

The Management of Diabetic Ketoacidosis in Adults

For young people under the age of 18 years use the Trafford Care of Children with DKA protocol on Trafford Diabetes Website

Diagnostic criteria: all three of the following must be present

- Capillary blood glucose above 11 mmol/L
- Capillary ketones above 3 mmol/L or urine ketones ++ or more
- Venous pH less than 7.3 and/or bicarbonate less than 15 mmol/L

<p>BOX 1: Immediate management: time 0 to 60 minutes</p> <p>(T=0 at time intravenous fluids are commenced) If intravenous access cannot be obtained request critical care support immediately</p> <p>Action 1: Commence 0.9% sodium chloride solution (use large bore cannula) via infusion pump. See Box 2 for rate of fluid replacement</p> <p>Action 2: Commence a fixed rate intravenous insulin infusion (IVII) (0.1 unit/kg/hr based on estimate of weight) 50 units human soluble insulin (Actrapid or Humulin S) made up to 50ml with 0.9% sodium chloride solution. If patient normally takes long acting insulin analogue (Lantus, Levemir) continue at usual dose and time</p> <p>Action 3: Assess patient</p> <ul style="list-style-type: none"> ○ Respiratory rate, temperature, blood pressure, pulse, oxygen saturation ○ Glasgow Coma Scale ○ Full clinical examination 	<p>Action 4: Further investigations</p> <ul style="list-style-type: none"> • Capillary and laboratory glucose • Venous BG • U & E • FBC • Blood cultures • ECG • CXR • MSU <p>Action 5: Establish monitoring regimen</p> <ul style="list-style-type: none"> • Hourly capillary blood glucose • Hourly urine ketone measurement • Venous bicarbonate and potassium at 60 minutes, 2 hours and 2 hourly thereafter <ul style="list-style-type: none"> • 4 hourly plasma electrolytes • Continuous cardiac monitoring if required • Continuous pulse oximetry if required <p>Action 6: Consider and precipitating causes and treat appropriately</p>
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<p>HDU/level 2 facility and/or insertion of central line may be required in following circumstances (request urgent senior review)</p>	
<ul style="list-style-type: none"> • Young people aged 18-25 years • Elderly • Pregnant • Heart or kidney failure • Other serious co-morbidities • Severe DKA by following criteria <ul style="list-style-type: none"> ○ Blood ketones above 6 mmol/L ○ Venous bicarbonate below 5 mmol/L 	<ul style="list-style-type: none"> • Venous pH below 7.1 • Hypokalaemia on admission (below 3.5 mmol/L) • GCS less than 12 • Oxygen saturation below 92% on air (Arterial blood gases required) • Systolic BP below 90 mmHg • Pulse over 100 or below 60bpm • Anion gap above 16 [Anion Gap = (Na⁺ + K⁺) – (Cl⁻ + HCO₃⁻)]



<p>BOX 2: Initial fluid replacement</p>	
<p>Restoration of circulating volume is priority</p>	
<p>Systolic BP (SBP) below 90 mmHg Likely to be due to low circulating volume, but consider other causes such as heart failure, sepsis, etc.</p>	
<ul style="list-style-type: none"> • Give 500ml of 0.9% sodium chloride solution over 10-15 minutes. If SBP remains below 90 mmHg repeat whilst requesting senior input. Most patients require between 500 to 1000ml given rapidly. • Consider involving the ITU/Critical Care Team. • Once SBP above 90 mmHg give 1000ml 0.9% sodium chloride over next 60 minutes. Addition of potassium likely to be required in this second litre of fluid. 	
<p>Systolic BP on admission 90 mmHg and over</p> <ul style="list-style-type: none"> • Give 1000ml 0.9% sodium chloride over first 60 minutes 	
<p>Potassium replacement:</p> <p>Potassium level (mmol/L)</p> <p>>5.5</p> <p>3.5 – 5.5</p> <p><3.5</p>	<p>Potassium replacement mmol/L of infusion solution</p> <p>Nil</p> <p>40 mmol/L</p> <p>senior review – additional potassium required</p>



BOX 3: 60 minutes to 6 hours

Aims of treatment:

- Rate of fall of ketones of at least 0.5 mmol/L/hr OR bicarbonate rise 3 mmol/L/hr and blood glucose fall 3 mmol/L/hr
- Maintain serum potassium in normal range
- Avoid hypoglycaemia

Action 1: Re-assess patient, monitor vital signs

- Hourly blood glucose (lab blood glucose if meter reading 'HI')
- Hourly blood ketones if meter available
- Hourly ketone urine measurement
- Venous blood gas for pH, bicarbonate and potassium at 60 minutes, 2 hours and 2 hourly thereafter
- If potassium is outside normal range, re-assess potassium replacement and check hourly, if abnormal after further hour seek immediate senior medical advice

Action 2: Continue fluid replacement via infusion pump as follows:

- 0.9% sodium chloride 1L with potassium chloride over next 2 hours
- 0.9% sodium chloride 1L with potassium chloride over next 2 hours
- 0.9% sodium chloride 1L with potassium chloride over next 4 hours
- Add 10% glucose 125ml/hr if blood glucose falls below 14 mmol/L

More cautious fluid replacement in young people aged 18-25 years, elderly, pregnant, heart or renal failure. (Consider HDU and/or central line)

Action 3: Assess response to treatment

Insulin infusion rate may need review if

- Capillary ketones not falling by at least 0.5 mmol/L/hr
- Venous bicarbonate not rising by at least 3 mmol/L/hr
- Plasma glucose not falling by at least 3 mmol/L/hr
- Continue fixed rate IVII until ketones less than 0.3 mmol/L, venous pH over 7.3 and/or venous bicarbonate over 18 mmol/L

If ketones and glucose are not falling as expected always check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction)
If equipment working but response to treatment inadequate, increase insulin infusion rate by 1 unit/hr increments hourly until targets achieved

Additional measures

- Regular observations and Early Warning Score (EWS)
- Accurate fluid balance chart, minimum urine output 0.5ml/kg/hr
- Consider urinary catheterisation if incontinent or anuric (not passed urine by 60 minutes)
- Nasogastric tube with airway protection if patient obtunded or persistently vomiting
- Measure arterial blood gases and repeat chest radiograph if oxygen saturation less than 92%
- Thromboprophylaxis with low molecular weight heparin
- Consider ECG monitoring if potassium abnormal or concerns about cardiac status

BOX 4: 6 to 12 hours

Aims:

- Ensure clinical and biochemical parameters improving
- Continue iv fluid replacement
- Avoid hypoglycaemia
- Assess for complications of treatment e.g. fluid overload, cerebral oedema
- Treat precipitating factors as necessary

Action 1: Re-assess patient, monitor vital signs

- If patient not improving by criteria in Box 3 seek senior advice
- Continue iv fluid via infusion pump at reduced rate
 - 0.9% sodium chloride 1L with potassium chloride over 4 hours
 - 0.9% sodium chloride 1L with potassium chloride over 6 hours
- Add 10% glucose 125ml/hr when blood glucose falls below 14 mmol/L

Reassess cardiovascular status at 12 hours; further fluid may be required

Check for fluid overload

Action 2: Review biochemical and metabolic parameters

- At 6 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose
- Resolution is defined as ketones less than 0.3 mmol/L, venous pH over 7.3 (do not use bicarbonate as a surrogate at this stage)
- Ensure referral has been made to diabetes team

**If DKA not resolved review insulin infusion (see BOX 3 Action 3)
If DKA resolved go to BOX 6**

BOX 5: 12 to 24 hours

Expectation: By 24 hours the ketonaemia and acidosis should have resolved. Request senior review if not improving

Aim:

- Ensure that clinical and biochemical parameters are continuing to improve or are normal
- Continue iv fluid replacement if not eating and drinking
- If ketonaemia cleared and patient is not eating and drinking move to a variable rate insulin infusion (VRII) as per local guidelines
- Re-assess for complications of treatment e.g. fluid overload, cerebral oedema
- Continue to treat precipitating factors
- Transfer to subcutaneous insulin if patient is eating and drinking normally

Action 1 – Re-assess patient, monitor vital signs

Action 2 – Review biochemical and metabolic parameters

- At 12 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose
- Resolution is defined as ketones <0.3 mmol/L, venous pH >7.3
- If not resolved review fluid **Box 4 Action 1** and insulin infusion **Box 3 Action 3**

If DKA resolved go to Box 6

BOX 6: Resolution of DKA

Expectation: Patient should be eating and drinking and back on normal insulin

If DKA not resolved identify and treat the reasons for failure to respond

This situation is unusual and requires senior and specialist input

Transfer to subcutaneous insulin

Convert to subcutaneous regime when biochemically stable (capillary ketones less than 0.3 mmol/L, pH over 7.3) and the patient is ready and able to eat.

Do not discontinue intravenous insulin infusion until 30 minutes after subcutaneous short acting insulin has been given

Conversion to subcutaneous insulin should be managed by the Specialist Diabetes Team. If the team is not available use local guidelines on website. If the patient is newly diagnosed it is essential they are seen by a member of the specialist team prior to discharge. Arrange follow up with specialist team.



Diabetic Keto Acidosis(DKA) Guidelines January 2012

The following bullet points highlight the important changes in the January 2012 DKA guideline

- ❑ Measurement of blood ketones (when available 2012) as opposed to urine ketones
- ❑ Measurement of venous pH as opposed to arterial blood gases (ABG - arterial blood gas only if pO₂ or pCO₂ measurement is required)
- ❑ Crystalloid solution sodium chloride 0.9% to be used as opposed to Hartmann solution
- ❑ A priming dose of insulin is not necessary, in the treatment of DKA, provided that the insulin infusion is started promptly at a dose of 0.1 unit per kg per hour.
- ❑ Replacing `sliding scale` insulin with a weight-based fixed-rate intravenous insulin infusion. A fixed insulin regimen of 0.1unit per kg per hour to be used for at least the first 6 – 12 hours of therapy. A traditional lower-dose variable rate insulin infusion(VRII)* to be used once ketonaemia has cleared.
- ❑ Remember that 0.1unit per kg per hour is a relatively concentrated solution of insulin and prevention of hypoglycaemia is paramount.
- ❑ Use both arms with a venflon in each arm. One side is for the sodium chloride 0.9% infusion with the insulin infusion piggy-backed. The other side is for the 10% glucose infusion, once the blood glucose has fallen to < 14 mmol/l.
- ❑ When the glucose infusion is commenced, it is given as well as sodium chloride, not in place of sodium chloride.
- ❑ Continue long-acting analogue insulin e.g. Lantus/Levemir at its usual dose.
- ❑ Potassium replacement is given through the sodium chloride 0.9% arm not glucose arm
- ❑ Do not give bicarbonate without senior consultant approval
- ❑ At least 2 venflons
 - one venflon for sodium chloride and insulin (“the sodium chloride arm”)
 - one venflon for glucose (“the glucose arm”)

*The terminology Variable Rate Insulin Infusion (VRII) will be replacing the term sliding scale

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Restarting subcutaneous insulin for patients already established on insulin

Previous regimen should generally be restarted

With all regimens the intravenous insulin infusion should not be discontinued for at least 30 to 60 minutes after the administration of the subcutaneous dose given in association with a meal.

Patients on basal bolus insulin

- There should be an overlap between the insulin infusion and first injection of fast acting insulin. The fast acting insulin should be injected with the meal and the intravenous insulin and fluids discontinued 30 minutes later.
- If the patient was previously on a long acting insulin analogue such as Lantus® or Levemir®, this should have been continued and thus the only action should be to restart their normal short acting insulin at the next meal.

If basal insulin has been stopped in error, the insulin infusion should not be stopped until some form of background insulin has been given. If the basal analogue is normally taken once daily in the evening and the intention is to convert to subcutaneous insulin in the morning, give half the usual daily dose of basal insulin as isophane (Insulatard®, Humulin I®) in the morning. This will provide essential background insulin until the long acting analogue can be recommenced. Check blood/urine ketone and glucose levels regularly.

Patient on twice daily fixed-mix insulin

- Re-introduce insulin before breakfast or evening meal. Do not change at any other time. Maintain insulin infusion until 30 minutes after subcutaneous insulin given

Patient of CSII (Insulin Pumps)

- Recommence at normal basal rate. Continue intravenous insulin infusion until meal bolus given. Do not recommence CSII at bedtime

Calculating subcutaneous insulin dose in insulin-naïve patients

Estimate Total Daily Dose (TDD) of Insulin

This estimate is based on several factors, including the patient's sensitivity to insulin, degree of glycaemic control, insulin resistance, weight and age.

The TDD can be calculated by multiplying the patient's weight (in kg) by

0.5 to 0.75 units.

Use 0.75 units/kg for those thought to be more insulin resistant i.e. teens, obese

Example: a 72kg person would require approximately 72×0.5 units or 36 units in 24 hours

Calculating a Basal Bolus (QDS) Regimen:

Give 50% of total dose with the evening meal in the form of long acting insulin and divide remaining dose equally between pre-breakfast, pre-lunch and pre-evening meal.

	Pre-breakfast	Pre-lunch	Pre-evening meal	Bedtime
Rapid acting insulin, e.g. Apidra®/Humalog®/Novorapid®	6 units	6 units	6 units	
Long acting insulin, e.g. Lantus®/Levemir®			18 units	

Administer 1st dose of fast acting s/c insulin prior to breakfast or lunch preferably. Administer before evening meal if monitoring can be guaranteed. Do not convert to subcutaneous regimen at bedtime.

In patients new to insulin therapy dose requirements may decrease within a few days as the insulin resistance associated with DKA resolves.

Close supervision from the specialist diabetes team is required. NB When established on Basal Bolus (QDS) the long acting insulin will be advised to be administered at 10pm

Calculating a twice daily (BD) regimen:

If a twice-daily pre-mixed insulin regimen is to be used, give two thirds of the total daily dose at breakfast, with the remaining third given with the evening meal

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