The Management of Diabetic Ketoacidosis in Adults

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What's Going On Around the UK

- 96.5% of hospitals have published protocols for the treatment of DKA
  (n = 249 Hospital Trusts. Sampson et al Diab Med 2007;24(6):643)
- Approximately 35,000 bed days are taken up annually by DKA in English Trusts
  (Sampson et al Diab Res Clin Pract 2007;77(1):92)
- 36% of UK Trusts do not refer their DKA's to the specialist diabetes team on the day of admission, 45.7% do not refer their HONK's
  (n = 249 Hospital Trusts. Sampson et al Diab Med 2007;24(6):643)

How It's Been Done So Far

- ABC
- Lots of normal saline
- Stat intravenous insulin followed by constant or variable rate intravenous insulin infusion
- A few other things (potassium, phosphate, ± bicarbonate, etc.)

What's *Actually* Happening…

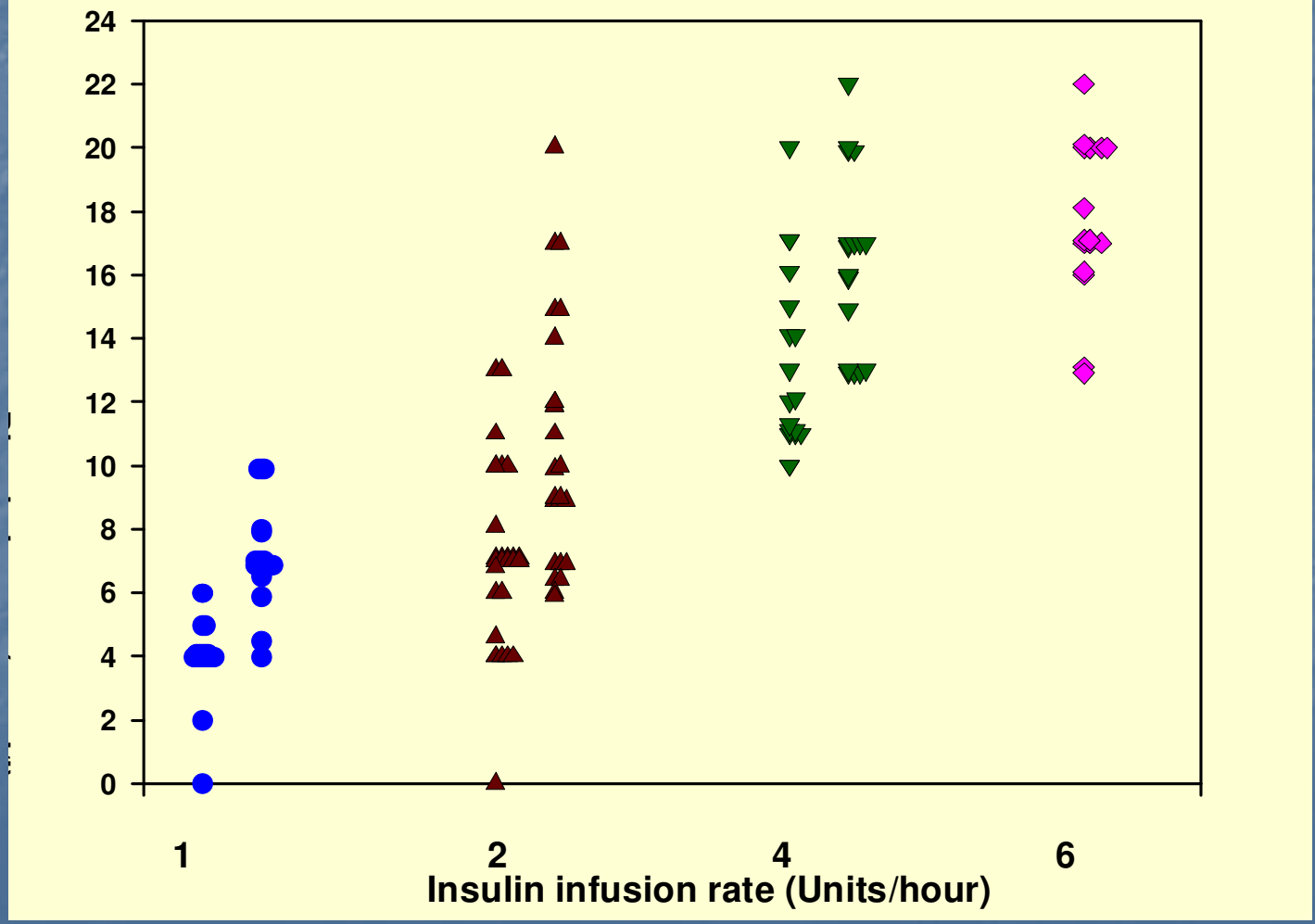
- Hopefully make the correct diagnosis
- Give a bit of, or too much, insulin; give (too much) fluid
- Criminally assault patient with arterial blood gas assessment, despite O_2 sats being 100%
- Put patient in a corner or on a non-medical ward…dependent on what bed manager says

What's *Actually* Happening…

- Forget to repeat bloods, or forget to call lab for result
- Forget to review patient
- Correct potassium 4 hours after it falls
- Stop long-acting subcutaneous insulin to ensure delayed recovery

Confusion Reigned!

Variability in perioperative IV sliding scale insulin infusion rates by glycaemic thresholds in 30 UK Acute Trusts (Sampson/Walden 2010)



Confusion Reigned!

Diabetes UK

ABCD

DISN UK GROUP

WEDS

Welsh Endocrine Diabetes Society

ACDC

Joint British Diabetes Societies Inpatient Care Group

The Management of Diabetic Ketoacidosis in Adults

Launched at DUK Liverpool 2010

"Consensus of Worthy Opinion"

Writing Group

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and many others

Areas of Controversy

- Measurement of venous pH
- The use of bedside ketone monitors
- The use of crystalloid not colloid
- Cautious fluid replacement in the young
- The fluid of choice is 0.9% sodium chloride solution

Areas of Controversy

- Continued use of long acting $^{s}/_{c}$ analogues
- The use of a fixed rate of insulin based on weight
- No bolus dose of insulin
- No intravenous bicarbonate routinely
- No phosphate replacement routinely

Paradigm Changes in the New Document

- Using ketones as the basis for treatment and monitoring, not glucose or bicarbonate
- Abolish the use of the useless arterial blood gas measurement and use venous samples instead
- The early and mandatory involvement of the specialist diabetes team

Why The Changes?

- Realisation that the main problem in DKA is the "K and A"
  - Blood sugar may be normal or only slightly elevated ("Euglycaemic DKA")
- Developments in last 10 years:
  - Venous pH is almost the same as arterial (0.02 pH units difference)
  - Bed side monitoring of pH; ketones; U&Es, bicarbonate and glucose available allowing measurement of essential metabolic parameters quickly

The Management of Diabetic Ketoacidosis in Adults

For young people under the age of 18 years use British Society of Paediatric Endocrinology and Diabetes (BSPED) guidelines: http://www.bsped.org.uk/professional/guidelines/docs/DKAGuideline.pdf

Diagnostic criteria: all three of the following must be present

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

BOX 1: Immediate management: time 0 to 60 minutes

(T=0 at time intravenous fluids are commenced)

If intravenous access cannot be obtained request critical care support immediately

Action 1: Commence 0.9% sodium chloride solution (use large bore cannula) via infusion pump.
See Box 2 for rate of fluid replacement

Action 2: Commence a fixed rate intravenous insulin infusion (IVI). (0.1unit/kg/hr based on estimate of weight) 50units human soluble insulin (Actrapid®, 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

Action 3: Assess patient
- Respiratory rate; temperature; blood pressure; pulse; oxygen saturation
- Glasgow Coma Scale
- Full clinical examination

Action 4: Further investigations
- Venous BG
- U & E
- FBC
- Blood cultures
- ECG
- CXR
- MSU

Action 5: Establish monitoring regimen
- hourly capillary blood glucose
- hourly capillary ketone measurement if available
- venous bicarbonate and potassium at 60 minutes, 2 hours and 2 hourly thereafter
- 4 hourly plasma electrolytes
- Continuous cardiac monitoring if required
- Continuous pulse oximetry if required

Action 6: Consider and precipitating causes and treat appropriately

HDU/level 2 facility and/or insertion of central line may be required in following circumstances (request urgent senior review)

- Young people aged 18-25 years
- Elderly
- Pregnant
- Heart or kidney failure
- Other serious co-morbidities
- Severe DKA by following criteria
  - Blood ketones above 6 mmol/L
  - Venous bicarbonate below 5 mmol/L
- Venous/arterial pH below 7.1
- Hypokalaemia on admission (below 3.5mmol/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 60 bpm
- Anion gap above16 [Anion Gap = (Na+ + K+) -(Cl- + HCO3-)]

BOX 2: Initial fluid replacement

Restoration of circulating volume is priority

Systolic BP (SBP) below 90mmHg

Likely to be due to low circulating volume, but consider other causes such as heart failure, sepsis.

- Give 500 ml of 0.9% sodium chloride solution over 10-15 minutes. If SBP remains below 90mmHg repeat whilst requesting senior input. Most patients require between 500 to 1000 ml given rapidly.
- Consider involving the ITU/critical care team.
- Once SBP above 90mmHg give 1000ml 0.9% sodium chloride over next 60 minutes. Addition of potassium likely to be required in this second litre of fluid

Systolic BP on admission 90 mmHg and over

- Give 1000 ml 0.9% sodium chloride over first 60 minutes

Potassium replacement

Potassium level (mmol/L)	Potassium replacement mmol/L of infusion solution
> 5.5	Nil
3.5-5.5	40 mmol/L
< 3.5	senior review – additional potassium required

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
- 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 125 ml/hr if blood glucose falls below 12 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 IVI 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

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 125 ml/hr if blood glucose falls below 12 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 0.3mmol/L, venous pH over 7.3 (do not use bicarbonate as a surrogate at this stage – see box xxxx).
- 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 IVI 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 <0.3mmol/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, 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. 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

Diabetes UK | DISN UK GROUP | ABCD | WEDS

Groups represented: Association of British Clinical Diabetologists; British Society for Endocrinology and Diabetes and Association of Children's Diabetes Clinicians; Diabetes Inpatient Specialist Nurse (DISN) Group; Diabetes UK; NHS Diabetes (England); Northern Irish Diabetologists; Society of Acute Medicine; Welsh Endocrine and Diabetes Society.

http://www.diabetes.nhs.uk/document.php?o=1038

How is DKA Defined?

- Ketonaemia of $\geq$3 mmol/L **OR** significant ketonuria (>2+ on dipstix)

AND

- Blood glucose >11.0 mmol/L or known to have DM

AND

- HCO_3^- <15 mmol/L **AND/OR** venous pH <7.3

Immediate Management: Time 0 to 60 Minutes

BOX 1: Immediate management: time 0 to 60 minutes

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See Box 2 for rate of fluid replacement

Action 2: Commence a fixed rate intravenous insulin infusion (IVII). (0.1unit/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

Action 3: Assess patient
- o Respiratory rate; temperature; blood pressure; pulse; oxygen saturation
- o Glasgow Coma Scale
- o Full clinical examination

Action 4: Further investigations
- Capillary and laboratory glucose
- Venous BG
- U & E
- FBC
- Blood cultures
- ECG
- CXR
- MSU

Action 5: Establish monitoring regimen
- Hourly capillary blood glucose
- Hourly capillary ketone measurement if available
- Venous bicarbonate and potassium at 60 minutes, 2 hours and 2 hourly thereafter
- 4 hourly plasma electrolytes
- Continuous cardiac monitoring if required
- Continuous pulse oximetry if required

Action 6: Consider and precipitating causes and treat appropriately

http://www.diabetes.nhs.uk/document.php?o=1038

Immediate Management: Time 0 to 60 Minutes

- Action 1: Commence 0.9% sodium chloride solution
- Action 2: Commence a fixed rate intravenous insulin infusion (IVII)
- Action 3: Assess patient (examination)
- Action 4: Investigations
- Action 5: Establish monitoring regime
- Action 6: Consider precipitating causes and treat appropriately

Consider Admission to Level 2 (HDU) Care

- Young people aged 18-25 years
- Elderly
- Pregnant
- Heart or kidney failure
- Other serious co-morbidities
- Severe DKA by following criteria
  - Blood ketones above 6 mmol/L
  - Venous bicarbonate below 5 mmol/L
  - Venous/arterial pH below 7.1
  - Hypokalaemia on admission (below 3.5mmol/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 60 bpm
  - Anion gap above16 [Anion Gap = $(Na^+ + K^+) - (Cl^- + HCO_3^-)$]

Fluid Replacement

BOX 2: Initial fluid replacement

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- Consider involving the ITU/critical care team.
- Once SBP above 90mmHg give 1000ml 0.9% sodium chloride over next 60 minutes. Addition of potassium likely to be required in this second litre of fluid

Systolic BP on admission 90 mmHg and over

- Give 1000ml 0.9% sodium chloride over first 60 minutes

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Potassium level (mmol/L)	Potassium replacement mmol/L of infusion solution
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Fluid Replacement

Fluid	Volume
0.9% sodium chloride 1L *	1000ml over 1st hour
0.9% sodium chloride 1L with potassium chloride	1000ml over next 2 hours
0.9% sodium chloride 1L with potassium chloride	1000ml over next 2 hours
0.9% sodium chloride 1L with potassium chloride	1000ml over next 4 hours
0.9% sodium chloride 1L with potassium chloride	1000ml over next 4 hours
0.9% sodium chloride 1L with potassium chloride	1000ml over next 6 hours
Re-assessment of cardiovascular status at 12 hours is mandatory, further fluid may be required	

- Need to be adapted depending on age (young adults, elderly) and clinical circumstances
- Crystalloid not colloid

Fluid Replacement

- **Add** glucose 10% @125 mls/hr when blood glucose falls below 14 mmol/L
- Potassium supplements as required
- Bicarbonate not recommended

Insulin

- Commence fixed rate insulin infusion
  - 0.1 unit/kg/hr based on estimate of present weight
  - 50 units human soluble insulin made up to 50ml with 0.9% sodium chloride solution
- If the patient normally takes long acting a insulin analogue continue at usual dose and time

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- hourly capillary blood glucose
- hourly capillary ketone measurement if available
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- Consider involving the ITU/critical care team.
- Once SBP above 90mmHg give 1000ml 0.9% sodium chloride over next 60 minutes. Addition of potassium likely to be required in this second litre of fluid

Systolic BP on admission 90 mmHg and over

- Give 1000 ml 0.9% sodium chloride over first 60 minutes

Potassium replacement

Potassium level (mmol/L)	Potassium replacement mmol/L of infusion solution
> 5.5	Nil
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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
- 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 125 ml/hr if blood glucose falls below 12 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 IVI 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

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 125 ml/hr if blood glucose falls below 12 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 0.3mmol/L, venous pH over 7.3 (do not use bicarbonate as a surrogate at this stage – see box xxxx).
- 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 IVI 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 <0.3mmol/L, venous pH>7.3
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Expectation: Patient should be eating and drinking and back on normal insulin.
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This situation is unusual and requires senior and specialist input.

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Conversion to subcutaneous insulin should be managed by the Specialist Diabetes Team. If the team is not available use local guidelines. 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

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60 minutes to 6 hours

- Aims of treatment
  - Rate of fall of ketones at least 0.5mmol/L/hr
  - OR bicarbonate rise 3 mmol/L/hr with BG fall 3mmol/L/hr
  - Maintaining potassium in the normal range
  - Avoidance of hypoglycaemia

If ketones and BG not falling as expected, check equipment is working then increase insulin by 1 unit/hr hourly until targets achieved

60 minutes to 6 hours

Action 1: monitoring

- Clinical signs
- Hourly BG and ketones using meter
- Venous blood gases (pH, bicarbonate, potassium) at 60 minutes, 2 hours then 2 hourly
- If the K^+ is outside normal range monitor hourly until in range

Action 2: fluid replacement

- 0.9% sodium chloride with potassium chloride
  - 1L in 2 hours
  - 1L in 2 hours
  - 1L in 4 hours
- Add 10% glucose 125 ml2/hr if BG falls below 14 mmol/L

60 minutes to 6 hours

Action 3: Assess response to treatment

- Check equipment and/or adjust insulin if targets not achieved

- Consider additional measures e.g. catheter, NG tube, thromboprophylaxis

6 to 12 hours

- Aims
  - Ensure clinical and biochemical parameters improving
  - Continue fluid replacement
  - Avoid hypoglycaemia
  - Assess for complications e.g. fluid overload, cerebral oedema

6 to 12 hours

- Check venous pH, bicarbonate and potassium at 6 hours
- Request senior advice if DKA not resolving
- Continue fluid replacement with addition of 10% glucose 125 mls/hour when BG falls below 14 mmol/L
- Reassess cardiovascular status at 12 hours – adjust rate of fluid as necessary
- Continue fixed rate insulin infusion until ketones cleared (<0.3 mmol/L) or pH over 7.3
- Ensure a referral has been made to the diabetes team

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Likely to be due to low circulating volume, but consider other causes such as heart failure, sepsis.

- Give 500 ml of 0.9% sodium chloride solution over 10-15 minutes. If SBP remains below 90mmHg repeat whilst requesting senior input. Most patients require between 500 to 1000 ml given rapidly.
- Consider involving the ITU/critical care team.
- Once SBP above 90mmHg give 1000ml 0.9% sodium chloride over next 60 minutes. Addition of potassium likely to be required in this second litre of fluid

Systolic BP on admission 90 mmHg and over

- Give 1000 ml 0.9% sodium chloride over first 60 minutes

Potassium replacement

Potassium level (mmol/L)	Potassium replacement mmol/L of infusion solution
> 5.5	Nil
3.5-5.5	40 mmol/L
< 3.5	senior review – additional potassium required

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
- 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 125 ml/hr if blood glucose falls below 12 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 IVI 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

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 125 ml/hr if blood glucose falls below 12 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 0.3mmol/L, venous pH over 7.3 (do not use bicarbonate as a surrogate at this stage – see box xxxx).
- 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 IVI 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 <0.3mmol/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, 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. 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

Groups represented: Association of British Clinical Diabetologists; British Society for Endocrinology and Diabetes and Association of Children's Diabetes Clinicians; Diabetes Inpatient Specialist Nurse (DISN) Group; Diabetes UK; NHS Diabetes (England); Northern Irish Diabetologists; Society of Acute Medicine; Welsh Endocrine and Diabetes Society.

12 to 24 hours

Expectation is that ketonaemia and acidosis will have resolved by 24 hours

Aim:

- Ensure clinical and biochemical improvement
- Continue IV fluid if not eating and drinking
- Change to variable rate insulin infusion if acidosis resolved but not eating
- Transfer to subcutaneous insulin once eating and drinking (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, 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. 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

Summary of Recommendations

- Treat patients in designated areas with trained staff
- Involve the diabetes team as early as possible
- Use bedside monitoring (with QC and laboratory checks) to allow regular assessment
- Monitor response to treatment by blood ketone measurement (may require change in Trust policy)
- Use fixed rate insulin until blood ketones cleared/acidosis resolved
- Audit outcomes and adherence to guidelines

Where to Find This Document

- http://www.diabetes.nhs.uk/tools_and_resources/reports_and_guidance
- It's the document labelled "Joint British Diabetes Societies Inpatient Care Group: The Management of Diabetic Ketoacidosis in Adults (PDF 2MB) - order reference: Diabetes 123"

Thank you for your attention