

Management (for detailed management, see Appendix 2)

Fluids

- ***Cerebral oedema is the major cause of death in childhood DKA***
- During the initial fluid resuscitation a high glucose may drop 10-15mmol/L, even without insulin infusion
- Headache, irritability, decreased consciousness, unstable body temperature, bradycardia and hypertension may indicate raised ICP – this is a medical emergency requiring urgent ICU advice and management – conference with referral/destination consultant immediately if this is detected

- Treat shock with bolus 10mL/kg of 0.9% Sodium Chloride. If shock persists, a further 10mL/kg may be required**. Avoid repeated fluid boluses as this may increase the risk of cerebral oedema. Use fluid boluses judiciously – seek specialist advice if further boluses are indicated. Do not use potassium containing fluids in boluses.**
- Excessively rapid fluid administration may lead to cerebral oedema, therefore rehydration occurs slowly over days. Consider reducing rehydration rate if more than 20 mL/kg boluses were administered
- IV fluids = maintenance + rehydration
- Rehydrate over 48 hours: (weight x % (as a number) dehydration x 10) / 48 hour = hourly rate

  e.g. A 12kg infant with 5% dehydration = (12 x 5 x 10) / 48 = 12.5 mL/hour (rehydration) **+ 44 mL/hr** (maintenance)
- Commence rehydration with 0.9% Sodium Chloride or if BSL less than or rapidly approaching 15mmol/L rehydrate with 0.9% Sodium Chloride + 5% Glucose (+/- potassium)

Electrolytes

- Measured serum sodium is an unreliable measure when the blood glucose level is elevated
- Corrected (actual) Na = Measured Na + 0.3 (glucose – 5.5)
- If measured sodium falls, a slower rate of fluid administration may be required and the referral/destination endocrinologist/intensivist should be informed
- Add Potassium when serum potassium level is known to be < 5mmol/L or the patient has passed urine. This is to prevent hypokalaemia induced by insulin, reversal of acidosis and the depletion of potassium in the urine caused by osmotic diuresis (as acidosis corrects the potassium moves into the cells and the serum potassium falls reflecting loss of total body potassium)
- In management of DKA, initial potassium requirement is 4-5 mmol/kg/day. This may vary along the course of DKA management. Potassium infusion rates of >0.25mmol/kg/hr or >10 mmol/hr require cardiac monitoring. Maximum infusion rate should not exceed 0.5 mmol/kg/hr or 20 mmol/hr without consultation with intensivist
- Potassium is usually supplemented with potassium chloride, but potassium dihydrogen phosphate may be recommended if the patient is hypophosphataemic (<1 mmol/L) or hyperchloraemic
- Change from 0.9% Sodium Chloride to 0.9% sodium chloride + 5% Glucose when BSL < 15mmol/L

Insulin Therapy

- Soluble insulin is the only form of insulin that can be given IV e.g. Actrapid, Humulin R, Novorapid, Humalog

- **Dilution: Patient >10kg**

  Add 50 units of insulin (Actrapid or Humulin R) to a 50 mL syringe containing 49.5 mL 0.9% sodium chloride (so that concentration is 1 unit/mL)

- **Dilution: Patient <10kg**

  Add 25 units of insulin (Actrapid or Humulin R) to a 50 mL syringe containing 49.75 mL 0.9% sodium chloride (so that concentration is 0.5 unit/mL)

  Example: 15kg child to receive 0.1 units/kg/hr of insulin infusion

  0.1 units x 15kg = 1.5 units/hour

  Have 50 units in 50mL (1mL/hr = 1 unit/hr) so run infusion at 1.5 mL/hour

Starting dose:

0.05 – 0.1 U/kg/hr ***or as otherwise advised by referral/destination endocrinologist***.

- Insulin is only commenced 1 hour after commencing rehydration fluids
- Insulin should not be given until the results of a formal blood glucose level and a venous acid base have been obtained. If 'formal' analysis not available, check with endocrinologist/intensivist
- Route: Insulin is given as a sideline infusion to maintenance/ rehydration fluid via a continuous infusion pump (in the event of IV extravasation the insulin and fluids will cease at the same time)
- Following initial drop in BGL as a result of fluid resuscitation, aim at reducing the BGL by approximately 4mmol/L per hour
- When BGL falls to or is rapidly approaching 15 mmol/L, change IV fluids to 0.9% NaCl + 5% Glucose (+/- potassium).
- If BGL < 8mmol/L, maintain BGL 8-10mmol/L by adding glucose. This can be done in 2 ways:
  - increase the glucose concentration of the maintenance/ rehydration IV fluids as advised
  - Run two IV fluid lines, with the same sodium and potassium content, but with different glucose concentrations to allow titration of glucose delivery depending on BGL.

- ***Generally, do not stop insulin or reduce it below starting dose, as a continuous supply of insulin is needed to prevent ketosis and prevent ongoing catabolism***.

Blood Sampling

- Repeat BGL 30 minutely for first 4 hours after starting insulin infusion, then hourly
- VBG, electrolytes and osmolality should be repeated after initial IV fluids and insulin infusion started and then repeated second hourly. Between presentation to calling NETS, to team's first look, this can easily slip behind schedule. Monitor anion gap and corrected sodium second hourly
- Site a second IV cannula for sampling *

General Information

- Intubation is rarely necessary and should be discussed with the intensivist
- Kussmaul breathing is a consequence of metabolic acidosis due to the accumulation of ketoacids
- If there are signs of raised intracranial pressure, consult with intensivist & endocrinologist
- ECG monitoring is helpful to assess for evidence of hypokalaemia (depressed T waves and a prolonged QT interval) and hyperkalaemia (raised T waves)
- If the patient is hyperkalaemic, anuric or oliguric, do not start potassium. Serum potassium levels usually fall within an hour of insulin therapy commencing
- Monitor fluid balance and clinical state of hydration carefully. Intravenous fluid infusion rate may need to be altered according to urine output
- If, after fluid resuscitation, corrected serum sodium is above 150, consider slowing rate of rehydration after discussion with intensivist or endocrinologist
- Treat underlying cause e.g. sepsis (rarely present)
- Oxygen via a Hudson mask will provide maximum tissue oxygenation to help reverse lactic acidosis and should be administered in the presence of altered consciousness
- Altered consciousness suggests cerebral oedema and may require more aggressive management – consult with receiving intensivist/NETS consultant.
- NBM and/or ice to suck only as may have an ileus caused by acidosis
- NG tube to prevent aspiration if the patient is vomiting and consciousness is impaired
- An IDC is desirable. Measure urine output hourly to provide an accurate fluid balance

Documentation

- History
- Fluid balance
- Pathology results
- Cardiorespiratory monitoring
- Neurological status

Complications (see Appendix 3)

- Cerebral oedema; 4–12 hours into treatment
- Hypokalaemia
- Hypoglycaemia
- Hypophosphataemia
- Acute renal failure
- Pulmonary oedema
- Microvascular thrombosis

- Cardiac dysrhythmias
- Cardiac arrest
- Death

References

1. Wolfsdorf JI et al. A Consensus Statement from the International Society for Pediatric and Adolescent Diabetes: Diabetic ketoacidosis and hyperglycemic hyperosmolar state. Pediatric Diabetes 2014: 15 (Suppl. 20): 154–179.
2. The Sydney Children's Hospital Network Diabetic Ketoacidosis (DKA) Practice Guideline May, 2018

Appendix 1- Assessment of Dehydration

Recent weight loss of ≥ 10% correlates with severe dehydration

Signs & Symptoms	Mild 3%	Moderate 5%	Severe 10%
Behaviours	Restless, thirsty, alert	Restless, thirsty, lethargic	Drowsy, limp, cold and sweaty
Blood pressure	Normal	Normal	+/- Hypotensive
Skin turgor	Skin readily retracts when pinched	Skin retracts slowly when pinched	'Tenting' of the skin Sunken eyes
Mucous Membranes	Moist, slightly dry	Dry	Dry/no tears
Fontanelle	Normotensive	Sunken	Very sunken
Urine	Normal to decreased	Decreased	Decreased

Appendix 2 - SCHN Algorithm for the Management of DKA

IMMEDIATE ASSESSMENT

Clinical History
Polyuria
Polydipsia
Weight loss *(weigh patient)*
Abdominal pain
Tiredness
Vomiting
Confusion

Clinical Signs
Assess hydration
Deep sighing respiration (Kussmaul)
Smell of ketones
Lethargy/drowsiness ± vomiting

Biochemical features & Investigations
Ketones in urine (or blood ketone meter)
Elevated blood glucose
Acidemia
Pathology tests: UEC, BGL; VBG; CMP; Osmolality
Other investigations as indicated
Antibodies (Insulin, GAD & IA-2), Coeliac screen, TSH and thyroid antibodies,

Diagnosis Confirmed
DIABETIC KETOACIDOSIS
Contact Endocrinology Team on-call

Severe (≥8%) Dehydration
Shock (reduced peripheral pulses, tachycardia, delayed CR)
Reduced conscious level

Moderate (5-7%) Dehydration
but not in shock
Clinically acidotic (hyperventilation)
Vomiting

Mild (3%) Dehydration and mild acidosis [pH 7.25 to 7.3]
Clinically well
Tolerating fluids orally

Resuscitation
Airway ± NG tube
Breathing (100% Oxygen)
Circulation
Disability
Exposure
Fluids:
- 0.9% sodium chloride 10mL/kg as a bolus then reassess and repeat if signs of shock are not reversed.
- If severely dehydrated but not overt shock, give 10mL/kg 0.9% sodium chloride over 1 hour.
- Generally do not exceed 30mL/kg.
- Reassess hydration status and continue fluids for the current hydration status (post bolus).

IV Therapy
Calculate fluid requirements:
Correct over 48 hours
0.9% sodium chloride
ECG for abnormal T-waves
Add potassium 40mmol/L once urine output confirmed

Therapy
Start with subcut insulin
Continue oral hydration

No improvement

Delay starting insulin until 1 hour of fluid administration has been given.
Check glucose prior to starting insulin
Commence at 0.05-0.1unit/kg/hour

Critical Observations
Hourly blood glucose level by bedside meter
Hourly fluid input & output
Neurological status at least hourly
UEC, VBG, glucose, osmolality (2nd hourly)
Monitor ECG for T-wave changes

Acidosis NOT improving

Re-evaluate
IV fluid calculations
Insulin delivery systems & dose
Need for additional resuscitation
Consider sepsis

Blood glucose ≤ 15mmol/L or falling >5mmol/L/hr after the initial fall associated with the first 1-2 hours of fluid therapy

IV Therapy
Change to IV fluids containing 5% glucose (either 0.9% or 0.45% sodium chloride or Plasma-Lyte 148 depending on corrected sodium and rate of change of this).
Maintain BGL >5mmol/L

Improvement
Clinically well, tolerating oral fluids

Transition to subcut Insulin
Start subcut insulin **then** stop IV insulin after an appropriate interval

Neurological
WARNING SIGNS: headache, slowing heart rate, irritability, decreased conscious level, incontinence, specific neurological signs

Exclude Hypoglycaemia

Is it Cerebral Oedema?

Management
Manage ABCDEF
Urgent consultation with ICU regarding management & in anticipation transfer to ICU
Consider Mannitol 0.5 – 1.0 g/kg or 3% sodium chloride [3-5 mL/kg]
Consider CT brain - **only** after patient stabilised

Algorithm for the Management of diabetic ketoacidosis. Adapted from ISPAD Clinical Practice Consensus Guidelines 2014 Compendium[1]

Appendix 3 - Complications of DKA

Cerebral oedema	*Hypokalaemia*	*Thrombosis*	*Hyperglycaemic Hyperosmolar State [HHS] and mixed HHS DKA*
Usually occurs in the first 24 hour after therapy is started. Usually presents with decreased consciousness, headache and signs of raised intracranial pressure, but there may be minimal symptoms until sudden collapse. May become life-threatening due to brain herniation. Water molecules leave the cells in a hyperosmolar state, but brain cells are protected from shrinkage by an active process that generates osmoprotective molecules (including the amino acids taurine and glutamate). If the serum tonicity is lowered too rapidly, the brain cells remain hypertonic and a disproportionate amount of water enters them. This is the rationale for slow correction of dehydration and hyperglycaemia in DKA. **Risk factors** for cerebral oedema: - severe acidosis and dehydration - extended history of poor control (presumed increase in osmoprotective adaptation) - young age - hypernatraemia, hyponatraemia, or falling serum sodium during therapy - excessive fluid replacement Despite these known risk factors, cerebral oedema may occur unpredictably	Total body deficit of potassium is present before initiation of therapy, irrespective of plasma concentration Potassium moves into cells as the acidosis is corrected with insulin administration	There is an increased thrombotic tendency. Prophylactic low dose heparin is not routinely recommended, but should be considered and discussed with intensivists for patients who have additional risk factors for thrombosis e.g. central venous catheter, young age, severe dehydration or coexisting HHS.	**Criteria for the diagnosis of HHS are**: - Plasma glucose greater than 33mmol/L - pH greater than 7.3 - Serum bicarbonate greater than 15mmol/L - Absent or mild ketonaemia - Calculated serum osmolality greater than 320mOsm/kg: [(2 x corrected plasma sodium) + plasma glucose] - Altered consciousness or seizures When the patient meets criteria for DKA with acidosis and ketosis, and the calculated serum osmolality greater than 320mOsm/kg then “mixed HHS DKA” is present. DKA treatment should be modified after discussion with Intensive Care Consultant and Endocrinologist on-call. (see Step 5: ongoing management)