Title:
A national survey of the management of diabetic ketoacidosis in the UK in 2014

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Keywords: Diabetic ketoacidosis; management; survey

Novelty Statement

a) In 2013 a revised version of national guidance on the management of DKA was published, however there are no data to show that these recommendations actually work
b) This is the largest national survey on the management of DKA
c) Most patients developed hypokalaemia and over 25% developed hypoglycaemia. There were also significant issues with care processes
d) The management of DKA will need to change to prevent hypokalaemia but will necessitate a shift in where patients are cared for. However, as a result of moving to a High Dependency or Intensive Care environment, care processes may improve.

Abstract

Aims

Outcomes for the management of diabetic ketoacidosis (DKA) remain largely unstudied. In a national survey we examined outcomes of adult patients presenting with DKA in 2014, mapped against accepted UK national guidance.

Methods

Data were collected in a standardised form covering clinical, and biochemical, outcome, risk, and discharge planning. The form was sent to all UK diabetes specialist teams (n=220). Anonymised data were collected on 5 consecutive patients admitted with DKA between 1.5.14 and 30.11.14

Results

283 forms were received (n=281 patients), from 72 hospitals, 71.4% used the national guidelines. 7.8% of cases occurred in existing inpatients. 6.1% of admissions were newly diagnosed diabetes. 33.7% of patients had had at least 1 episode of DKA in the preceding year. The median time to starting 0.9% sodium chloride and intravenous insulin was 41.5 minutes and 60 minutes respectively. Median time to resolution was 18.7 hours, and median length of hospital stay was 2.6 days. Significant adverse biochemical outcomes occurred; with 27.6% of patients developing hypoglycaemia and 55% reported hypokalaemia. There were also significant issues with care processes.

Initial nurse led observations were well carried out, but subsequent patient monitoring remained suboptimal. Most patients were not seen by a member of

the diabetes specialist team during the first 6 hours, but 95% were seen before discharge.

A significant minority of discharge letters to primary care did not contain necessary information.

Conclusion

Despite widespread adoption of national guidance, several areas of DKA management are suboptimal, being associated with avoidable biochemical and clinical risk.

Keywords
Diabetic ketoacidosis; Management; Guideline; National; Survey

Introduction

Diabetic ketoacidosis (DKA) is a common and significant contributor to mortality and morbidity in people with type 1 diabetes [1]. It is a common experience among clinicians that much of the in hospital morbidity experienced by patients is related to DKA treatment, and that there is wide variability in the definition of DKA and use of guidelines between teams. To date, there has only been one study that looked in detail at DKA outcomes that mapped outcomes against a standardised guideline [2].

In 2010 the UK Joint British Diabetes Societies for Inpatient Care (JBDS-IP) published national guidance on the management of DKA, and revised these in 2013 [3,4]. These guidelines have achieved high levels of adoption in the UK and suggest a formal diagnosis be based on a pH of <7.3, a blood glucose level of >11.0 mmol/L or a previous diagnosis of diabetes, and a blood ketone level of >3.0 mmol/L. The guidelines emphasised the importance of normalisation of ketone levels, using bedside ketone monitors to aid treatment, and a weight based, fixed rate intravenous insulin infusion (FRIII) in the initial management until the DKA had resolved. Fluid and potassium replacement guidance was also given. Several small scale audits within individual diabetes and acute medicine departments had been presented in regional and national meetings as abstracts, suggesting there was enthusiasm to assess the management of DKA nationally.

To address gaps in our understanding of modern DKA outcomes, we conducted a national survey on the management of DKA against the standards in the nationally adopted JBDS guidelines [4].

Patients and Methods

A data collection questionnaire was developed using the 2013 JBDS guideline as a template [See online materials - Appendix 1]. This questionnaire was sent out by email to all 220 UK specialist diabetes teams.

We accessed the databases of Diabetes UK, the Association of British Diabetologists (ABCD), and the Diabetes Inpatient Specialist Nurse (DISN) UK Group. This was the network that was also used to conduct the 2012 survey.

One clinician from each Trust was asked to fill in and return a single form for each of the subsequent 5 patients admitted to their institution between May and November 2014 with a diagnosis of DKA. This number was chosen to try to gain as much meaningful information from individual units, without burdening them.

Data were analysed using SPSS software (IBM Ltd, Portsmouth, UK).

The Clinical Audit and Improvement Department of the Norfolk and Norwich University Hospitals NHS Foundation Trust deemed this survey a service

improvement exercise and that the project did not require multi-site ethical, research governance or audit approval.

Results:

Clinical details (Table 1)

283 forms were received from 72 hospitals. 281 individual patient forms were received, with 2 patients having 2 admissions each. The participating hospitals are listed in Appendix 2. The demographics of the patients and where they received treatment are shown (Table 1).

Admissions for DKA were least frequent between 8pm and 7am, with only 29.4% of admissions during the night, but the remainder were spread equally throughout the rest of the day. There were no differences in the pH or bicarbonate levels in those admitted during the night compared to those admitted during the day. The median length of stay for the whole cohort was 2.6 days (IQR 1.5, 4.8) with a mean of 4.2 days (SD 5.6). 7.8% of all episodes had developed in existing in-patients, and 33.7% of patients had had at least 1 previous admission for DKA in the preceding 12 months (median 2, range 1 - 100).

Management in the first hour (Table 2)

The diagnosis of DKA was made a median of 35.5 minutes (IQR 18, 81) after initial presentation to the emergency room. 0.9% sodium chloride solution was first started a median of 41.5 minutes (IQR 21, 90), and the median time for

the fixed rate intravenous insulin infusion being started was 60 minutes (IQR 29, 105). Table 2 shows issues surrounding the diagnosis and management of the patients during the first hour after admission. Senior review occurred immediately in 34.3%, and after the initial management, in a further 50.9%. No senior review was carried out in 2.1%.

Biochemical changes in first 24 hours (Figures 1a – 1c)

Admission mean pH (±SD) was 7.16 (±0.15), the mean glucose was 28.7 mmol/l (±10.9), mean blood ketone concentration was 5.68 mmol/l (±1.5), and mean bicarbonate was 11.3 mmol/l (±5.1). The mean potassium on admission was 4.8 mmol/l (±1.0). Figures 1a, 1b and 1c show the changes in pH, bicarbonate and potassium values during the course of the 24 hours following admission. In 55.1% of cases, the potassium levels were outside the range of 4.0 – 5.5 mmol/l. As figure 1c shows, mean potassium dropped, with 18.6% and 67.1% of patients having a potassium concentration less than 4.0mmol/l at 1 hour and 24 hours respectively. The mean lowest recorded potassium during the admission was reported as 3.65 mmol/l (±0.66), suggesting that the majority of the out-of-range potassium was due to hypokalaemia.

The mean lowest recorded glucose was 4.7 mmol/l (±2.3), with 27.6% of patients developed overt hypoglycaemia. The median time to developing hypoglycaemia was 14.7 hours (IQR 10.5, 25.0) after admission. 29.6% of patients in whom the long acting insulin was not continued developed hypoglycaemia, with 36.6% developing hypoglycaemia if it was continued.

Adherence to guidelines (Table 3)

The results showing the continued management of the patients during and after the first hour and up to 24 hours are shown in Table 3. 20.1% of respondents felt that potassium replacement was not done in accordance with their guidelines. In addition, 0.9% sodium chloride solution and a fixed rate intravenous insulin infusion were also not used according to local protocols in 9.9% and 7.8% respectively. There was no statistical difference between glucose or potassium levels between those who reported following the guidelines and those who did not.

Resolution and on-going in-hospital management (Table 4)

The median length of time to resolution of DKA was 18.7 hours (IQR 11.3, 27.8). This is in contrast to previous data that suggested that resolution was achieved in 12.1 hours [2]. Whilst 83.1% of teams said that the resolution of DKA had been confirmed, only 11% of respondents said they used pH to diagnose resolution, 17.3% used ketone measurement, 95% used glucose and 5.3% used bicarbonate.

Patients were discharged from hospital a median of 2.6 days after admission (IQR 1.5, 4.8).

Discharge planning (Table 5)

Table 5 shows the steps involved prior to discharge.

Discussion

This large national survey - 30% of UK hospitals participated - has found that most have adopted or adapted the national guidelines produced by the Joint British Diabetes Societies for Inpatient Care group for the management of patients presenting with DKA [4]. Prior to the publication of the national guidance and this analysis, there was no way of knowing if the standards of care used to treat DKA were effective. Previous work has shown that the use of a standardised management protocol is associated with improved outcomes, in particular, reducing length of stay [5], but there are few data looking at modern national outcomes in DKA management [6-8].

This survey was undertaken using the framework of this national guidance; we found that despite widespread adoption, the majority of patients develop hypokalaemia, and more than 27% developing hypoglycaemia during their treatment. These data do not show any differences between the risk of developing hypoglycaemia or hypokalaemia and whether the guideline for potassium replacement or the intravenous insulin regimen was used or not. However, given that there are no previous data on this scale, it is not known if there has been an improvement in overall standards of care since individual hospitals adopted or adapted the guideline. What the current data suggest is several areas of management were well carried out – in particular ‘process

issues' – carried out in the first few hours after presentation. These were most likely to be carried out by nursing staff in the emergence department. Tables 2 to 5 show where practice was well carried out. However, these data also show that there is some room for continued improvement in many areas and that the guideline needs amending, to ensure more aggressive potassium replacement, and an adjustment of the intravenous insulin regimen. However, there remain significant shortfalls in management, in particular 'process issues' surrounding monitoring, e.g. capillary glucose or ketone measurements, urine output, etc., that need to be addressed.

Morbidity and Mortality Associated with DKA

There are few recent data on the incidence and prevalence of DKA, and in particular the morbidity and mortality caused by this condition. Data from the Centers for Disease Controls in the US reported that between 1988 and 2009 the age adjusted discharge rate for DKA as the first listed diagnosis rose from 3.2 to 4.6 per 10,000 population [9]. In England and Wales, the National Diabetes Audit in 2011/2012 data reported that there had been 7608 adults with at least 1 episode of DKA during that year, representing a crude prevalence of 3.57% [10].

In this dataset there was 1 reported death, 33 days after admission with DKA that had resolved within 24 hours of admission, in a 72 year old man with a hospital acquired pneumonia and osteomyelitis. Mortality data from Birmingham, UK was reported to have decreased from 3.9% between 1971-

1991 to 1.8% between 2000 and 2009 [11,12]. More recently, some authors have suggested that with improvements in overall care, deaths from hyperglycaemic crisis and DKA have been declining [13], but it remains a condition with a significant mortality in adults of between 0.7 and 5% [12,14,15].

Our data show that 7.8% of patients had developed DKA during their inpatient stay. This is in marked contrast to the data from the National Diabetes Inpatient Audit, which suggested that only 0.4% of patients developed DKA who took part in that audit developed DKA during that admission [1]. The data collection strategy was different, and the patient population was different, but the large number is still striking. 32.8% had had at least 1 episode of DKA in the previous 12 months (range 1-100). The causes of inpatient DKA were not given in 4 cases, in 9 cases, patients had developed infections (urinary tract, gastroenteritis or dental), 2 patients developed vomiting (1 post-partum), in 6 cases, there were insulin administration errors. That so many people developed DKA whilst a hospital inpatient is clearly of great concern. The failure to administer insulin correctly has been identified as a ‘Never Event’ by NHS England [16]. As a result of this data it would be prudent for hospitals to have mechanisms for every case of in hospital DKA to be investigated, and interventions put in place to prevent these from recurring.

Management of DKA in the First Hour

10 people (3.5%) presented with blood glucose levels of 12mmol/l or less, suggesting that ‘euglycaemic ketoacidosis’ remains an important differential diagnosis. Furthermore, given that 14.8% of all patients required a ‘stat’ dose of insulin within the first hour after diagnosis, this suggests there may have been a delay in treatment in these individuals, even though the median time to starting fluids and insulin was 41.5 and 60 minutes respectively after initial presentation to the emergency room.

That almost all patients were treated with 0.9% sodium chloride solution (‘normal saline’) suggests that most acute medical teams and diabetes specialist teams use this as the first line fluid of choice. This issue has previously been discussed elsewhere [17]. The data to show that alternative fluids are associated with better outcomes is lacking [18].

The move to a fixed rate intravenous insulin infusion (FRIII) has been very quickly taken up across the UK and is a clear change of practice since the introduction of the JBDS guideline. In addition, the use of venous blood gases analysis is now very frequent. This has been advocated because the perceived difference between arterial and venous bicarbonate is small enough to be clinically insignificant when making management decisions in DKA [19].

Nurse led initial observations were carried out in most cases. However, factors that may have more traditionally fallen to the doctors were less well done. Of note is that only 33.9% of patients had a record of their feet being

looked at, despite recommendations that the feet of all patients with diabetes admitted to hospital should be examined [20].

80.9% of patients had their blood ketone levels measured. There has been an argument against the use of hand held, point of care ketone testing meters in hospital because of their potential inaccuracy and lack of well conducted clinical trials [21]. However to date, these fears do not seem to have resulted in any measurable patient harms and have become an integral part of the management of DKA [22].

The lack of a chest X-ray in 1 in 4 and an ECG in 14% of admissions warrants further investigation. Potassium remains the most significant electrolyte disturbance in DKA. Due to both metabolic acidosis and osmotic diuresis, it has been estimated that even in ‘mild’ DKA, at the time of presentation, an individual may have a deficit of 3-5mmol/Kg [23]. Therefore adequate potassium replacement is paramount, but this has its problems due to potential of acute cardiac toxicity if given too fast. National guidelines suggest replacement regimens [4,23], but it is clear that these need to be altered, because most patients developed hypokalaemia. From the current database, there is no evidence of harm from the lowered levels of potassium. In addition, to replace potassium more aggressively may mean the insertion of a central venous catheter, and/or being cared for in a Level 2/3 (High Dependency/Intensive Care Unit) environment where a cardiac monitor is available. This shift would have potentially major consequences on resources, given that just 55% of patients are cared for in the acute medical unit, or a

Level 1 (general) medical ward where monitored beds are less likely to be available than on a high dependency or intensive care unit. This may cause more controversy, because a survey of 13 intensive care units across the East of England showed that most did not adhere to any form of national guidance [24].

The changes over time in, pH, bicarbonate and potassium are shown in Figures 1, 2 and 3 respectively. Potassium levels continued to drop as shown, despite 77.4% of teams saying that they followed their potassium replacement guidelines. Figure 1 shows how pH levels rise to 7.35 by just under 19 hours after admission, with Figure 2 showing the changes in bicarbonate levels, rising to greater than 15mmol/L by 6 hours.

The most commonly identified precipitants were infection (44.6%), and non-compliance (19.7%). Other causes included newly diagnosed diabetes in 6.1% and alcohol/ drugs related (5.8%). In 18.7% of current cases, no precipitant was identified. This data is in contrast to recent work from the paediatric population who suggested that up to 25% of cases were due to newly diagnosed diabetes [25].

A quarter of patients did not have an appropriate monitoring regimen instituted. More than 1 in 7 patients did not have their capillary glucose measured hourly, despite being on an intravenous insulin infusion. This issue was also previously identified in the UK National Diabetes Inpatient Audit 2013 [1]. In addition, even though DKA is a recognised medical emergency,

and patients are usually very ill, 26.9% did not have hourly observations taken, and over 1 in 5 did not have hourly assessment of urine output. It would seem that if an appropriate monitoring regimen was not in place, then it is unlikely that the potassium or glucose was also correctly managed. Thus the data reporting that monitoring frequency was inadequate are likely to be underestimates.

Together, these failures in process issues and patient management after the initial assessments on admission may be a reflection in how busy nursing and medical staff are in the ward areas where patients with DKA are cared for (Table 1). Further work needs to be done to assess if this lack of appropriate monitoring leads to any patient harm.

Hypoglycaemia

Hypoglycaemia developed in 27.6% of all patients, at a median time of 14.7 hours after treatment was started. It is possible that the currently used insulin infusion regimen is too aggressive when glucose levels drop, and it may be necessary to adjust the insulin infusion rate. Our data differs from that from Crasto et al who found that their median time to developing hypoglycaemia (just under 12.9 hours) was after their median time to resolution (12.1 hours), suggesting that the intravenous insulin infusion was used for too long [2]. In the present study, there was no relationship between developing hypoglycaemia and not getting 10% dextrose when the blood glucose dropped below 14mmol/l. These may be due to the relatively small numbers in

these groups. That more than a third of patients developed hypoglycaemia whilst continuing with a long acting insulin is of concern. Previous work has shown that continuing the basal insulin is associated with a reduction in rebound hyperglycaemia [26]. Given the data to show that hypoglycaemia is a strong predictor for increased length of hospital stay and mortality [27,28], more work will need to be done to determine what the optimal approach should be.

On-going Management in Hospital

In two thirds of people, treatment and monitoring was reviewed by junior medical staff alone, with no further senior involvement being recorded. This is concerning because of the data showing that confidence amongst junior doctors in managing diabetes remains low [29]. Similarly, 53% of all DKA admissions did not involve the diabetes specialist team during the acute phase of the illness, despite the evidence that input from the diabetes team helps to reduce the length of hospital stay [30]. In addition, in the UK, diabetes specialist team involvement is integrated into recommendations from the National Institute for Clinical and Healthcare Excellence (NICE) [20].

Discharge and Follow-up

Perhaps unsurprisingly, almost 83% of all admission did not receive psychological support prior to discharge. There are data to show that eating disorders are more common in this population and early identification and

intervention is likely to help further deterioration [31]. The provision of this service is known to be lacking in many teams although advocated by NICE as an important part of a diabetes team [32].

In many cases, the discharge letter to the primary care team did not contain the correct name of the insulin, the right dose of insulin or the correct insulin delivery device. Discharge summaries are most often filled out by the most junior members of the medical team – doctors who are only 1 or 2 years post-qualification. As mentioned, the data show that a large number of admissions had no contact with the diabetes specialist team, and with the previous work showing low confidence among junior staff when managing diabetes, it may well be that this combination led to these omissions [29].

Further areas of concern highlighted were that over 30% of patients did not have any form of follow up by the diabetes specialist team within 30 days of discharge, and that communication with the primary care team was poor. In the UK, there is a recommendation that a written care plan be drawn up between the patient and the diabetes specialist team, and that a copy of the care plan be sent to the primary care team. However, this was not done in 41.3% and 38.2% or cases respectively.

Access to ketone testing on discharge was limited. More than 1 in 4 patients had no access to ketone testing on discharge, despite almost a third of patients having had a previous admission with DKA in the previous year. Previous work – albeit of low quality – has shown early identification of

ketonaemia and hyperglycaemia may allow for appropriate treatment to be started (even at home) if patients have hand held ketone monitors [33].

Limitations

There are several limitations to our data. We asked for voluntary contributions from teams across the UK, and for sequential cases admitted to hospital but some case selection may have occurred. There may have been particular reason to choose patients who developed DKA as an inpatient to try and highlight poor practices in their place of work, or to submit data where the outcomes were deemed better than in most case. There is no way of knowing if such case selection took place, and the data are presented in the assumption that across the UK the data were done so in 'good faith'. Furthermore, due to the nature of the data collection exercise, because the authors did not perform a direct review of the medical records, the authors were unable to verify the accuracy of the information submitted. In addition, whilst individuals have said that they have adopted the guidelines it may be that the medical and nursing staff are not using it correctly.

An important omission was the glucose data after admission. Hence we are unable to provide predictors for severity. We did not ask for a definition of hypoglycaemia (although this is widely accepted to be less than 4mmol/L) or the frequency of occurrence of hypoglycaemic episodes. In addition, only 72 (out of a possible 220) hospitals returned any data. Despite this, we feel that

the forms returned are likely to be a reasonable representation of patients presenting daily to emergency teams across the UK and elsewhere.

It is not known whether the areas where deficiencies have been highlighted (e.g. foot examination), was because it was not done or not recorded.

Importantly, because of the nature of the survey, we collected no personal information on individual patients. Thus we have no way of linking to the UK National Diabetes Audit and so correlate the current data with frequency of previous admissions, hospital clinic attendance rates, previous HbA1c, socioeconomic data, or the presence of other co-morbidities. Previous work has shown that poor glycaemic control and frequent clinic non-attendance, female gender, the presence of psychological problems and comorbidities all increased the risk of DKA [12,34]. Other factors reported in the US included low household income, having a low education, and having no health insurance [34]. Linkage of local DKA data to nationwide databases is needed to allow investigators to look at predictors of DKA, and to calculate the prevalence, something were unable to do because we had no denominator.

In summary we believe that these data represent the largest ever nationwide survey on the management of DKA. The data show that a large majority of Trusts have adopted the UK national guidelines and we show several novel and important findings including the low mortality, swift biochemical resolution, and the relatively low length of hospital stay. We also show no differences in outcomes between those who follow the national guidelines and those who do

not, although this conclusion may be limited to the small numbers. However, there remain important areas where further work is needed. In particular to determine whether the development of low potassium and glucose is due to the poor adherence to the current guideline or because the guideline is wrong. In addition, there remain a significant number of process issues that individual hospitals must address, which may include increased education for staff. Furthermore, there may be a small number of patients who are cared for by inexperienced, junior staff and who do not come into contact with more senior members of the medical team, or the diabetes specialist team. Patients may be discharged with the incorrect name and/or dose of insulin on the discharge letters. These issues highlight the need for Trusts to make education and training mandatory for all medical and nursing staff. Future work needs to include prospective randomised studies to assess the efficacy and safety of each part of the pathway. It is likely that these will require very large patient numbers due to the heterogeneity of the population. We feel that the existence of national guidelines in multiple sites in the UK allows the valuable process of audit against hard quantitative end points, and a cycle of improvement. To this end, each hospital that contributed data for this survey (listed in online appendix 2) will be sent their own results with a summary of the aggregated national results to aid self-improvement.

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Conflict of Interest The authors declare that there is no duality of interest associated with this manuscript.

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Table 1 – n=283

Gender	Male	51.9%	Missing data	1.8%
	Female	46.3%		
Mean age – years (±SD)		37.8 (±18.5)		
Ethnicity	White	81.6%	Missing data	14.5%
	Mixed White/ Asian or White / Black Caribbean	0.8%		
	Indian / Asian	1.4%		
	African / Black	1.5%		
	Other	0.4%		
Treatment Area	Level 1 (General ward)	15.9%	Missing data	2.8%
	Level 2 (High dependency)	14.2%		
	Level 3 (Intensive care)	9.5%		
	Acute Medical Unit	39.2%		
	Accident and Emergency	10.2%		
	Combination	7.9%		

Table 2 – n=283

Variable	Yes (%)	No (%)	Missing data (n (%))
Was the Diagnosis Made According to Local Criteria?	67.1	3.2	84 (29.7)
Was the Diagnosis Made Using JBDS Criteria?	71.4	18.7	28 (9.9)
Seen by ICU or a Senior?	85.9	7.1	19 (6.7)
Was the Care Given in an Appropriate Area?	94	2.1	10 (3.5)
Was a 'Stat' Insulin Dose Given?	14.8	84.1	3 (1.1)
Was 0.9% Sodium Chloride Solution Used?	96.5	3.2	1 (0.4)
Was an FRIII used?	91.5	8.5	0 (0)
Potassium Replacement in Accordance with Local Protocol?	79.9	12.9	20 (7.2)
Early Warning Score Recorded?	91.2	3.2	16 (5.7)
Respiratory Rate Recorded?	96.5	0.4	9 (3.2)
Temperature Recorded?	95.4	0	13 (4.6)
Pulse Rate Recorded?	97.2	0	8 (2.8)
Oxygen Saturations Recorded?	97.2	0	8 (2.8)
Glasgow Come Scale Recorded?	89.8	6.7	10 (3.5)

Full History Recorded?	95.8	3.2	3 (1.1)
Full Examination Recorded?	92.6	3.2	11 (3.9)
Foot Examination Recorded?	33.9	47.7	52 (18.4)
Blood Ketones Recorded?	80.9	15.9	9 (3.2)
Capillary Blood Glucose Recorded?	97.5	0.7	5 (1.8)
Venous Plasma Glucose Recorded?	93.3	4.2	7 (2.5)
Urea and Electrolytes Recorded?	98.9	0	3 (1.1)
Venous Blood Gases Recorded?	92.9	5.7	4 (1.4)
Full Blood Count Performed?	92.2	3.2	13 (4.6)
ECG Performed?	79.9	14.1	17 (6.0)
CXR Performed?	69.3	23.7	20 (7.1)
Urinalysis Performed?	74.9	13.1	34 (12)

Table 3 – n=283

Variable	Yes (%)	No (%)	Missing data (n (%))
Was IV 0.9% Sodium Chloride Solution Replacement Given as per Local Guidance?	89.4	9.9	2 (0.7)
Was Potassium Replaced as per Local Guidance?	77.4	20.1	7 (2.5)
Did Potassium Levels Remain between 4.0 - 5.5 mmol/L?	43.1	55.1	5 (1.8)
Was a FRIII used as per Local Guidance	90.5	7.8	5 (1.8)
Was an Appropriate Monitoring Regimen Established?	70.3	25.1	13 (4.6)
Capillary Glucose Levels Measured Hourly?	81.6	13.1	15 (5.3)
Ketone Levels Measured Hourly?	57.6	37.1	15 (5.3)
Observations of Vital Signs taken Hourly?	67.8	26.9	15 (5.3)
EWS measured Hourly?	67.1	32.5	21 (7.4)
Urine Output Documented?	74.2	22.6	9 (3.2)
Was 10% Glucose started when the Glucose Dropped to <14mmol/l?	82.7	15.2	6 (2.1)
Review of Fluid Balance with the Rate of Normal Saline Amended if Appropriate?	68.9	20.8	29 (10.2)
Was a Long Acting Insulin Continued?	58.3	38.5	8 (2.8)

Was there a Review of Metabolic Response to Treatment?	85.9	5.7	22 (7.8)
If Yes, Were Appropriate Changes in Treatment Made?	58.7	10.2	86 (30.4)
Did The Patient Ever Develop Hypoglycaemia?	27.6	67.5	14 (4.9)
If Progress was not Satisfactory, Did a Senior Review Occur?	33.2	52.3	41 (14.5)
Was a Precipitating Cause Found?	77.0	13.8	25 (8.8)
Was a Referral to Diabetes Team Made?	92.6	4.2	9 (3.2)

Table 4 – n=283

Variable	**Yes (%)**	**No (%)**	**Missing data (n (%))**
Was Resolution of DKA Confirmed?	83.1	9.2	22 (7.8)
Treatment and Monitoring Reviewed by SpR/Consultant on-call?	11.0	67.5	61 (21.6)
Was the Specialist Diabetes Team Involved During the Acute Phase?	13.4	53.0	95 (33.6)
Where Necessary, was a VRIII Used According to Local Policy?	50.9	43	17 (6.1)
When Eating & Drinking and no Ketones, Were They Transferred to Subcutaneous Insulin?	87.6	7.1	16 (5.7)
Was This Transition to Subcutaneous Insulin Managed Appropriately?	83.4	12.4	12 (4.2)
After DKA Resolution, Were They Reviewed by the DIST?	95.1	3.9	3 (1.1)

Table 5 – n=283

Did the Patient Receive Education Support Before Discharge?	86.8	8.8	13 (4.6)
Did the Patient Receive Psychological Support Before Discharge?	8.1	82.7	26 (9.2)
Did the Discharge Letter Contain all the Correct Clinical Information?	91.2	2.5	17 (6.0)
Did the Discharge Letter Contain the Correct Insulin Dose?	76.3	15.5	23 (8.1)
Did the Discharge Letter Contain the Correct Delivery Device?	56.9	32.5	30 (10.6)
Did the Discharge Letter Contain the Correct Insulin Name?	83.7	8.8	20 (7.1)
Did Follow up by DIST Take Place Within 30 Days?	54.1	31.1	41 (14.5)
Were there Any Post-Discharge Complications?	9.2	83.0	22 (7.8)
Was There a Written Care Plan Between Patient and DIST?	46.6	41.3	34 (12.0)
Was a Copy of the Care Plan sent to GP?	53.4	38.2	24 (8.5)
Did the Patient have Access to Ketone Testing on Discharge?	55.5	26.1	52 (18.4)

Legends

Table 1

Baseline demographics of patients.

Table 2

Management of the patient in the first hour after diagnosis of DKA was made. The number and percentage of missing data for each variable is shown.

JBDS – Joint British Diabetes Societies for Inpatient Care Group

ICU – Intensive Care Unit

FRIII – Fixed Rate Intravenous Insulin Infusion

ECG – Electrocardiogram

CXR – Chest X-Ray

EWS – Early Warning Score

Table 3

Ongoing management between 1 and 24 hours after the diagnosis of DKA was made.

VRIII – Variable Rate Intravenous Insulin Infusion

Table 4

Data showing the management of DKA beyond 24 hours, once the resolution of DKA had been confirmed.

SpR – Specialist Registrar

DIST – Diabetes Inpatient Specialist Team

Table 5

Data showing the management of DKA once resolution had been confirmed.

DIST – Diabetes Inpatient Specialist Team

GP – General Practitioner

Figure 1a

Changes in pH over time

Figure 1b

Changes in bicarbonate over time (mmol/l). The error bars are ±1SD

Figure 1c

Changes in potassium over time (mmol/l). The error bars are ±1SD

Online Appendix 1

Questionnaire sent to adult diabetes teams in all UK hospitals

Online Appendix 2

List of all contributing hospitals, contributors, and the numbers of forms they submitted

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