Whittington Health NHS

Diabetic Ketoacidosis (DKA) in Adults

Subject:	Diabetic Ketoacidosis (DKA) in Adults
Policy Number	N/A
Ratified By:	Clinical Guidelines Committee
Date Ratified:	V2 August 2010, reviewed with minor change October 2014 March 2015 and July 2017
Version:	5.0
Policy Executive Owner:	Clinical Director, Integrated Medicine
Designation of Author:	Dr K Anthony Consultant in Diabetes and Endocrinology
Name of Assurance Committee:	As above
Date Issued:	August 2017
Review Date:	3 years hence
Target Audience:	Medical and Nursing Staff involved in management of DKA
Key Words:	Diabetes, Ketoacidosis, Ketones, Insulin, Hyperglycaemia

Version Control Sheet

Version	Date	Author	Status	Comment
4.0	March 2015	Karen Anthony	OFF LINE	Updated guideline. Main change is a shift from urine ketone testing for diagnosis to blood ketone testing in diagnosis and monitoring.
5.0	July 2017	Karen Anthony	LIVE	Minor change to text to reinforce use of fixed rate insulin infusion. Prescription charts for FRII and VRII incorporated as Appendices.

➢ Criteria for use

This guideline is for use in adults aged 18yr or older who fulfil the diagnostic criteria for diabetic ketoacidosis (DKA):

- Blood glucose >10.0 mmol/l or known diabetes
- Ketonaemia 3.0 mmol/L or over (or significant ketonuria 2+ or more)
- Acidosis present (bicarbonate ≤15mmol/L or pH≤7.3)

The majority of patients with DKA will be hyperglycaemic. However, patients with known diabetes will occasionally present with DKA and normal blood glucose (euglycaemic DKA).

➢ Background/ introduction

Diabetic ketoacidosis (DKA) is a life-threatening complication of diabetes. DKA occurs due to absolute or relative insulin deficiency, accompanied by excessive counter-regulatory hormone secretion (adrenaline, cortisol, glucagon). This results in excessive lipolysis with release of free fatty acids which are metabolised to ketoacids.

DKA is usually seen in Type 1 diabetes but can occur in Type 2 diabetes (ketosis-prone Type 2 diabetes). 10% of cases of DKA occur in a person not previously diagnosed with diabetes. Common precipitants for DKA include infection and other intercurrent illness such as myocardial infarction, but frequently no clear precipitant is identified.

Due to improvements in management, mortality from DKA in the UK has fallen from 8% to <1.0% in the past 20 years. In 2011 there were 260 deaths from DKA in England and Wales.

All patients admitted with DKA must be referred to the Diabetes Team **on admission** (inpatient Diabetes Specialist Nurse (DSN) bleep 2706, Diabetes SpR bleep 3086 or 3147).

➢ Inclusion/ exclusion criteria

- Inclusion criteria: adults aged 18yr or older who fulfil the diagnostic criteria for DKA
- Exclusion criteria: other causes of ketoacidosis (predominantly alcoholic)

➢ Diagnosis and Investigations

The introduction of bedside blood ketone testing replaces the use of urine ketone testing for diagnosis and monitoring in DKA. Blood ketone monitoring measures beta-hydroxybutyrate which is the key ketone produced in DKA, and is a quantitative test, enabling its use in monitoring progress towards resolution of DKA.

Blood ketone monitoring replaces urine ketone monitoring in acute areas (ED, Ambulatory Care, AAU, Critical Care). Patients admitted with DKA should remain in these acute areas until ketoacidosis has resolved (blood ketones <0.6mmol/l), and the patient has been medically assessed as clinically stable for transfer.

Other hospital wards will continue to use urine ketone testing in patients who develop significant hyperglycaemia during admission.

Diagnosis of DKA is made on a combination of hyperglycaemia >10 mmol/L (or known diabetes), ketonaemia ≥3mmol/L and acidosis. If blood ketone monitoring is not available (eg in the rare event of suspected DKA developing in a patient already admitted to a ward other than AAU or Critical Care), then ketonuria 2+ or more should be present.

Interpretation of Blood Ketone results:

<0.6 mmol/L	Normal
0.6-1.5 mmol/L	Elevated
1.6-2.9 mmol/L	At risk of DKA
≥3.0 mmol/L	Likely DKA – confirm with venous blood gas

Urgent Investigations:

- Capillary blood glucose
- Capillary blood ketone concentration (or urine ketones when blood ketone testing not available)
- Urea and electrolytes and pH via arterial blood gas analyser

Consider:

- Chest X-ray
- Electrocardiogram (ECG)
- Blood cultures
- MSU

- Amylase
- Troponin T

Assess Severity:

The presence of one or more of the following indicates need for immediate senior review with consideration of admission to HDU/ITU:

- Blood ketones >6.0 mmol/L
- Bicarbonate <5.0 mmol/l
- Venous/arterial pH <7.1
- K+<3.5 on admission
- GCS <12
- O2 saturation <92%
- Systolic BP<90
- Pulse rate >100 or <60
- Anion gap ((Na+ + K+) – (Cl- + HCO3-)) >16

➢ Clinical management

The cornerstones of clinical management are fluid replacement and insulin replacement. Attention to the potassium level is also important.

Appendices 1 – 3 (Insulin prescription charts and DKA monitoring flowchart) should be printed and completed for each patient).

➢ Fluid replacement

Immediate fluids are **essential**. The aims of fluid replacement are restoration of circulating volume, correction of electrolyte imbalance and clearance of ketones. IV fluids must be administered as soon as possible after presentation to ED. Delay beyond 60 minutes is unacceptable and potentially life-threatening. If venous access is problematic then enlist help of Critical Care.

The average fluid deficit in DKA is 4-6L. Caution in the elderly or compromised cardiovascular system.

Total volume replaced will depend on clinical assessment of response.

If hypotensive (systolic <90mmHg) give 500ml 0.9% saline over 10-15 minutes first.

Suggested replacement with 0.9% saline if BP systolic >90mmHg:

- 1L in 1hr then
- 1L over 2hr + KCl

- 1L over 2hr + KCl
- 1L over 4hr + KCl
- 1L over 4hr + KCl
- 1L over 6hr + KCl

Potassium Supplementation

Patients are often hyperkalaemic at presentation. Potassium will fall rapidly with insulin infusion, and unless potassium is replaced hypokalaemia will ensue. Add KCl to the second and subsequent litres of 0.9% IV saline administered.

Measure potassium at presentation, 1hr, 2hr then 2hrly for the first 6hr.

Add KCl to each litre of 0.9% saline as follows:

Plasma K	KCl added to each litre
<3.5	40mmol + consider increased infusion rate
3.5-5.5	40mmol
>5.5	Nil

Stop KCl if patient anuric but continue IV fluids.

➢ Insulin replacement

The primary aim of insulin treatment in DKA is to suppress ongoing ketogenesis and resolve acidosis, not correction of blood glucose.

A fixed rate insulin infusion (FRII) must be used until acidosis resolves. An IV stat dose is not required as long as the insulin infusion is started promptly. **See Appendix 1 for FRII prescription.**

Add 50 units Actrapid to 49.5ml 0.9% saline and administer IV via a syringe driver.

Infuse at 6 ml/hr (ie 6 units/hr) until plasma ketone concentration <0.6 mmol/L. In the event of plasma ketone monitoring being unavailable continue FRII until bicarbonate >18mmol/L or pH>7.3.

Monitor plasma ketone concentration hourly. If not falling by at least 0.5mmol/L/hr (or bicarbonate not rising by >3mmol/L/hr), then increase insulin infusion rate by 1 unit/hr. Reassess hourly and increase infusion rate by a further 1 unit/hr if target rate of fall in plasma ketones still not achieved.

Continued fixed rate insulin infusion is required to inhibit ketoacid formation. Never stop insulin infusion. Once plasma glucose or capillary glucose <14 mmol/L add 10% glucose IV infusion at 125ml/hr whilst continuing fluid replacement with 0.9% saline as above. Do not reduce insulin infusion rate in response to falling plasma glucose unless the ketone target has been met.

If the patient normally takes insulin glargine (Lantus), detemir (Levemir) or degludec (Tresiba) continue this at the usual dose and time.

Patients using continuous subcutaneous insulin infusion (insulin pump)

Patients using continuous subcutaneous insulin infusion (insulin pump) may continue to run their insulin pump at its usual basal infusion rate **if well enough to manage their pump and have an adequate supply of pump equipment. If the patient is too unwell to manage their pump or if there is any doubt as to their current capacity to do so then discontinue the insulin pump infusion until they are well enough to manage this.**

➢ Monitoring and Metabolic Targets

Until ketoacidosis resolved measure:

- Routine observations (HR, BP, Respiratory rate, temp) hourly
- Capillary blood glucose (CBG) hourly (if bedside meter reads 'Hi' send sample to lab or analyse venous blood on blood gas analyser)
- Plasma ketone concentration hourly using bedside ketone meter
- pH, bicarbonate and potassium at 1hr, 2hr then 2hrly until pH>7.3 and K in normal range.
- Strict fluid balance chart with hourly urine output if catheterised
- GCS hourly if reduced level of consciousness

Aim for:

- Fall in blood ketone concentration of at least 0.5 mmol/L/hr
- Rise in venous bicarbonate of at least 3.0 mmol/L/hr
- Fall in capillary glucose of 3.0 mmol/L/hr
- Potassium to be maintained at 4.0-5.0 mmol/L

➢ General Measures

- Cardiac monitor
- O2 if sats <95% (unless contraindicated by co-existing lung disease)
- Urinary catheter if elderly, reduced conscious level, severely dehydrated or no urine output after 1hr of rehydration.
- Broad spectrum antibiotics if infection suspected.
- Low molecular weight heparin as per Thromboprophylaxis in Adult Medical Patients Hospital Guideline.
- Discuss early with Diabetes SpR (bleep 3086 or 3147) or Diabetes Consultant (via Switchboard) if concerns re progress
- All patients with DKA **must** be referred to the diabetes team (DSN or SpR) **on admission.** This enables early specialist input, which is a requirement of the national Best Practice Tariff for Diabetic Ketoacidosis.

➢ Continuing Management once acidosis resolved:

Switch from fixed rate to variable rate insulin infusion once blood ketone concentration <0.6mmol/L and pH>7.3. (see Appendix 2 for VRII prescription).

Add 50 units Actrapid to 49.5ml 0.9% saline and administer IV via a syringe driver

Capillary blood glucose (mmol/L)	ml/hr
0 – 4.0	0.5
4.1 – 7.0	1.0
7.1 – 10.0	2.0
10.1 – 15.0	3.0
15.1 – 20.0	4.0
20.1 – 28.0	6.0
>28.0	6.0 and call doctor

Reassess fluid requirements.

Once fluid replete and acidosis has resolved, continue maintenance IV fluids until the patient is eating and drinking. Use 0.9% saline until glucose <14mmol/L, then switch to 5% dextrose.

Conversion to subcutaneous insulin.

Once acidosis has resolved and the patient is eating and drinking, convert to subcutaneous (SC) insulin. The Diabetes Team will advise regarding this but if not available this guidance should be followed. Discontinue IV fluids at this stage.

1. **Patients on basal bolus insulin (eg Lantus/Levemir with Novorapid/Humalog at meals) (the majority)**

Long acting insulin analogues should have been continued whilst on IV insulin (see 'Insulin replacement' above). If not, basal insulin must be recommenced before converting to SC insulin.

Give SC quick acting insulin dose just before meal and stop IV insulin infusion 1 hr later.

2. **Patients on twice daily pre-mixed insulin eg Novomix 30, Humalog Mix 25, Humulin M3**

Restart SC insulin either before breakfast or the evening meal. Stop IV insulin infusion 1 hr later.

3. **Patients on CSII (insulin pump)**

Patients who have continued their pump from admission should continue running this at the usual basal rate.

For all other patients, once well enough, ask the patient to recommence their pump at their usual basal infusion rate. Continue IV variable rate insulin infusion until the the next meal, when the patient has given a mealtime bolus of insulin using their insulin pump.

Do not restart insulin pump at night.

4. **Patients not previously insulin treated (mainly newly diagnosed Type 1 diabetes)**

All newly diagnosed patients with DKA must be seen by a member of the Diabetes Team before discharge.

Patients not previously insulin treated will need to commence both long acting and quick acting insulin. The diabetes team will advise re appropriate insulin and dose.

- **Contacts (inside and outside the Trust including out-of-hours contacts)**

Diabetes Specialist Nurse: Bleep 2706 or ext 3344

Diabetes SpR: Bleep 3086 or 3147

Diabetes Consultant: Via Switchboard

- **References (evidence upon which the guideline is based)**

1. Joint British Diabetes Societies Inpatient Care Group

   The Management of Diabetic Ketoacidosis in Adults.

   Sept 2013.

- **Compliance with this guideline (how and when the guideline will be monitored e.g. audit and which committee the results will be reported to) Please use the tool provided at the end of this template**

Appendix 1- Fixed Rate Intravenous (IV) Insulin Infusion Prescription for Diabetic Ketoacidosis (DKA)

Hospital Number:	
Name:	
Date of birth:	**Ward:**

Prescriber's name (PRINT):		Date:
Prescriber's signature:		Time:
Nurse 1 name (PRINT):		Date:
Nurse 1 signature:		Time:
Nurse 2 name (PRINT):		Date:
Nurse 2 signature:		Time:

Add 50 units of Actrapid ... to 49.5 ml sodium chloride 0.9% IV solution in a 50 ml syringe.

Use a syringe driver. The infusion rate in ml/hour is the same as units of insulin per hour.

Commence Fixed Rate Insulin Infusion:

Set the infusion rate at <u>6 ml/hr</u> (6 units insulin/hr)

- **<u>DO NOT</u> stop or reduce the insulin infusion rate until acidosis resolved*:**blood ketones < 0.6 mmol/L or
- bicarbonate > 18 mmol/L or pH > 7.3 (if blood ketones not available)

- **<u>INCREASE</u> insulin infusion by 1 unit/hr if ketones not falling** (by 0.5 mmol/L/hr)
- **<u>DO NOT</u> reduce the insulin infusion rate in response to falling plasma glucose** unless blood ketones < 0.6 mmol/L.
- **<u>DO NOT</u> reduce the insulin infusion rate if plasma glucose / CBG < 14 mmol/L:**
  - add 10% glucose IV infusion at 125 ml/hour
  - continue fluid replacement with 0.9% saline
- **<u>CONTINUE</u> long acting basal insulin (e.g. Lantus, Levemir, Abasaglar, Tresiba)**
- **Switch to Variable Rate IV Insulin Infusion (VRIII) ["insulin sliding scale"] <u>ONLY</u> when acidosis resolved*. See Appendix 2, page…… for VRIII guidance.**

Appendix 2 - Sliding Scale [Variable Rate Intravenous (IV) Insulin Infusion] Prescription

Not to be used in **INITIAL** treatment of DKA or HHS, in Paediatric Patients or in Pregnancy

Hospital Number:
Surname:
First name:
Date of birth: Ward:
Gender: Consultant:
Date of Admission:

After 6 hours assess the capillary blood glucose results on the starting/regular regimen. Some patients may be insulin resistant/sensitive. If this is the case, increase/decrease the insulin infusion rates.

Patients on subcutaneous long acting insulin (e.g Lantus or Abasaglar [Glargine], Levemir [Detemir])or Degludec [Tresiba], or should continue with this insulin as usual in addition to the IV insulin infusion.

* If CBG less than 4.0 mmol/L, refer to Hypoglycaemia Management for Adult Inpatients with Diabetes

50 units of Actrapid insulin made up to 50ml with sodium chloride 0.9% IV solution. This means that the syringe pump setting (infusion rate) in ml/hour is the same as units of insulin per hour. Each prescribed regimen is valid for 24 hours**.**

Starting/Regular regimen		**Alternative regimen**		**Alternative regimen**	
Start at: (Time and date)		Start at: (Time and date)		Start at: (Time and date)	
Prescriber's signature		Prescriber's signature		Prescriber's signature	
Capillary blood glucose [CBG] (mmol/L)	Syringe pump setting in ml/hour (same as insulin units/hour)	Capillary blood glucose [CBG] (mmol/L)	Syringe pump setting in ml/hour (same as insulin units/hour)	Capillary blood glucose [CBG] (mmol/L)	Syringe pump setting in ml/hour (same as insulin units/hour)
0-4.0	0.0 * See above	**0-4.0**	* See above	**0-4.0**	* See above
4.1-7.0	1.0	**4.1-7.0**		**4.1-7.0**	
7.1-10.0	2.0	**7.1-10.0**		**7.1-10.0**	
10.1-15.0	3.0	**10.1-15.0**		**10.1-15.0**	
15.1-20.0	4.0	**15.1-20.0**		**15.1-20.0**	
20.1-28.0	6.0	**20.1-28.0**		**20.1-28.0**	
28.1 or above	6.0 + call doctor	**28.1 or above**	+ call doctor	**28.1 or above**	+ call doctor
Review time:		Review time:		Review time:	

Insulin preparation		**Insulin preparation**		**Insulin preparation**	
Time & date of preparation		Time & date of preparation		Time & date of preparation	
Batch no. of insulin		Batch no. of insulin		Batch no of insulin	
Batch no. of NaCl		Batch no. of NaCl		Batch no of NaCl	
Nurse signature		Nurse signature		Nurse signature	
Witness signature – If applicable		Witness signature – If applicable		Witness signature – If applicable	
Time & date discontinued		Time & date discontinued		Time & date discontinued	
Nurse signature		Nurse signature		Nurse signature	
Witness signature – If applicable		Witness signature – If applicable		Witness signature – If applicable	

Appendix 3

DKA Flowchart

To be printed out and completed during admission. Keep in Observation Folder then file in notes on discharge.

Name

Hospital Number

Date of Birth

Date

Measure CBG hourly. NB if bedside meter reads 'Hi' or '>20', venous blood must be sent to the lab or analysed in blood gas analyser.

Measure blood ketone concentration hourly.

Measure pH, bicarbonate and K at 1 hr, 2 hr then 2 hourly for 6 hr or longer until pH >7.3 and K in normal range.

Convert from fixed rate to variable rate insulin infusion once blood ketone concentration <0.6 mmol/L and pH >7.3.

Hour post admission:	**00**	**01**	**02**	**04**	**06**	**08**	**10**	**12**	**14**	**16**	**18**	**20**	**22**
Biochemical results													
Plasma Ketones													
pH													
Plasma bicarbonate													
K+													
Plasma glucose or CBG													

To be completed and attached to any procedural document when submitted to the appropriate committee for consideration and approval

		Yes/No	Comments
1.	**Does the procedural document affect one group less or more favourably than another on the basis of:**		
	• Race	No	
	• Ethnic origins (including gypsies and travellers)	No	
	• Nationality	No	
	• Gender	No	
	• Culture	No	
	• Religion or belief	No	
	• Sexual orientation including lesbian, gay and bisexual people	No	
	• Age	No	
	• Disability - learning disabilities, physical disability, sensory impairment and mental health problems	No	
2.	**Is there any evidence that some groups are affected differently?**	No	
3.	**If you have identified potential discrimination, are any exceptions valid, legal and/or justifiable?**	No	
4.	**Is the impact of the procedural document likely to be negative?**	No	
5.	**If so can the impact be avoided?**	N/A	
6.	**What alternatives are there to achieving the procedural document without the impact?**	N/A	
7.	**Can we reduce the impact by taking different action?**	N/A	

If you have identified a potential discriminatory impact of this procedural document, please refer it to the Director of Human Resources, together with any suggestions as to the action required to avoid/reduce this impact.

For advice in respect of answering the above questions, please contact the Director of Human Resources.

Checklist for the Review and Approval of Procedural Document

To be completed and attached to any procedural document when submitted to the relevant committee for consideration and approval.

	Title of document being reviewed:	Yes/No	Comments
1.	**Title**		
	Is the title clear and unambiguous?	Yes	
	Is it clear whether the document is a guideline, policy, protocol or standard?	Yes	
2.	**Rationale**		
	Are reasons for development of the document stated?	Yes	
3.	**Development Process**		
	Is it clear that the relevant people/groups have been involved in the development of the document?	Yes	
	Are people involved in the development?	Yes	
	Is there evidence of consultation with stakeholders and users?	Yes	
4.	**Content**		
	Is the objective of the document clear?	Yes	
	Is the target population clear and unambiguous?	Yes	
	Are the intended outcomes described?	Yes	
5.	**Evidence Base**		
	Are key references cited in full?	N/A	
	Are supporting documents referenced?	N/A	
6.	**Approval**		
	Does the document identify which committee/ group will approve it?	Yes	
7.	**Dissemination and Implementation**		
	Is there an outline/plan to identify how this will be done?	Yes	
8.	**Document Control**		
	Does the document identify where it will be held?	Yes	
9.	**Process to Monitor Compliance and Effectiveness**		
	Are there measurable standards or KPIs to	Yes	

	Title of document being reviewed:	Yes/No	Comments
	support the monitoring of compliance with and effectiveness of the document?		
	Is there a plan to review or audit compliance with the document?	Yes	
10.	**Review Date**		
	Is the review date identified?	Yes	
	Is the frequency of review identified? If so is it acceptable?	Yes	
11.	**Overall Responsibility for the Document**		
	Is it clear who will be responsible for co-ordinating the dissemination, implementation and review of the document?	Yes	

Executive Sponsor Approval			
If you approve the document, please sign and date it and forward to the author. Procedural documents will not be forwarded for ratification without Executive Sponsor Approval			
Name		Date	
Signature			
Relevant Committee Approval			
The Director of Nursing and Patient Experience's signature below confirms that this procedural document was ratified by the appropriate Governance Committee.			
Name		Date	
Signature			
Responsible Committee Approval – only applies to reviewed procedural documents with minor changes			
The Committee Chair's signature below confirms that this procedural document was ratified by the responsible Committee			
Name		Date	
Name of Committee		Name & role of Committee Chair	
Signature			

Tool to Develop Monitoring Arrangements for Policies and guidelines

What key element(s) need(s) monitoring as per local approved policy or guidance?	Who will lead on this aspect of monitoring? Name the lead and what is the role of the multidisciplinary team or others if any.	What tool will be used to monitor/check/observe/Assess/inspect/ authenticate that everything is working according to this key element from the approved policy?	How often is the need to monitor each element? How often is the need complete a report ? How often is the need to share the report?	What committee will the completed report go to?
Element to be monitored	**Lead**	**Tool**	**Frequency**	**Reporting arrangements**
Time from arrival in ED to administration of IV fluids **Time from arrival in ED to administration of IV insulin** **Proportion of patients receiving >4L fluid in first 24hr** **Adherence to recommended frequency of monitoring of biochemical parameters: glucose, blood ketones, bicarbonate, pH, potassium** **Switch from fixed rate to variable rate insulin infusion at appropriate time.**	**Karen Anthony,** **Consultant in Diabetes and Endocrinology**	**Ongoing annual audit of DKA management.**	**Annual**	**Presentation at departmental and divisional audit meetings.** **Report to Clinical Governance Dept**