Management of Diabetic Ketoacidosis

1.Purpose of the Policy	To guide the management of patients admitted to DCCM with a diagnosis of diabetic ketoacidosis (DKA).
2.Responsibility	All DCCM medical and nursing staff
3.Guideline management – Principles and Goals	This guideline outlines the resuscitation and treatment of patients with DKA to manage their: • Fluid deficit • Acidosis and ketonaemia • Electrolyte abnormalities • Hyperglycaemia • Identify the precipitating cause of the DKA. DKA usually occurs in type I diabetes. In type II diabetes it may be the initial presentation or secondary to severe stress e.g. sepsis, myocardial infarction. A lack of insulin leads to an increase in the counter regulatory hormones – glucagon, cortisol, growth hormone and catecholamines. These cause gluconeogenesis and glycogenolysis, which increase blood glucose levels. Hyperglycaemia causes an osmotic diuresis with fluid and electrolyte losses in the urine. Lipolysis driven by the counter regulatory hormones, increases the amount of free fatty acids which are converted to ketone bodies which cause a high anion gap metabolic acidosis and electrolyte shifts. Blood glucose is just a surrogate for the underlying metabolic abnormality which is an increase in serum ketones. Hence the treatment goal is to decrease serum ketones.
4. Diagnostic criteria	DKA is defined as: BSL > 11 mmol/L Serum/Urine ketones positive pH < 7.30 HCO_3^- < 15.0 mmol/L DCCM referral is recommended patients with or one or more of the following after initial treatment: Age < 18 Pregnant Significant comorbidities e.g. renal failure

	Biochemical: Ketones >6.0 mmol/l (Beta-hydroxy butyrate) HCO_3^- < 5 mmol/l pH <7.0 Vital signs: GCS ≤ 12 SpO_2 ≤ 92% on air Trajectory after 4 hours treatment: Clinical deterioration Failure to increase ph and decrease ketones with appropriate treatment.
5. Inclusion Criteria	All patients with DKA and hyperosmolar hyperglycaemic syndrome (HHS)
6. Exclusion Criteria	Patients with starvation or alcoholic ketoacidosis or lactic acidosis
7. Process of treatment	Assess ABC. Consider the precipitating cause. All patients should have an arterial line. Consider a central line if ongoing IV potassium replacement is needed. Take initial bloods, then ABG 2 hourly and ketones measured with meter 2 hourly. Check beta-hydroxy butyrate levels in the laboratory 12 hourly.
8. Fluid administration and deficits:	Deficits: 70 kg adult will have up to 7 L deficit Water 100 ml/kg Na^+ 7 – 10 mmol/kg (correct serum Na^+ for blood glucose) Corrected Na^+ = measured Na^+ plus glucose/3 e.g. corrected Na^+ = 135 +27/3 = 144mmol/L Cl^- 3 – 5 mmol/kg K^+ 3 – 5 mmol/kg
9. Treatment	Consider fluid given in ED. If Systolic < 90mmHg 1000ml Plasmalyte stat Repeat if systolic still <90mmHg If systolic >90mmHg 1000ml stat as above (consider fluid given in ED) Hour 1 1000ml plasmalyte Hour 2 1000ml plasmalyte Hour 3 500ml plasmalyte Hour 4 500ml plasmalyte

If the BSL ≤ 14
Continue resuscitation fluid if required
Add 10% dextrose at 125 ml/hour to support BSL until ketones <0.6 mmol/l

Insulin:
K^+ must be >3.5 mmol/l before starting insulin.
Start at 0.1 units/kg/hr of actual body weight. Do not give a bolus.

Aim is to decrease BSL by 3 mmol/hour once patient resuscitated. Initial IV fluid boluses can decrease the BSL quickly.

If BSL not decreasing by 3 mmol/hr increase insulin by 1 unit/hr.

If BSL decreasing by more than 3 mmol/hr, there are 2 possible treatments:

- If ketones are high and not decreasing by 0.5 mmol/hr, keep insulin infusion constant and add 10% dextrose if BSL ≤ 14 mmol/l.
- If ketones are decreasing by ≥ 0.5mmol/hr, then decrease insulin to 0.05 units/kg/hr
  Support BSL with 10% dextrose if BSL ≤ 14 mmol/l.

Long acting insulin:

If the patient already takes long acting insulin, give the usual dose at the usual time subcutaneously.
If the patient is a newly diagnosed diabetic:

- When DKA is resolved give Lantus 0.25units/kg once daily subcut as part of the ward subcut regime.

Electrolytes:
Potassium – K^+ < 3.5 mmol/l
Give 20 mmol KCl/hr until K^+ >3.5mmol/l
Give this as well as Plasmalyte

- K^+ 3.5 – 4.5mmol/l.
  Give 10 mmol KCl/hr + IV fluids

- K^+ >5.0 withhold K+ replacement

	Magnesium- Keep in normal range Add 10 mmol $MgS0_4$/hr once and recheck Phosphate – is often low. There is no benefit in replacing phosphate unless the patient is symptomatic e.g. respiratory or skeletal muscle weakness. If phosphate is given, check for hypocalcaemia. Sodium – Use corrected sodium (Corrected Na^+=measured sodium+glucose/3). If hyponatraemia develops and they are receiving IV glucose, consider increasing to 50% glucose.
10. Metabolic treatment targets	Ketones – decrease by 0.5 mmol/hr Bicarbonate – increase by 3.0 mmol/hr Glucose – reduce by 3.0 mmol/hr Potassium – maintain 4 – 5.5 mmol/l
11. Resolution of DKA	Ketones < 0.6 mmol/l ph > 7.3 HCO_3^- > 18 mmol/l BSL < 11 mmol/L Eat and drink as desired. Convert to subcut insulin not sliding scale (See appendix). Refer to Gen Med/ diabetes nurse.
12. Complications	• Cerebral oedema: Symptomatic cerebral oedema is uncommon in adults. It is more common in children under the age of 12 who are severely acidotic. • Hyperchloremic metabolic acidosis is common when 0.9% NaCl is used as a resuscitation fluid. It is characterised by : - Cl^- ≥ 110 mmol/l - HCO_3^- ≤ 20 mmol/l - Anion gap- low/normal • HCO_3^- is rarely required. May be considered if Ph is persistently less than 6.9
13. Restarting usual insulin when DKA is resolved.	<u>Patients usually on insulin</u>: Restart their usual insulin. Overlap usual insulin and insulin infusion

	• If patient on basal bolus regime, give usual fast acting insulin with meal, stop IV insulin infusion and IV fluids 30 – 60 minutes later. • If patient on fixed-mix insulin, then give usual dose with a meal and stop IV insulin infusion after 30 – 60 minutes. • Give usual long acting insulin at usual time and dose if not already given. <u>Insulin naive patients</u>: Estimate total daily dose (TDD). TDD = Patient weight x 0.5 units e.g. 70 kgs x 0.5 units = 35 units/day give half as long acting insulin with evening meal divide the remainder into 3 give as rapid acting insulin before meals e.g. TDD 35 units give 17 units Lantus with evening meal and 6 units Novorapid before meals.
14.Transfer to ward.	All patients MUST have an insulin prescription before going to the ward. This can be either an insulin infusion, or a GIK infusion at a rate agreed to by the accepting team or subcut insulin charted by DCCM or the accepting team.
15.HHS	<u>Hyperosmolar Hyperglycaemic Syndrome (HHS)</u> HHS and DKA are the two opposite extremes of the hyperglycaemia, hperosmolarity and ketosis spectrum. HHS is evaluated and treated the same as DKA. Important differences are that HHS has more severe hypovolaemia and hyperosmolality; the patients are older, have more comorbidities and are often obtunded on presentation. The treatment goals are rehydration, slow reduction of hyperglycaemia and hyperosmolarity over days.

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<td>15. Other forms of acidosis</td>
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<tr><th>SEVERE DKA</th><th>HHS</th></tr>
<tr><td>Onset : < 24 hours</td><td>2 – 3 days</td></tr>
<tr><td>Clinical: Type I
New onset type II
Type II & Stress
ph < 7.0
Glucose < 45 mmol/L
Osmolality variable
Ketones > 8.0 mmol/L
Hypovolaemia – moderate
Rarely obtunded unless ph <7.0
Osmolality > 320 mosmol/L.</td><td>Type II
Older

ph > 7.3
Glucose > 45 mmol/L
Osmolality > 320 mosmol/L
Ketones < 1.0 mmol/L
Hypovolaemia – Severe

Obtunded (pl osm >320 mosmol/L)</td></tr>
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<u>Differential Diagnosis of Acidosis, ketosis and altered level of Consciousness</u>
1. Alcoholic ketoacidosis: ketoacidosis with normal blood glucose and HbA1C in a patient with known chronic alcohol use.
2. Starvation ketoacidosis: ketoacidosis with normal glucose and HbA1C- low carbohydrate diet/anorexia
3. Lactic acidosis
4. Metabolic encephalopathy.
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<td>16. Disclaimer</td>
<td>No document can cover all variations required for specific circumstances. It is the responsibility of the health-care practitioners using this ADHB document to adapt it for safe use within their own institution, recognise the need for specialist help and call for it without delay, when an individual patient falls outside of the boundaries of this document.</td>
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DKA PROTOCOL

Diagnosis : BSL > 11 mmol/L; Serum/urine ketones positive; Venous pH < 7.30; HCO3 < 15.0 mmol/L

INSULIN	ASSESS HYDRATION STATUS	ELECTROLYTES
Check K^+ > 3.5 mmol/L **INSULIN INFUSION** Start at 0.1 units/kg/hr (Flip over to see a chart as a guide) **AIM**: To reduce BSL by 3 mmol/hr. If not, increase insulin infusion by 1 unit/hour until BSL starts to decrease by 3 mmol/hr. If BSL decreases > 6 mmol/hr, reduce infusion to 0.05 units/kg/hr. **TARGET**: TO KEEP BSL 8-10 mmol/L until Ketones < 0.6 mmol/L When BSL ≤ 14 mmol/L, reduce the infusion rate to 0.05 – 0.1 units/kg/hr. DO NOT DROP INSULIN INFUSION less than 3 units/hr. If required increase glucose intake to maintain BSL 6 – 10 mmol/L until serum ketones are < 0.6 mmol/hr. **LANTUS:** Give usual dose of regular Long acting insulin NOCTE, if not given in the last 24 hours.	**IF SYSTOLIC < 90 MM OF Hg**, take age, cormorbidities, concomitant medications into account. Give a litre of Plasmalyte over 15 mins. (Hydration needs to be titrated as per each patient's requirement) **If Systolic > 90mm of Hg.** HOUR 1: 1000 ml plasmalyte HOUR 2: 1000 ml plasmalyte HOUR 3: 500 ml of plasmalyte HOUR 4: 500 ml of plasmalyte WHEN BSL< 14 mmol/L change fluids to 10% dextrose 125 ml/hr. ***If pH < 7.10***: 1000 ml of plasmalyte/hr, for first 4 hours is recommended. Check serum lactate. Re-evaluate for hypovolaemia.	**POTASSIUM** ***K^+ < 3.5 mmol/L*** Give 20 mmol/h of KCl until K^+> 3.5 mmol/L along with plasmalyte, then start Insulin infusion. ***K^+ > 3.5 – 4.5 mmol/L*** Give 10 mmol of KCl/hr, along with the intravenous fluids. ***K^+ > 5.0 mmol/L*** Withhold potassium replacement. A litre of Plasmalyte contains 5 mmol K^+ Keep Mg in its normal range. Phosphate: no benefit in replacement of phosphate unless patient is symptomatic. Give **DVT** Prophylaxis early**.**

DKA PROTOCOL

Initial Tests: FBC/Coags/ Extended Biochemistry/VBG/BSL/Serum Ketones/lab beta-Hydroxybutyrate/Blood Cultures/ Urinalysis & Culture/ ECG.
Ongoing blood tests: 2 hourly ABG's and fingerprick ketones.

A table has been compiled to assist calculation of the insulin dose for weight:

Weight in kg	Insulin dose/hr
<50	Review
50 - 59	5 Units
60 - 69	6 Units
70 - 79	7 Units
80 – 89	8 Units
90 - 99	9 Units
100 - 109	10 Units
110 - 119	11 Units
120-129	12 Units
>150	15 Units

HYDRATION

An adult weighing 70 kg may have up to 7 litres in deficit.

Typical deficit may be:

Water: 100 ml/kg

Na^+: 7 – 10 mmol/kg

(Corrected Na^+: (glucose/3)+ Na^+)

Chloride: 3-5 mmol/kg

Potassium: 3 – 5 mmol/kg

In patients with renal or cardiac failure, as well as elderly and adolescents, the rate and volume of fluid replacement may need to be modified.

METABOLIC TREATMENT TARGETS

Recommended targets:

- Reduction of serum Ketones by 0.5 mmol/hr
- Increase the venous bicarbonate by 3.0 mmol/l/hr
- Reduction in capillary blood glucose by 3.0 mmol/hr
- Maintain Potassium between 4.0 and 5.5 mmol/hr

Resolution of DKA is defined as
Ketones less than 0.6 mmol/l
Venous pH > 7.3
BSL < 11 mmol/L
HCO_3 > 18 mmol/l

Supporting evidence:

Joint British Diabetes Societies Inpatient Care Group:
The management of diabetic ketoacidosis in adults
2nd edition: Update Sept 2013