Joint British Diabetes Societies Inpatient Care Group

The Management of Diabetic Ketoacidosis in Adults

Second Edition

Update: September 2013

This document has been endorsed by the Intensive Care Society

This document is coded JBDS 02 in the series of JBDS documents

Other JBDS documents:

The management of the hyperosmolar hyperglycaemic state (HHS) in adults with diabetes. August 2012 - JBDS 06

Glycaemic management during the inpatient enteral feeding of stroke patients with diabetes. June 2012 - JBDS 05

Self-management of diabetes in hospital. March 2012 - JBDS 04

The management of adults with diabetes undergoing surgery and elective procedures: improving standards. April 2011 - JBDS 03

The hospital management of hypoglycaemia in adults with diabetes mellitus. Revised September 2013 - JBDS 01

These documents are available to download from the ABCD website at http://www.diabetologists-abcd.org.uk/JBDS/JBDS.htm and the Diabetes UK website at www.diabetes.org.uk

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British Society of Paediatric Endocrinology and Diabetes (BSPED) guidelines for the management of DKA in young people under the age of 18 years can be found at: http://www.bsped.org.uk/clinical/docs/DKAGuideline.pdf

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Foreword

Diabetic ketoacidosis (DKA), though preventable, remains a frequent and life threatening complication of type 1 diabetes. Unfortunately, errors in its management are not uncommon and importantly are associated with significant morbidity and mortality. Most acute hospitals have guidelines for the management of DKA but it is not unusual to find these out of date and at variance to those of other hospitals. Even when specific hospital guidelines are available audits have shown that adherence to and indeed the use of these is variable amongst the admitting teams. These teams infrequently refer early to the diabetes specialist team and it is not uncommon for the most junior member of the admitting team, who is least likely to be aware of the hospital guidance, to be given responsibility for the initial management of this complex and challenging condition.

To address these issues the Joint British Diabetes Societies (JBDS), supported by NHS Diabetes, has produced this revision of the 2010 guidance developed by a multidisciplinary group of practicing specialists with considerable experience in this area. Where possible the guidance is evidence based but also draws from accumulated professional experience. A number of modifications have been made including addition of the criteria to define resolution of DKA and the option to continue human basal insulins in patients who normally take these to manage their day-to-day diabetes.

The management is clearly presented and divided into a number of key steps in the care pathway; the first hour, the next six hours, next twelve hours etc.

Importantly, conversion to subcutaneous insulin and preparing for discharge home are included. Audit is encouraged against defined standards.

The guideline is clearly written and accompanied by a practical and easy to follow flow chart to be used in admitting departments and wards managing DKA. Also included online in the update is an example of an Integrated Care Pathway, this can be modified for local use and is not presented as a *fait accompli*.

The authors should be congratulated on their achievement. These guidelines are recommended to all diabetes hospital teams for rapid introduction and for acceptance as the national guideline for managing DKA. Their widespread introduction should significantly improve the care of people admitted with DKA.

Since this guideline was launched in March 2010, over 5000 copies of the guidelines have been distributed by NHS Diabetes, with countless more being downloaded from the website. In addition, the subsequent publication in Diabetic Medicine (Savage MW et al, Diabetic Medicine 2011;28(5):508-515) has been cited numerous times. Furthermore in the 2012 National Diabetes Inpatient Audit 170 of 216 hospitals reported introducing new DKA guidelines with the majority adopting or modifying the JBDS guidelines.

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Acronyms:

NPSA – National Patients Safety Agency

ISPAD – International Society for Pediatric and Adolescent Diabetes

BSPED – British Society of Paediatric Endocrinology and Diabetes

FRIII – Fixed rate intravenous insulin infusion

VRIII – Variable rate intravenous insulin infusion

The references can be found in the on-line version of this document at www.diabetologists-abcd.org.uk/JBDS/JBDS.htm or www.diabetes.org.uk

Introduction

There are several currently available national and international guidelines for the management of Diabetic Ketoacidosis (DKA) in both adults and children [1-6].

In the last decade, however, there has been a change in the way patients with DKA present clinically and in addition there has been rapid development of near-patient testing technology. Until recently there was no easily available assay for ketone bodies hence capillary glucose, venous pH and bicarbonate were used to diagnose and monitor response to treatment in DKA.
Near patient testing for 3-beta-hydroxybutyrate is now readily available for the monitoring of the abnormal metabolite allowing for a shift away from using glucose levels to drive treatment decisions in the management of DKA.

These guidelines have been developed to reflect the development in technology and reflect new practice in the UK. They are evidence based where possible but are also drawn from accumulated professional knowledge and consensus agreement. They are intended for use by any health care professional that manages DKA in adults.

Definition and diagnosis

DKA consists of the biochemical triad of ketonaemia (ketosis), hyperglycaemia, and acidaemia.

Pathophysiology

Diabetic ketoacidosis (DKA) is a complex disordered metabolic state characterised by hyperglycaemia, acidosis, and ketonaemia. DKA usually occurs as a consequence of absolute or relative insulin deficiency that is accompanied by an increase in counter regulatory hormones (i.e., glucagon, cortisol, growth hormone, catecholamines). This type of hormonal imbalance enhances hepatic gluconeogenesis and glycogenolysis resulting in severe hyperglycaemia. Enhanced lipolysis increases serum free fatty acids that are then metabolised as an alternative energy source in the process of ketogenesis [7]. This results in accumulation of large quantities of ketone bodies and subsequent metabolic acidosis. Ketones include acetone, 3-beta-hydroxybutyrate, and acetoacetate. The predominant ketone in DKA is 3-beta-hydroxybutyrate.

DKA has been considered to be indicative, or even diagnostic, of type 1 diabetes, but increasingly there are cases of ketone-prone type 2 diabetes being recognised. However, the initial treatment is the same.

There are several mechanisms responsible for fluid depletion in DKA. These include osmotic diuresis due to hyperglycaemia, vomiting - commonly associated with DKA - and eventually, inability to take in fluid due to a diminished level of consciousness. Electrolyte shifts and depletion are in part related to the osmotic diuresis. Hyperkalaemia and hypokalaemia need particular attention.

Epidemiology

The true incidence is difficult to establish. Population based studies range from 4.6 to 8 episodes per 1,000 patients with diabetes [8,9]. DKA remains a significant clinical problem in spite of improvements in diabetes care [10,11]. In the USA the prevalence has risen [12], whilst mortality has fallen [13,14]. Importantly however, the 2012 National Diabetes Inpatient Audit also found that a large number of people developed DKA whilst already in hospital, thus this complication is not just found at the 'front door' [15].

Mortality and morbidity

An improved understanding of the pathophysiology of DKA together with close monitoring and correction of electrolytes has resulted in a significant reduction in the overall mortality rate from this life-threatening condition. Mortality rates have fallen significantly in the last 20 years from 7.96% to 0.67% [13,14].

The mortality rate is still high in developing countries and among non hospitalised patients [16]. This high mortality rate illustrates the necessity of early diagnosis and the implementation of effective prevention programmes.

Cerebral oedema remains the most common cause of mortality, particularly in young children and adolescents. The main causes of mortality in the adult population include severe hypokalaemia, adult respiratory distress syndrome, and co-morbid states such as pneumonia, acute myocardial infarction and sepsis [17].

DIAGNOSIS:
Ketonaemia $\geq$ 3.0mmol/L **or** significant ketonuria (more than 2+ on standard urine sticks)
Blood glucose > 11.0mmol/L or known diabetes mellitus
Bicarbonate ($HCO3^-$) < 15.0mmol/L **and/or** venous pH < 7.3

Rationale for best practice
The new paradigm

Ketones and acidosis

Before the publication of the first edition of these guidelines, management of DKA focused on lowering the elevated blood glucose with fluids and insulin, using arterial pH and serum bicarbonate to assess metabolic improvement. This was based on the assumption that this would efficiently suppress ketogenesis and reverse acidosis. This strategy recognised that blood glucose is only a surrogate for the underlying metabolic abnormality. Recent developments allow us to focus on the underlying metabolic abnormality, ketonaemia, which simplifies treatment of those who present with modest elevation of blood glucose but with an acidosis secondary to ketonaemia - 'euglycaemic diabetic ketoacidosis' [8,18,19]. This clinical presentation is not uncommon and should not be forgotten when glucose levels are not particularly raised. Improved patient education with increased blood glucose and ketone monitoring has led to partial treatment of DKA prior to admission with consequent lower blood glucose levels at presentation.

Bedside Monitoring

These guidelines recommend that management be based on bedside monitoring of patients with DKA. Blood glucose is routinely checked at the bedside, but portable ketone meters now also allow bedside measurement of blood ketones (3-beta-hydroxybutyrate). This is an important advance in the management of DKA [20-25]. A recent meta-analysis comparing the use of blood ketones versus urinary ketones in DKA showed that blood measurements were associated with reduced emergency department assessment, hospitalisations and a shorter time to recovery, thus potentially saving money [26]. The resolution of DKA depends upon the suppression of ketonaemia, therefore measurement of blood ketones now represents best practice in monitoring the response to treatment [27].

Access to blood gas and blood electrolyte measurement is now relatively easy and available within a few minutes of blood being taken. Therefore glucose, ketones and electrolytes, including bicarbonate and venous pH, should be assessed at or near the bedside.

This recommendation raises important issues:

- Staff must be trained in the use of blood glucose and ketone meters
- The meters should be subject to rigorous quality assurance
- Laboratory measurement will be required in certain circumstances, such as when blood glucose or ketone meters are 'out of range'

It is recognised that almost all units now have access to ketone meters. However, guidance is also given on monitoring treatment using the rate of rise of bicarbonate and fall in blood glucose as alternative measures.

The involvement of Diabetes Specialist Teams

The diabetes specialist team must always be involved in the care of those admitted to hospital with DKA. Their involvement shortens patient stay and improves safety [28-31]. This should occur as soon as possible during the acute phase but will depend on local circumstances. In line with the recently introduced Best Practice Tariff for DKA, specialists must also be involved in the assessment of the precipitating cause of DKA, management, discharge, and follow up [32]. This will include assessment of the patient's understanding of diabetes plus their attitudes and beliefs as well as ensuring the provision of structured education. Specialist involvement is essential to ensure regular audit and continuous quality improvement in the implementation of DKA guidelines. The practice of admitting, treating and discharging patients with DKA without the involvement of the diabetes specialist team is unsafe

and likely to compromise safe patient care. This is a governance issue [33].

Recommended changes in management listed in the 2010 guidance

- Measurement of blood ketones, venous (not arterial) pH and bicarbonate and their use as treatment markers
- Monitoring of ketones and glucose using bedside meters when available and operating within their quality assurance range
- Replacing 'sliding scale' insulin with weight-based fixed rate intravenous insulin infusion (FRIII)
- Use of venous blood rather than arterial blood in blood gas analysers
- Monitoring of electrolytes on the blood gas analyser with intermittent laboratory confirmation
- Continuation of long acting basal insulin analogues as normal
- Involvement of the diabetes specialist team as soon as possible

Uptake of the 2010 guideline

The National (England mainly) Inpatient Diabetes Audit [34] has shown that 170 of 216 hospitals reported introducing new DKA guidelines, with the majority adopting or modifying the JBDS guidelines. However, a recent audit of Intensive Care and High Dependency Units in East Anglia demonstrated that for the sickest patients there remains controversy over the fluid regimen advocated [35]. This current update acknowledges these differences of opinion.

Modification for 2013

- Some units have been continuing human basal insulin in patients taking these insulins (Humulin I®, Insulatard® , Insuman Basal®) with no apparent problems – it is recommended that this be considered for such patients - *see Controversial Areas*
- A maximum initial insulin infusion rate of 15 units per hour is recommended [36,37]
- Resolution of DKA is defined as pH > 7.3 units; bicarbonate > 15.0mmol/L; and blood ketone level < 0.6mmol/L (rather than < 0.3mmol/L), in order to avoid re-starting the FRIII if the ketone level rebounds upon discontinuation of the FRIII
- Newly presenting type 1 patients should be given Lantus® or Levemir® at a dose of 0.25 units per kg once daily subcutaneously. However, local policies should be followed when deciding which insulin(s) to start. Diabetes specialist teams should be involved in this decision

General management issues

Fluid administration and deficits

There is universal agreement that the most important initial therapeutic intervention in DKA is appropriate fluid replacement followed by insulin administration.

The main aims for fluid replacement are:

- Restoration of circulatory volume
- Clearance of ketones
- Correction of electrolyte imbalance

The typical fluid and electrolyte deficits are shown in the table below. For example, an adult weighing 70kg presenting with DKA may be up to 7 litres in deficit. This should be replaced as crystalloid.
In patients with kidney failure or heart failure, as well as the elderly and adolescents, the rate and volume of fluid replacement may need to be modified. The aim of the first few litres of fluid is to correct any hypotension, replenish the intravascular deficit, and counteract the effects of the osmotic diuresis with correction of the electrolyte disturbance.

Table: Typical deficits in DKA in adults

Water - 100ml/kg
Sodium - 7-10mmol/kg
Chloride - 3-5mmol/kg
Potassium - 3-5mmol/kg

The type of fluid to be used is discussed in detail in *Controversial Areas*.

Insulin therapy

A fixed rate intravenous insulin infusion (FRIII) calculated on 0.1 units/per kilogram body weight is recommended (see table below to assist). It may be necessary to estimate the weight of the patient. *See Controversial Areas*. Insulin has several effects [38], but the following are the most important when treating DKA:

- Suppression of ketogenesis
- Reduction of blood glucose
- Correction of electrolyte disturbance

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

WEIGHT in KG	INSULIN DOSE PER HOUR (Units)
60-69	6
70-79	7
80-89	8
90-99	9
100-109	10
110-119	11
120-130	12
130-139	13
140-150	14
>150	15 (any dose higher than this should be on the advice of the Diabetes Specialist Team)

Metabolic treatment targets

The recommended targets are

- Reduction of the blood ketone concentration by 0.5mmol/L/hour
- Increase the venous bicarbonate by 3.0mmol/L/hour
- Reduce capillary blood glucose by 3.0mmol/L/hour
- Maintain potassium between 4.0 and 5.5mmol/L

If these rates are not achieved, then the FRIII rate should be increased (*see Management of DKA* Section B, Action 2).

Intravenous glucose concentration

The management should be focused on clearing ketones as well as normalising blood glucose. It is often necessary to administer an intravenous infusion of 10% glucose in order to avoid hypoglycaemia and permit the continuation of a FRIII to suppress ketogenesis. Introduction of 10% glucose is recommended when the blood glucose falls below 14.0mmol/L. It is important to continue 0.9% sodium chloride solution to correct circulatory volume. It is quite often necessary to infuse these solutions concurrently (Section B, Action 2). Glucose should be continued until the patient is eating and drinking normally.

Special patient groups

The following groups of patients need specialist input as soon as possible and special attention needs to be paid to their fluid balance.

- Elderly
- Pregnant
- Young people 18 to 25 years of age (see section on cerebral oedema)
- Heart or kidney failure
- Other serious co-morbidities

Patient considerations

In line with several aspects of the Best Practice Tariff, patients with diabetes who are admitted with DKA should be referred to the diabetes specialist team within one working day and should be counselled about the precipitating cause and early warning symptoms. Failure to do so is a missed educational opportunity. Things to consider are:

- Identification of precipitating factor(s) e.g. infection or omission of insulin injections
- Review of their usual glycaemic control
- Review of their injection technique / blood glucose monitoring / equipment / injection sites
- Prevention of recurrence e.g. provision of written sick day rules
- Insulin ineffective e.g. the patient's own insulin may be expired or denatured. This should be checked prior to reuse
- Assess the need for, and where necessary, provision of handheld ketone meters for use at home
- Provision of a contact number on how to contact the diabetes specialist team out of hours
- Education of health care professionals on the management of ketonaemia
- Provision of a written care plan – allowing the patient to have an active role in their own diabetes management, with a copy of this going to their GP

Controversial areas

The clinical assessment and aims of treatment in the management of DKA are not controversial. However, there is still disagreement about the optimum treatment regimen and where the evidence base is not strong, recommendations are based on consensus and experience. Some of the more controversial points will now be considered and good practice recommendations are made. The recommendations are given first followed by the rationale.

Recommendations

1. Measure venous rather than arterial bicarbonate and pH
2. Blood ketone meters should be used for near patient testing
3. Crystalloid rather than colloid solutions are recommended for fluid resuscitation
4. Cautious fluid replacement in young adults
5. 0.9% sodium chloride solution is the recommended fluid of choice on the general medical ward (recommended as it is commercially available with premixed potassium chloride, and therefore complies with NPSA recommendation)
6. Subcutaneous long-acting analogue/human insulin should be continued
7. Insulin should be administered as a FRIII calculated on body weight
8. Do not use a priming (bolus) dose of insulin
9. Bicarbonate administration is not recommended routinely
10. Phosphate should not be supplemented routinely
11. What should the rate of glucose lowering be?

1. Arterial or venous measurements?

Over the last few years evidence has accumulated to show that the difference between venous and arterial pH is 0.02-0.15 pH units and the difference between arterial and venous bicarbonate is 1.88mmol/L [39-41]. This will neither affect the diagnosis nor management of DKA and it is not necessary to use arterial blood to measure acid base status [42]. Venous blood can be used in portable and fixed blood gas analysers and therefore venous measurements (pH, bicarbonate, and potassium) are easily obtained in most admitting units.

Arterial line insertion should only be performed if its use will influence management, i.e. for frequent arterial oxygen level measurements or monitoring blood pressure in the critically unwell patient.

2. Blood ketone measurement?

Ketonaemia is the hallmark of DKA. Frequent repeated measurement of blood 3-beta-hydroxybutyrate has recently become a practical option due to the availability of bedside meters which can measure blood ketone levels. Compelling evidence supports the use of this technology for diagnosis and management of DKA [20,21,24-26]. The resolution of DKA depends upon the suppression of ketonaemia and measurement of blood ketones now represents best practice in monitoring the response to treatment. Whilst high levels of ketones might not give consistent results, these levels are still well above the levels needed to diagnose and manage DKA and should not interfere with management as outlined here [43].

3. Colloid versus crystalloid?

A recent critical care consensus document suggests that colloids should be avoided where possible due to a potential risk of increased mortality and morbidity associated with their use [44]. Furthermore, a recent Cochrane review also did not support the use of colloid in preference to crystalloid fluid [45]. Therefore, we recommend the use of crystalloid fluid as the initial fluid of choice.

4. Rate of fluid replacement?

There is concern that rapid fluid replacement may lead to cerebral oedema in children and young adults. National and international paediatric

guidelines recommend cautious fluid replacement over 48 hours. No randomised controlled trials exist to guide decision making in this area. We therefore recommend cautious fluid replacement in small young adults who are not shocked at presentation.

5. 0.9% sodium chloride solution or Hartmann's solution for resuscitation?

There has been much debate about the relative merits of these two solutions [46]. Two randomised trials published since the 2010 version of this guideline have compared 0.9% sodium chloride solution to Hartmann's solution [47,48]. Neither has shown the superiority of one fluid over the other in terms of clinical outcomes. We therefore recommend that 0.9% sodium chloride with pre-mixed potassium chloride should be the default solution for fluid resuscitation, because it is compliant with NPSA recommendations. Furthermore, diabetes specialists and physicians have a vast experience in the safe use of this fluid. We also recognise that many critical care units will prefer to use balanced crystalloids such as Hartmann's solution. This is acceptable provided local policies are followed for the safe administration of additional potassium chloride.

Infusion solution	Advantages	Disadvantages
0.9% sodium chloride	• Decades of clinical experience • Readily available in clinical areas • Commercially available ready mixed with potassium at required concentrations, 20mmol/L (0.15%) or 40mmol/L (0.3%) • Supports safe practice with injectable potassium (NPSA compliant (NPSA alert 2002))	• Hyperchloraemic metabolic acidosis which may cause renal arteriolar vasoconstriction leading to oliguria and a slowing of resolution of acidosis
Compound sodium	• Balanced crystalloid with minimal tendency to hyperchloraemic metabolic acidosis	• Insufficient potassium if used alone • Not commercially available with adequate pre-mixed potassium. Potassium addition in general clinical areas is unsafe. (NPSA alert 2002) • Unfamiliar and not routinely kept on medical wards

6. Continuation of long-acting insulin analogues and basal human insulins?

In the last few years the use of long acting basal insulin analogues (Levemir®, Lantus®, and more recently Tresiba®) has become widespread. Continuation of subcutaneous analogues during the initial management of DKA provides background insulin when the IV insulin is discontinued. This avoids rebound hyperglycaemia when IV insulin is stopped [49] and should avoid extending the length of stay. This only applies to long acting analogues and does not obviate the need to give short acting insulin before discontinuing the intravenous insulin infusion.

Clinical experience suggests that continuation of pre-existing prescriptions of human basal insulins is also safe; it is not presently recommended these should always be continued, but it is recognised that this is a course of action some units might wish to undertake; audits of practice will help clarify their use, but in the view of many experts there is not much difference between the onset of action and duration of actions of human basal insulin compared with the long acting human analogues [50].

7. Fixed-rate intravenous insulin infusion (FRIII) versus variable rate intravenous insulin infusion?

Patient demographics are changing and patients with DKA are now more likely to be obese. They may also have other insulin-resistant states such as pregnancy. Evidence has led to the re-emergence of FRIII in adults in the USA and international paediatric practice [1,5,6].

Fixed dose(s) per kilogram body weight enable rapid blood ketone clearance, which is readily

monitored using bed-side ketone measurement. The fixed rate may need to be adjusted in insulin resistant states if the ketone concentration is not falling fast enough, and/or the bicarbonate level is not rising fast enough. (A study in England should shortly clarify whether the weight-based approach is superior, or not, to flat rate infusion of 6 units per hour. For now weight based insulin is recommended).

8. Initiating treatment with a priming (bolus) dose of insulin?

A priming dose of insulin in the treatment in DKA is not necessary provided that the insulin infusion is started promptly at a dose of at least 0.1 unit/kg/hour [6].

9. Intravenous bicarbonate?

Adequate fluid and insulin therapy will resolve the acidosis in DKA and the use of bicarbonate is not indicated [51-53]. The acidosis may be an adaptive response as it improves oxygen delivery to the tissues by causing a right shift of the oxygen dissociation curve. Excessive bicarbonate may cause a rise in the CO_2 partial pressure in the cerebrospinal fluid (CSF) and may lead to a paradoxical increase in CSF acidosis [51]. In addition, the use of bicarbonate in DKA may delay the fall in blood lactate: pyruvate ratio and ketones when compared to intravenous 0.9% sodium chloride infusion [52]. There is some evidence to suggest that bicarbonate treatment may be implicated in the development of cerebral oedema in children and young adults [54].

10. Use of intravenous phosphate?

Whole-body phosphate deficits in DKA are substantial, averaging 1mmol/kg of body weight. There is no evidence of benefit of phosphate replacement [55] thus we do not recommend the routine measurement or replacement of phosphate. However, in the presence of respiratory and skeletal muscle weakness, phosphate measurement and replacement should be considered [56].

11. What should the rate of glucose lowering be?

The data from the studies published in the 1970s [57,58] showed that using low dose insulin infusions (i.e. 0.1 units/Kg/hr) resulted in glucose levels coming down at about the same rate as the high dose insulin given in the preceding decades, with glucose levels coming down by about 50-60% in the first 4 hours. The theoretical risk of large osmotic shifts due to rapid changes in plasma glucose are very rare in DKA, and thus the safety of using 0.1 unit/Kg/hr outweighs any risk.

Serious complications of DKA and their treatment

Hypokalaemia and hyperkalaemia

Hypokalaemia and hyperkalaemia are potentially life-threatening conditions during the management of DKA. There is a risk of acute pre-renal kidney injury associated with severe dehydration and it is therefore recommended that no potassium be prescribed with the initial fluid resuscitation or if the serum potassium level remains above 5.5mmol/L. A normal or even elevated serum potassium concentration may be seen due to the extracellular shift of potassium in acidotic conditions, and this very poorly reflects the patient's total potassium stores. However, potassium will almost always fall as the DKA is treated with insulin. Thus it is recommended that 0.9% sodium chloride solution with potassium 40mmol/L (ready-mixed) is prescribed as long as the serum potassium level is below 5.5mmol/L and the patient is passing urine. If the serum potassium level falls below 3.5mmol/L the potassium regimen needs review. Where the fluid balance permits, an increase in the rate of the infusion of 0.9% sodium chloride solution with potassium 40mmol/L is possible. Otherwise, a more concentrated potassium infusion will be needed and to ensure safe practice, all aspects of its use must comply with local and national guidance [59,60].

Trusts need to ensure that they have local protocols in place, which allow for the safe administration of concentrated potassium solutions. This may require transfer to a higher care environment. Electrolyte measurements can be obtained from most modern blood gas analysers and should be used to regularly monitor sodium, potassium and bicarbonate levels.

Hypoglycaemia

The blood glucose may fall very rapidly as ketoacidosis is corrected and a common mistake is to allow the blood glucose to drop to hypoglycaemic levels. This may result in a rebound ketosis driven by counter-regulatory hormones. Rebound ketosis lengthens duration of treatment.

Severe hypoglycaemia is also associated with cardiac arrhythmias, acute brain injury and death. Once the blood glucose falls to 14.0mmol/L, intravenous 10% glucose needs to be commenced alongside the 0.9% sodium chloride solution to prevent hypoglycaemia.

Cerebral oedema

Cerebral oedema causing symptoms is relatively uncommon in adults during DKA although asymptomatic cerebral oedema may be a common occurrence [61]. The observation that cerebral oedema usually occurs within a few hours of initiation of treatment has led to the speculation that it is iatrogenic [62]. However, this is disputed since subclinical cerebral oedema may be present before treatment is started [63]. The exact cause of this phenomenon is unknown; previous work in animals and humans has suggested that cerebral hypoperfusion with subsequent reperfusion may be the mechanism operating [54,64,65].

Cerebral oedema associated with DKA is more common in children than in adults. In the UK, previous data suggested that around 70 to 80% of diabetes-related deaths in children under 12 years of age were as a result of cerebral oedema [66]. The UK case control study of cerebral oedema complicating DKA showed that children who developed cerebral oedema were more acidotic and, after severity of acidosis was corrected for, insulin administration in the first hour and volume of fluid administered over the first 4 hours were associated with increased risk [67]. Retrospective evidence has shown increased risk for cerebral oedema after bicarbonate administration [53].

Pulmonary oedema

Pulmonary oedema has only been rarely reported in DKA. As with cerebral oedema, the observation that pulmonary oedema usually occurs within a few hours of initiation of treatment has led to the speculation that the complication is iatrogenic and that rapid infusion of crystalloids over a short period of time increases the likelihood of this complication [68]. Elderly patients and those with impaired cardiac function are at particular risk and appropriate non-invasive or invasive monitoring should be considered.

DKA Pathway of care

DKA is a medical emergency with a significant morbidity and mortality. It should be diagnosed promptly and managed intensively. The specialist diabetes team should always be involved as soon as possible and ideally within 24 hours because this has been demonstrated to be associated with a better patient experience and reduced length of stay.

For young people under the age of 18 years, contact your paediatric diabetes service and use the BSPED DKA guidelines which can be found at http://www.bsped.org.uk/clinical/docs/DKAGuideline.pdf

Assessment of severity

The presence of one or more of the following may indicate severe DKA.

- Blood ketones over 6mmol/L
- Bicarbonate level below 5mmol/L
- Venous/arterial pH below 7.0
- Hypokalaemia on admission (under 3.5mmol/L)
- GCS less than 12 or abnormal AVPU scale
- Oxygen saturation below 92% on air (assuming normal baseline respiratory function)
- Systolic BP below 90mmHg
- Pulse over 100 or below 60bpm
- Anion gap above 16 **[Anion Gap = ($Na^+ + K^+$) – ($Cl^- + HCO_3^-$)]**

If the patient exhibits any of these signs they should be reviewed by a consultant physician and considered for referral to a Level 2/HDU (High Dependency Unit) environment [69]. It may also be necessary to consider a surgical cause for the deterioration. If surgery is required there will need to be an urgent senior multidisciplinary discussion on the optimum time to operate.

Provision of care

Local care pathways should identify the units that are to care for DKA patients. Nursing staff appropriately trained in Level 2/HDU should take the lead in hands on patient care.

New principles

The insulin infusion rate is calculated by weight, which may need to be estimated. Administration by weight allows insulin resistant states to be at least partially accommodated. Reliance on standard VRIII regimens will fail to accommodate for the very obese or the pregnant patient and risks premature reduction of insulin dosage. Where blood ketone measurements are available the adequacy of the insulin regimen is determined by the rate of fall of the ketones and will need revision if this is inadequate. If bedside ketone measurement is not available, the venous bicarbonate level can be used to assess the response to treatment during the first 6 hours, but may be less reliable thereafter due to the confounding influence of the high chloride levels associated with large volumes of 0.9% sodium chloride solution. This is particularly important when glucose levels are relatively normal. Supplementary glucose solution may need to be infused at some stage in treatment to provide substrate. This will permit the FRIII to be maintained, avoid hypoglycaemia and allow the full suppression of ketone production.

A. Hour 1: Immediate management upon diagnosis: 0 to 60 minutes.

T = 0 at time intravenous fluids are commenced. If there is a problem with intravenous access, critical care support should be requested immediately

Aims

- Commence IV 0.9% sodium chloride solution
- Commence a FRIII but only after fluid therapy has been commenced
- Establish monitoring regime appropriate to patient; generally hourly blood glucose (BG) and hourly ketone measurement, with at least 2 hourly serum potassium and bicarbonate for the first six hours
- Clinical and biochemical assessment of the patient
- Involve the diabetes specialist team at the earliest possible stage

Action 1 - Intravenous access and initial investigations

- Rapid ABC (Airway, Breathing, Circulation)
- Large bore IV cannula (use ports to reduce infection risk) and commence IV fluid replacement (See Action 2)
- Clinical assessment
- Respiratory rate; temperature; blood pressure; pulse; oxygen saturation
- Glasgow Coma Scale. NB: a drowsy patient in the context of DKA is serious and the patient requires critical care input. Consider an NG tube with airway protection to prevent aspiration
- Full clinical examination

Initial investigations should include:

- Blood ketones
- Capillary blood glucose
- Venous plasma glucose
- Urea and electrolytes
- Venous blood gases
- Full blood count
- Blood cultures
- ECG
- Chest radiograph if clinically indicated
- Urinalysis and culture
- Continuous cardiac monitoring
- Continuous pulse oximetry
- Consider precipitating causes and treat appropriately
- Establish usual medication for diabetes
- Pregnancy test in women of child bearing age

Action 2 – Restoration of circulating volume

Assess the severity of dehydration using pulse and blood pressure. As a guide 90mmHg may be used as a measure of hydration but take age, gender and concomitant medication into account.

Systolic BP (SBP) on admission below 90mmHg

Hypotension is likely to be due to low circulating volume, but consider other causes such as heart failure, sepsis, etc.

- Give 500ml of 0.9% sodium chloride solution over 10-15 minutes. If SBP remains below 90mmHg this may be repeated **whilst awaiting senior input**. In practice most patients require between 500 to 1000ml given rapidly.
- If there has been no clinical improvement reconsider other causes of hypotension and seek an **immediate senior assessment**. Consider involving the ITU/critical care team.
- Once SBP above 90mmHg follow fluid replacement as shown below

Systolic BP on admission 90mmHg and over

Below is a table outlining a typical fluid replacement regimen for a previously well 70kg adult. This is an illustrative guide only. A slower infusion rate should be considered in young adults (see Controversial Areas).

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	

*Potassium chloride may be required if more than 1 litre of sodium chloride has been given already to resuscitate hypotensive patients

Exercise caution in the following patients

- Young people aged 18-25 years
- Elderly
- Pregnant
- Heart or kidney failure
- Other serious co-morbidities

In these situations admission to a Level 2/HDU facility should be considered. Fluids should be replaced cautiously, and if appropriate, guided by the central venous pressure measurements.

Action 3 - Potassium replacement

Hypokalaemia and hyperkalaemia are life threatening conditions and are common in DKA. Serum potassium is often high on admission (although total body potassium is low) but falls precipitously upon treatment with insulin. Regular monitoring is mandatory.

Potassium level in first 24 hours (mmol/L)	Potassium replacement in mmol/L of infusion solution
Over 5.5	Nil
3.5-5.5	40
Below 3.5	Senior review as additional potassium needs to be given (see serious complications section)

Action 4 - Commence a fixed rate intravenous insulin infusion (FRIII)

- If a weight is not available from the patient, estimate it in kilograms
- If the patient is pregnant, use her present weight and call for immediate senior obstetric help as well
- Start a continuous FRIII via an infusion pump. This is made of 50 units of human soluble insulin (Actrapid®, Humulin S®) made up to 50ml with 0.9% sodium chloride solution. Ideally this should be provided as a ready-made infusion
- Infuse at a fixed rate of 0.1 unit/kg/hr (i.e. 7ml/hr if weight is 70kg) (See table on page 12)
- Only give a bolus (stat) dose of intramuscular insulin (0.1 unit/kg) if there is a delay in setting up a FRIII
- If the patient normally takes Lantus®, Levemir® or Tresiba® subcutaneously continue this at the usual dose and usual time (although the option exists to continue human basal insulin as well)
- Insulin may be infused in the same line as the intravenous replacement fluid provided that a Y connector with a one way, anti-siphon valve is used and a large-bore cannula has been placed

B. 60 minutes to 6 hours

Aims:

- Clear the blood of ketones and suppress ketogenesis
- Achieve a rate of fall of ketones of at least 0.5mmol/L/hr
- In the absence of ketone measurement, bicarbonate should rise by 3.0mmol/L/hr and blood glucose should fall by 3.0mmol/L/hr
- Maintain serum potassium in the normal range
- Avoid hypoglycaemia

Action 1 – Re-assess patient, monitor vital signs

- During this time, patients should be reviewed hourly initially to ensure that adequate progress is being made in reducing the ketone and/or glucose concentrations
- Consider urinary catheterisation if the patient is incontinent or anuric (i.e. not passed urine by 60 minutes)
- Consider naso-gastric tube insertion if the patient is obtunded or persistently vomiting
- If the oxygen saturation falls, then perform an arterial blood gas measurement and request a repeat chest radiograph

- Regular observations and Early Warning Score (EWS) charting as appropriate
- Maintain an accurate fluid balance chart, the minimum urine output should be no less than 0.5ml/kg/hr
- Continuous cardiac monitoring in those with severe DKA
- Give low molecular weight heparin as per NICE guidance [70]

Action 2 – Review metabolic parameters

- Measure blood ketones and capillary glucose hourly (note: if meter reads "blood glucose over 20mmol/L" or "Hi" venous blood should be sent to the laboratory hourly or measured using venous blood in a blood gas analyser until the bedside meter is within its QA range)
- Review patient's response to FRIII hourly by calculating the rate of change of ketone level fall (or rise in bicarbonate or fall in glucose).
- Assess the resolution of ketoacidosis
    - o If blood ketone measurement is available and blood ketones are not falling by at least 0.5mmol/L/hr call a prescribing clinician to increase the insulin infusion rate by 1.0 unit/hr increments hourly until the ketones are falling at target rates (also check infusion**)
    - o If blood ketone measurement is not available, use venous bicarbonate. If the bicarbonate is not rising by at least 3.0mmol/L/hr call a prescribing clinician to increase the insulin infusion rate by 1 unit/hr increments hourly until the bicarbonate is rising at this rate**
    - o Alternatively use plasma glucose. If the glucose is not falling by at least 3.0mmol/L/hr call a prescribing clinician to increase the insulin infusion rate by 1.0 unit/hr increments hourly until glucose falls at this rate. Glucose level is not an accurate indicator of resolution of acidosis in euglycaemic ketoacidosis, so the acidosis resolution should be verified by venous gas analysis**

**** 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)**

- Measure venous blood gas for pH, bicarbonate and potassium at 60 minutes, 2 hours and 2 hourly thereafter
- If the potassium is outside the reference range, assess the appropriateness of the potassium replacement and check it hourly. If it remains abnormal after a further hour, seek immediate senior medical advice (see Action 3 p20)
- Continue the FRIII until the ketone measurement is less than 0.6mmol/L, venous pH over 7.3 and/or venous bicarbonate over 18mmol/L (see section C)
- Do not rely on urinary ketone clearance to indicate resolution of DKA, because these will still be present when the DKA has resolved
- If the glucose falls below 14.0mmol/L, commence 10% glucose given at 125ml/hour alongside the 0.9% sodium chloride solution
- Monitor and replace potassium because it may fall rapidly

Action 3 – Identify and treat precipitating factors

Action 4

Patients presenting with newly diagnosed type 1 diabetes should be given Lantus® or Levemir® (or human NPH insulin, depending on local policy) at a dose of 0.25 units/Kg subcutaneously once daily to mitigate against rebound ketosis when they are taken off the FRIII [49].

C. 6 to 12 hours.

Aim:

The aim within this time period is to:

- Ensure that clinical and biochemical parameters are improving
- Continue IV fluid replacement
- Continue insulin administration
- Assess for complications of treatment e.g. fluid overload, cerebral oedema

- Continue to treat precipitating factors as necessary
- Avoid hypoglycaemia

Action 1 – Re-assess patient, monitor vital signs

- If the patient is not improving then seek senior advice
- Ensure a referral has been made to the specialist diabetes team

Action 2 – Review biochemical and metabolic parameters

- At 6 hours check the venous pH, bicarbonate, potassium, as well as blood ketones and glucose
- Resolution of DKA is defined as ketones less than 0.6mmol/L and venous pH over 7.3 (do not use bicarbonate as a surrogate at this stage because the hyperchloraemic acidosis associated with large volumes of 0.9% sodium chloride will lower bicarbonate levels)

If DKA resolved go to section E.

If DKA not resolved refer to Action 2 in Section B.

D. 12 to 24 HOURS

Expectation:

By 24 hours the ketonaemia and acidosis should have resolved

Aim:

- Ensure that the clinical and biochemical parameters are improving or have normalised
- Continue IV fluids if the patient is not eating and drinking
- If the patient is not eating and drinking and there is no ketonaemia move to a VRIII as per local guidelines
- Re-assess for complications of treatment e.g. fluid overload, cerebral oedema
- Continue to treat any precipitating factors as necessary
- Transfer to subcutaneous insulin if the patient is eating and drinking normally. Ensure that the subcutaneous insulin is started before the IV insulin is discontinued. Ideally give the subcutaneous fast acting insulin at a meal and discontinue IV insulin one hour later

Action 1 – Re-assess patient, monitor vital signs

Action 2 – Review biochemical and metabolic parameters

- At 12 hours check venous pH, bicarbonate, potassium, as well as blood ketones and glucose
- Resolution of DKA is defined as ketones less than 0.6mmol/L, and venous pH over 7.3

If DKA resolved go to section E.

If DKA not resolved refer to Action 2 in Section B and seek senior specialist advice as a matter of urgency.

NB: Do not rely on bicarbonate alone to assess the resolution of DKA at this point due to the possible hyperchloraemia secondary to high volumes of 0.9% sodium chloride solution. The hyperchloraemic acidosis will lower the bicarbonate and thus lead to difficulty is assessing whether the ketosis has resolved. The hyperchloraemic acidosis may cause renal vasoconstriction and be a cause of oliguria.

Expectation: Patients should be eating and drinking and back on normal insulin. If this expectation is not met within this time period it is important to identify and treat the reasons for the failure to respond to treatment. **It is unusual for DKA not to have resolved by 24 hours with appropriate treatment** and requires senior and specialist input.

E. Conversion to subcutaneous insulin

The patient should be converted to an appropriate subcutaneous regime when biochemically stable (blood ketones less than 0.6mmol/L, pH over 7.3) and the patient is ready and able to eat. Conversion to subcutaneous insulin is ideally managed by the diabetes specialist team. If the team is not available see Appendix 1. If the patient is newly diagnosed, it is essential they are seen by a member of the specialist team prior to discharge.

Specialist diabetes team input

In line with the Best Practice Tariff, if they are not already involved, the local diabetes team should be informed and the patient reviewed within 24 hours of admission [32]. Specialist diabetes team input is important to allow re-education, to reduce the chance of recurrence, and to facilitate appropriate follow up.

Implementation of the guidelines

Repeated audits by many diabetes units in all constituent UK countries have consistently demonstrated poor adherence to local (or national) guidelines in the management of DKA. There are two main problems to be addressed:

1) The guidelines must be implemented

2) The guidelines must be audited

The guidelines must be reviewed regularly: The next planned review is 2016.

Commissioning of care

Diabetic Ketoacidosis is a recognised common medical emergency and must be treated appropriately. For this to occur, the Health Economies within the United Kingdom must address management of DKA in the context of provision of expert medical and nursing input within secondary care. In the majority of cases people with type 1 diabetes should be under specialist care. Commissioners, Primary Care Providers, Local Diabetes Networks and Diabetes Directorates within the Acute Trusts, should co-operate and ensure the Quality Indicators and Audit Standards set out below are met.

Audit

Quality indicators

Every Acute Trust should have a local management plan in place based upon these, or other authoritative guidelines. Guidelines must be current and valid and should not be used if the review date has expired. If there is no review date, they should not be used.

Every Acute Trust should have nominated care areas for patients with diabetic ketoacidosis.

Every Acute Trust should have trained Health Care Workers available to measure blood ketone levels 24 hours per day.

Every Acute Trust should have a Quality Assurance Scheme in place to ensure accuracy of blood glucose and ketone meters.

People admitted to hospital with diabetic ketoacidosis receive educational and psychological support prior to discharge and are followed up by a diabetes specialist team (NICE CG15).

We recommend that every Acute Trust use performance indicators to assess the quality of care given (examples given in Appendix 2). A Treatment Pathway document may be beneficial, as adherence to guidelines for this condition is very poor and integrated pathway documents (an example of which is given online) would improve compliance.

Appendix 1

Restarting subcutaneous insulin for patients already established on insulin

The patient's previous regimen should generally be re-started if their most recent HbA1c suggests acceptable level of control i.e. HbA1c 64mmol/mol (<8.0%)

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.

If the patient was 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 to 60 minutes later
- If the patient was previously on a long acting insulin analogue such as Lantus®, Levemir®, or Tresiba® this should have been continued and thus the only action should be to restart their normal short acting insulin at the next meal
- If the basal insulin had been stopped in error, the insulin infusion should not be stopped until some form of background insulin has been given. If the basal analogue was 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®, Insuman basal®) in the morning, This will provide essential background insulin until the long acting analogue can be recommenced. Check the blood ketone and glucose levels regularly

If the patient was on twice daily fixed-mix insulin

- Re-introduce the subcutaneous insulin before breakfast or before the evening meal. Do not change at any other time. Maintain the insulin infusion until 30 to 60 minutes after the subcutaneous insulin was given

If the patient was on CSII

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

Calculating the 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 x 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 the first dose of fast acting subcutaneous insulin preferably prior to breakfast or lunch. Only administer the first dose before the evening meal if appropriate monitoring can be guaranteed. Do not convert to a subcutaneous regimen at bed time.

In patients new to insulin therapy dose requirements may decrease within a few days because the insulin resistance associated with DKA resolves. Close supervision from the diabetes specialist team is required.

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.

Appendix 2

Audit standards for the management of the adult patient with diabetic ketoacidosis

Purpose of these audit standards

- Maximise patient safety and quality of care
- Support professional best practice
- Deliver enhanced patient satisfaction
- Reduce Trust operating costs (litigation, complaint procedures)
- Contribute to improved financial performance (reduced length of stay)

Institutional Standards:	
Indicator	**Standard**
Access:	
Has the Trust either adopted these National Guidelines or has their own alternative, evidence based and audited internal guidelines for the management of the adult patient admitted with diabetic ketoacidosis?	Yes
Does the Trust collect data about the outcomes for patients admitted with diabetic ketoacidosis?	Yes
Does the Trust have the services of a dedicated Diabetes Inpatient Specialist Nurse (DISN) at staffing levels most recently recommended by Diabetes UK (1.0 WTE per 300 beds)?	Yes
Institutional Accountability and Integrity:	
Does the Trust have a 'clinical lead' for the management of the adult patient admitted with diabetic ketoacidosis with responsibility for implementation of the DKA guidelines?	Yes
NPSA Standards [71,72]	
All regular and single insulin (bolus) doses are measured and administered using an insulin syringe or commercial insulin pen device. Intravenous syringes must never be used for insulin administration.	100%
The term 'units' is used in all contexts. Abbreviations, such as 'U' or 'IU', are never used	100%
All clinical areas and community staff treating patients with insulin have adequate supplies of insulin syringes and subcutaneous needles, which staff can obtain at all times.	100%
An insulin syringe must always be used to measure and prepare insulin for an intravenous infusion.	100%

A training programme should be put in place for all healthcare staff (including medical staff) expected to prescribe, prepare and administer insulin (e.g. the safe use of insulin and the safe use of intravenous insulin e-learning packages from NHS Improving Quality).	100%
Policies and procedures for the preparation and administration of insulin and insulin infusions in clinical areas are reviewed to ensure compliance with the above.	100%
Department of Health 'Never Event' Standard [73]	
Death or severe harm as a result of maladministration of insulin by a health professional.	Never
Additional Best Practice Tariff Standards [32]:	
People admitted to hospital with diabetic ketoacidosis should be referred to the diabetes specialist team on admission.	100%
People admitted to hospital with diabetic ketoacidosis should be seen by member of the diabetes specialist team within 1 working day of admission.	100%
People with diabetes should have access to the diabetes specialist team.	100%
Where clinically appropriate, people with diabetes should have the choice to self monitor their condition.	80%
People admitted to hospital with diabetic ketoacidosis receive educational support from a member of the diabetes specialist team prior to discharge. This education should include • Review of usual glycaemic control • Review of injection technique/blood glucose monitoring/equipment/sites • Discussion of sick day rules • Assessment of the need for home ketone testing (blood or urinary) with education to enable this • Provision of contact telephone numbers for the diabetes specialist team including out of hours	100%
Patients are seen by a diabetologist or DISN prior to discharge.	100%

People admitted to hospital with diabetic ketoacidosis receive psychological support from a member of the diabetes specialist team prior to discharge.	75%
People admitted to hospital with diabetic ketoacidosis receive follow up by a diabetes specialist team.	100%
People admitted to hospital with diabetic ketoacidosis should be discharged with a written care plan: a process that allows the person with diabetes to have active involvement in deciding, agreeing and owning how their diabetes is managed. This should be copied to the GP.	100%
Percentage of patients where their discharge is delayed because of diabetes related problems.	0%
Access to structured education offered within three months.	100%
Institutional Accountability and Integrity:	
Percentage of patients with diabetes identified as such on hospital patient administration system.	95%
Percentage of clinical coding that identifies people with diabetes correctly.	100%
Patient and Staff Satisfaction:	
Percentage of staff who feel that they have sufficient levels of appropriate and timely support from the Diabetes Inpatient Specialist Team.	100%
Percentage of patients who express satisfaction with their patient journey, using validated tools such as the Diabetes Treatment Satisfaction Questionnaire (DTSQ) and the Diabetes Treatment Satisfaction Questionnaire for Inpatients (DTSQ-IP).	80%

Statement for inpatient guidelines

These guidelines have been developed to advise the treatment and management of diabetic ketoacidosis in adults.

The guideline recommendations have been developed and reviewed by a multidisciplinary team led by the Joint British Diabetes Society (JBDS) and including representation from Diabetes UK. People with diabetes have been involved in the development of the guidelines via stakeholder events organised by Diabetes UK.

It is intended that the guideline will be useful to clinicians and service commissioners in planning, organising and delivering high quality diabetes inpatient care. There remains, however, an individual responsibility of healthcare professionals to make decisions appropriate to the circumstance of the individual patient, informed by the patient and/or their guardian or carer and taking full account of their medical condition and treatment.

When implementing this guideline full account should be taken of the local context and in line with statutory obligations required of the organisation and individual. No part of the guideline should be interpreted in a way that would knowingly put people, patient or clinician at risk.

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Adult Diabetic Ketoacidosis Emergency Care Pathway

Print the whole document and use in the case notes for this episode. (NOT to be used for HHS (HONK) and NOT to be used for those less than 18 years old, even if they have DKA)

ADDRESSOGRAPH LABEL

These guidelines are based on the Joint British Diabetes Societies DKA Guidelines (Dhatariya 2013)
This chart is designed so that prescription and relevant observations can be recorded together.

Doctor: All prescriptions for insulin and fluids must be signed.

Nurse: All entries must be signed.

Site: **Ward:** **Consultant:** **Date:**

ENTRY (diagnostic) CRITERIA: (Tick boxes if criteria present, all must be ticked to establish diagnosis)

Established or new diagnosis of diabetes mellitus **and one or more of** ☐

Capillary blood ketonaemia on Trust approved ketone meter of >3mmol/L ☐

Or ketonuria ++ or more on Ketostix® (ONLY for diagnostic purposes, not management)

AND Venous bicarbonate <15mmol/L (use venous blood in analyser) **OR** venous pH <7.3 *** ☐

***The standard of care is venous blood gases. Measure arterial blood gases ONLY if patient has a reduced conscious level or low oxygen saturations; increased respiratory rate is not respiratory distress *per se* because an acidosis increases respiratory rate.

EXIT CRITERIA

Resolution of ketonaemia <0.6 mmol/L **and** ☐

Venous bicarbonate >15 mmol/L **and** ☐

Diabetes controlled with subcutaneous insulin **and** ☐

Patient eating and drinking **and** ☐

Patient has been seen by diabetes team, or there is a plan to do so ☐

OR Exit from pathway has been recommended by the diabetes team ☐

New principles in the management of DKA:

1. Aim to treat the cause of the acidosis, i.e. the ketonaemia
2. Insulin is to be given as a standard dose per kg until the ketones are cleared
3. Use bedside meters (Trust approved only) for glucose and ketone measurements
4. Use blood gas machines on HDU/EAU for venous pH (there no significant difference from arterial pH), venous HCO3-, and U&Es.
5. Use 0.9% sodium chloride solution for resuscitation, not colloid. Do not use Hartmann's (however, ITU patients may differ).
6. Only use a variable rate intravenous insulin infusion with 10% glucose when the blood glucose is <14mmol/L
7. Give both 0.9% sodium chloride and glucose together if ketones are present (>1.0mmol/L and glucose <14mmol/L)
8. Patients should be seen by the diabetes specialist team within one working day of admission
9. Upon discharge patients should be offered appropriate outpatient follow up, have access to psychological support and be offered structured education

Adult Diabetic Ketoacidosis Emergency Care Pathway

DKA pathway: Guidance for use

Initial results and guidance for use of the pathway:

ADDRESSOGRAPH LABEL

ESSENTIAL INITIAL RESULTS, ALL MUST BE DOCUMENTED	
Blood ketones _____mmol/L Blood glucose _____mmol/L Venous bicarbonate _____mmol/L Venous (or arterial) pH_____ Potassium _____mmol/L [Beware initial low K+, if low (<3.5 mmol/L) call for senior immediately] Creatinine _____ µmol/L	
EARLY MANAGEMENT – 1st hour fluids / potassium / insulin	

Intravenous fluid	• If systolic BP < 90mmHg:
	  • Give 1 litre of 0.9% sodium chloride solution over 15 minutes
	  • If systolic BP remains < 90mmHg repeat and call senior medical colleague for advice
	  • Consider septic shock / heart failure as a potential cause
	  • Consider calling the critical care outreach team from HDU/ITU
	  Do NOT use plasma expanders
	• If the systolic BP is > 90mmHg
	The rate of fluid replacement depends on the age / fitness / dehydration of the patient. Plan fluid replacement and use clinical judgment
	Typically though:
	  • 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 given at 125ml/hr if the blood glucose falls below 14mmol/L
	More cautious fluid replacement should be considered in young people aged 18-25 years, elderly, pregnant, heart or renal failure. (Consider HDU and/or central line)
	Reduce the rate of fluid replacement in the elderly / cardiac disease / mild DKA (bicarbonate >10mmol/L). More rapid infusion increases risk of respiratory distress syndrome and cerebral oedema

Potassium
 	
NB: Low potassium KILLS
	Serum potassium is often normal or high initially but total body potassium is low
	• Add potassium using pre-prepared bags only as follows:
	  o >5.5mmol/L - none
	  o 3.5 – 5.5mmol/L - 10 mmol in each 500 ml (i.e. 20 mmol/L)
	  o <3.5mmol/L - senior advice is required and possible pharmacy involvement. In addition the patient MUST be looked after in a High Care Area
	Anticipate a fall in potassium and replace, once the first plasma potassium result is known SEE APPENDIX 1

Adult Diabetic Ketoacidosis Emergency Care Pathway

ADDRESSOGRAPH
LABEL

Insulin	DO NOT STOP subcutaneous NPH insulin (Insulatard®, Humulin I®, Insuman Basal®), or analogue (Lantus®, Levemir® or Tresiba®). DO disconnect Continuous Subcutaneous Insulin Infusion (CSII) pump and DO NOT attempt to use it without diabetes specialist team input under any circumstances. A Fixed Rate Intravenous Insulin Infusion (FRIVII) is to be used at 0.1 U/Kg of patient weight Add 50 units of soluble insulin made up to 50ml with 0.9% sodium chloride solution in a 50ml syringe Weigh or estimate patient weight in Kg, if pregnant, use their current pregnant weight Infuse intravenous insulin using Trust–approved syringe driver Paradigm / ethos is to drive ketones down aggressively by at least 0.5mmol/L per hour. A variable rate intravenous insulin infusion is NOT to be used until blood ketones are < 0.6mmol/L.
Other Important Notes and Measures	Call the diabetes specialist team or diabetes inpatient specialist nurse as soon as possible If ketone and / or glucose levels do not fall as expected, call for senior advice High Care Area (HDU or dedicated beds) care is needed if: • Hypokalaemia is present on admission (K+ <3.5mmol/L) • Young (18 - 25 years old) • regnant. Call for urgent senior obstetric involvement. KETONES KILL BABIES, NOT GLUCOSE • GCS <12 • Shocked: pulse >100bpm or systolic BP <90mmHg Consider urinary catheter if no urine passed after 2 hours or incontinent Consider naso-gastric tube and aspiration if the patient does not respond to commands (NB protect airway) Consider thromboprophylaxis with low-molecular weight heparin in elderly or high risk patients unless it is contraindicated. If the patient is in a "hyperosmolar" state, fully anticoagulate with low-molecular weight heparin unless contraindications exist; see BNF and consider referring to the National Guideline on the Management of HHS Screen for infection and give antibiotics if clinical evidence of infection (NB The WBC is not helpful because it may be markedly raised from DKA alone) Continue the FRIII and fluids until the acidosis is reversed and the VRIII until the patient is ready to eat and drink Discontinue the VRIII 30-60 minutes after the subcutaneous insulin has been given
Bicarbonate administration	In most cases bicarbonate is **NOT** helpful and is potentially dangerous If bicarbonate is being considered, the patient should be in a level 2 (HDU / ITU) environment Only consider after discussion with the consultant in charge of the patient's care
Re-starting subcutaneous insulin	If you are confident enough, re-start subcutaneous insulin without diabetes specialist team input as follows (firstly ensure that the long acting analogue, if the patient was previously on it, was not stopped): • Allow the patient to eat • If no sickness, inject normal meal time insulin and stop intravenous insulin 30-60 minutes later Otherwise await the input of the diabetes specialist team

Adult Diabetic Ketoacidosis Emergency Care Pathway

ADDRESSOGRAPH
LABEL

MULTIDISCIPLINARY TEAM PROGRESS NOTES

Adult Diabetic Ketoacidosis Emergency Care Pathway

ADDRESSOGRAPH
LABEL

MULTIDISCIPLINARY TEAM PROGRESS NOTES

DKA Pathway: Fluid Balance Chart (print as many sheets as required for this admission)

Add potassium using pre-prepared bags only as follows:

- **Greater than 5.5mmol/L - none**
- **Between 3.5 – 5.4mmol/L - 10 mmol in each 500 ml**
- **Less than 3.5mmol/L - call for senior advice and consider contacting pharmacy for K+ supplement**

ADDRESSOGRAPH
LABEL

Adult Diabetic Ketoacidosis Emergency Care Pathway

Fluid balance Ward_____ Date_____

Previous day's intake (ml)		Previous day's output (ml)		Balance	

THE INTAKE RECORD MUST ONLY DETAIL COMPLETED VOLUMES OF DRINKS/INFUSIONS

Intake/Input		Output
	Device no.	
1	.....	
2	.....	1 .....
3	.....	2 .....
4	.....	3 .....

INTAKE (ml)								OUTPUT (ml)						
Brought forward														
Time	Oral						Running Total	Urine						Running Total
01.00														
02.00														
03.00														
04.00														
05.00														
06.00														
07.00														
08.00														
09.00														
10.00														
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16.00														
17.00														
18.00														
19.00														
20.00														
21.00														
22.00														
23.00														
24.00														
24hr TOTAL														

Adult Diabetic Ketoacidosis Emergency Care Pathway

Ward_____ Date_____

ADDRESSOGRAPH LABEL

DKA Pathway: Fixed Rate Intravenous Insulin Infusion (FRIII)

(Print as many sheets as required for this admission)

Patients weight (or estimated weight in Kg)..... If estimated tick box

Fixed Rate Intravenous Insulin Infusion to use whilst the patient is still ketotic or acidotic (ketones greater than 0.6mmol/L and/or HCO_3^- less than 15mmol/L
Add 50 units soluble insulin (Actrapid®/Humulin S®) made up to 50ml with 0.9% sodium chloride solution in a 50ml syringe
Use a new column and delete the previous prescription each time the insulin prescription is changed

	PRESCRIPTION					ADMINISTRATION		
Ketone/Bicarbonate	Insulin	Insulin units/hour	Alternative Insulin rate, doctor to sign	Batch number	Start time	Signature	Finish time	Signature
If Blood Ketones >0.6 mmol/L and/or $HCO3^-$ <15mmol/L	0.1 Units/Kg per hour (e.g. For a 80 Kg man give 8 units per hour							
Signature								
Bleep number								
Date								
Time								

Adult Diabetic Ketoacidosis Emergency Care Pathway

Ward_____ Date_____

ADDRESSOGRAPH LABEL

DKA pathway insulin syringe infusion control document

TO BE COMPLETED BY THE NAMED NURSE							
SYRINGE DRIVER CONTROLLED INSULIN INFUSION (record hourly)							
Date and time	Blood Glucose mmol/L	Blood Ketone mmol/L	Rate units/ hour	Volume left in syringe (ml)	Volume infused in one hour (ml)	Total volume infused (ml)	Signature

Adult Diabetic Ketoacidosis Emergency Care Pathway

DKA pathway bedside and laboratory results

ADDRESSOGRAPH
LABEL

Bedside and laboratory Results
Check creatinine, electrolyte and venous bicarbonate at 2 hours then 2 to 4 hourly until venous bicarbonate >15 mmol/L

Date and time	Ketones	Sodium	Potassium	Creatinine	Bicarbonate	Glucose	Signature

Adult Diabetic Ketoacidosis Emergency Care Pathway

Ward_____ Date_____

ADDRESSOGRAPH LABEL

DKA Pathway: Variable Rate Intravenous Insulin Infusion (VRIII)

(Only use when the ketone levels are less than 0.6mmol/l and then stop using the FRIII)

Variable Rate Intravenous Insulin Infusion to use once the patient is no longer ketotic or acidotic (ketones less than 0.6mmol/L and/or $HCO3^-$ greater than 15mmol/L
Add 50 units soluble insulin (Actrapid®/Humulin S®) made up to 50ml with 0.9% sodium chloride solution in a 50ml syringe.
Use a new column and delete the previous prescription each time the insulin prescription is changed

	PRESCRIPTION					ADMINISTRATION		
Blood glucose (mmol/L)	Insulin units/hour	Insulin units/hour	Insulin units/hour	Batch number	Start time	Signature	Finish time	Signature
>14	6							
12.1 – 14	4							
10.1 – 12	3							
7.1 – 10	2							
4 – 7	1							
<4	0.5							
Signature								
Bleep number								
Date								
Time								