Medically facilitated discharge of adult diabetic ketoacidosis admissions: precipitants and average length of stay

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Abstract

Aims To assess the impact of medically facilitated discharge by a specialist registrar on diabetic ketoacidosis (DKA) length of stay (LOS) and to collect data from these DKA admissions for a descriptive summary of their clinical and biochemical characteristics.

Method DKA admissions were identified through the electronic patient management system, Monday to Friday over a 9 month period. The admitting team was then offered assistance with discharge planning (‘study intervention’). The registrar also collected clinical information for all identified DKA admissions.

Results There were 71 DKA admissions; 92% had type 1 diabetes and 56% were overnight admissions. Following exclusion of four admissions with prolonged LOS secondary to major comorbidities, mean LOS fell from 3.7 (± 1.0) to 2.8 (± 0.3) days. Facilitated discharge had no major impact on LOS. The commonest precipitant for admission was insulin omission, accounting for 65% of admissions. Local practice was to discharge patients following resolution of acidosis, but prior to complete abolition of ketosis.

Conclusions The majority of DKA admissions were of short duration. Achieving further reduction in LOS is therefore difficult. Insulin omission was the commonest DKA precipitant. Diabetes clinical resources may be best allocated on preventing DKA admissions, rather than facilitating early discharge.

The mean LOS (length of stay) for patients discharged from hospital with DKA (diabetic ketoacidosis) has fallen over the last two decades. Historically, studies from the UK and USA have reported mean LOS of around 6.1 to 6.9 days, but the mean LOS in the United States for patients admitted with DKA as the primary diagnosis has fallen from 5.7 days in 1988 to 3.4 days in 2009. Multiple factors are likely to have contributed to this shortening of mean LOS. These include widespread use of clinical management guidelines, patients’ ability to make an earlier self-diagnosis of DKA and the involvement of specialist diabetes nurses.

Although patient mortality associated with DKA is low, DKA admissions have significant impact on patients’ quality of life and represent an ongoing cost to the health care system.

The primary objective of this prospective study is to assess the impact of providing a facilitated discharge service, with early involvement of an appropriately trained medical specialist (a senior endocrinology registrar attached to the local hospital’s Diabetes Centre) on LOS.
The secondary objectives are to describe the clinical characteristics of patients admitted with DKA, including the triggers for the development of DKA and patients’ biochemical characteristics, including discharge beta-hydroxybutyrate levels.

Method

Setting—The study was undertaken in a tertiary teaching hospital (Christchurch Hospital, New Zealand) that serves a population of predominantly European New Zealanders with a high prevalence of type 1 diabetes; the prevalence in the 20–24 year age group is 427 per 100,000 which approaches the level seen in high risk Scandinavian populations. The hospital serves a geographically well-defined population of around 500,000 people. It has 650 inpatient beds and admits in excess of 35,000 patients annually. The multidisciplinary diabetes team, which is located adjacent to the hospital in the Diabetes Centre, includes registrars undertaking advanced training in endocrinology / diabetes. Admissions with DKA that are not able to be treated quickly and ‘turned around’ by the Emergency Department team are usually cared for by the Department of General Medicine.

Only a minority of the General Medicine teams are led by consultants with a specialist interest in diabetes. The General Medicine teams can access input from both nursing and medical members of the multidisciplinary diabetes team but typically this might occur late during DKA admission. The study took place between February and November 2010.

Intervention—Prior to commencement of this study, local diabetologists and endocrine trainees were asked to identify modifiable delays in the DKA discharge process. These included late switching of intravenous variable insulin infusion to subcutaneous insulin, not providing patients with an appropriate and timely prescription for diabetes related medical products and not replacing or upgrading diabetes medical devices. An additional delay related to the time associated with processing a referral from the admitting team to the multidisciplinary diabetes team.

The senior registrar’s intervention aimed to provide proactive, timely specialised input at an earlier time point than usual, thereby reducing the delays identified above. Prior to study commencement, the specialist registrar notified all General Medicine consultants and their junior team members about the aims of the study intervention.

Patient identification—The registrar identified adult (>15 years old) admissions with DKA, by checking the hospital’s electronic patient management system each weekday morning. Once a potential DKA admission had been identified, the admitting team was then offered specialist registrar facilitation of patient discharge planning, starting as early during the DKA admission as possible. The registrar was available on weekdays (Monday to Friday), thus patients admitted over the weekend could only be offered the intervention if they were still present on the ward the following Monday.

Calculating length of stay (LOS)—The Coding Department was asked to provide LOS data at completion of the study. Local coding practice is as follows: Irrespective of the time of day an admission occurs, LOS is recorded as Day 1 on the day of admission and the time from midnight is counted as Day 2, thus LOS data is treated as a categorical variable.

A calculation of the time saved on LOS by the intervention was made by the registrar, for each of the patients assessed. Time saved per admission (hours) was obtained by estimating the delay in discharge timing that would have occurred if usual care (typically General Medicine team led decision making) had occurred.

A couple of examples are provided below, to illustrate how these estimations were done: Typically, the transition from intravenous to subcutaneous insulin would be made after the post-acute consultant ward round and the variable insulin infusion would be stopped two hours after the next meal, thus the transition would be complete by the mid-afternoon. The specialist registrar’s early intervention typically allowed earlier transition onto subcutaneous insulin and the time difference between these two clinical processes was estimated.

Similarly, referrals to a diabetes multidisciplinary team member such as the diabetes nurse or dietitian were typically made by General Medicine team after the post-acute ward rounds, usually in the early afternoon. An estimate of the time difference was made between the early activation of these referrals
by the specialist registrar and the time they would have been taken, if the General Medicine team had undertaken these referrals.

Reconciliation of diabetic ketoacidosis (DKA) admissions identified during the study and DKA discharges identified by the Coding Department—On study completion, DKA cases identified by the registrar were checked against the Coding Department’s discharge diagnoses, to ensure that all eligible cases were included in the secondary study outcome; the prospective audit of DKA clinical and biochemical characteristics.

Demographic, clinical and biochemical data—The diagnosis of DKA was based on the presence of hyperglycaemia (blood glucose greater than 10 mmol/L) and also the presence of ketoacidosis. Demographic, clinical and biochemical data that had been collected as part of the patient’s routine clinical care were collated on all identified admissions, including admissions that did not have registrar intervention (weekend admissions, admissions under clinical teams that did not require diabetes registrar involvement in the patient’s care). The type and level of registrar intervention needed for individual patients was recorded. The precipitants for DKA were also identified. Where possible this was done at the time of admission by interviewing the patient and also from collateral history.

If the patient was not directly assessed by the registrar, the relevant information was obtained from discussions with the admitting team or by case note review, during or as soon after the admission as was practically possible. Patients were identified as having recurrent DKA if they had had a previous admission with DKA within the 9-month study period.

In addition to the biochemical information collected routinely by the admitting teams, measurement of capillary beta-hydroxybutyrate was undertaken by the endocrine registrar close to discharge, in selected patients with a paucity of discharge biochemical information. This allowed assessment of the degree of ketosis at discharge for audit purposes. These capillary test results were not conveyed to the General Medicine team.

Unless otherwise stated, averages are given as a mean (± SD). Statistical comparisons were undertaken using standard parametric methods. The study had local Ethics Committee approval (Ethics reference: URA/10/EXP/025).

Results

Number of admissions with diabetic ketoacidosis (DKA)—After reconciliation of cases of DKA identified by the registrar with those identified by the Coding Department, 54 patients with 71 admissions for DKA were identified over the study period.

Forty-four patients had only 1 admission. Ten patients had recurrent admissions: four had 2 admissions, five had 3 admissions and one had 4 admissions. There were no DKA fatalities over the period of study. All subsequent data describes these 71 admissions.

Patient characteristics—Median age was 27 years and age ranged from 15 to 80 years, 40 (56%) DKA admissions were male. With regards to diabetes type, 66 (93%) had type 1 diabetes, four (6%) had type 2 diabetes and one (1%) had pancreatic insulin insufficiency from chronic alcoholic pancreatitis. Five (7%) admissions were for newly diagnosed diabetes; four (6%) type 1 diabetes and one (1%) type 2 diabetes.

Length of stay (LOS): description and exploration of clinical determinants of LOS—LOS ranged from 2 to 32 days, with 40 (56%) admissions staying for 2 days (overnight) and 67 (94%) admissions having a LOS of 7 days or less. Once admitted, no patient was discharged on the same day. LOS distribution for the DKA admissions is summarised in Figure 1.
Figure 1. Length of stay distribution for diabetic ketoacidosis (DKA) admissions (n=71)

![Length of stay distribution for diabetic ketoacidosis (DKA) admissions](chart)

Note: †No patient was admitted and discharged on same day, thus there were no “one day” admissions. Four DKA long stayers labelled as A, B, C and D.

There were four admissions with prolonged LOS and their clinical characteristics are detailed in Table 1.

Table 1. Clinical description of diabetic ketoacidosis (DKA) long stayers (n=4)

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Discharge diagnosis and medical comorbidities</th>
<th>LOS (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>25</td>
<td>Type 1 DM, gastroparesis, anaemia requiring inpatient gastroscopy</td>
<td>12</td>
</tr>
<tr>
<td>B</td>
<td>51</td>
<td>Type 2 DM, concurrent septic illness, cognitive impairment, required rehabilitation</td>
<td>15</td>
</tr>
<tr>
<td>C</td>
<td>46</td>
<td>Alcoholic pancreatitis, alcohol withdrawal, prolonged ICU admission</td>
<td>18</td>
</tr>
<tr>
<td>D</td>
<td>80</td>
<td>New Type 1 DM, ICU admission, prolonged delirium, deconditioning, required rehabilitation and placement</td>
<td>32</td>
</tr>
</tbody>
</table>

Note: LOS=length of stay; DM=diabetes mellitus; ICU=intensive care unit.

Mean LOS for the total (71) admissions was 3.7 (±1.0) days. This fell to 2.8 (±0.3) days when the four longer stay admissions were excluded. The 52 admissions reviewed by the registrar had a median LOS of 2.0 (2.0–6.0) days and mean LOS of 2.7 (±0.3) days. For the remaining 15 admissions that did not receive registrar input, the median LOS was 2.0 (2.0–7.0) days and mean LOS was 3.0 (±0.8) days.

The American Diabetes Association’s DKA diagnostic criteria, defined in their 2009 consensus statement, are more conservative than this study’s more inclusive diagnostic criteria. Considering those admissions of 7 days duration or less (n = 67), 56 admissions satisfied ADA criteria for DKA and their mean LOS of 2.8 (±0.3) days was identical to mean LOS for the 67 admissions, utilising this study’s inclusive criteria.
The mean age of overnight admissions was younger than the mean age of those requiring longer (3 to 7 days) admissions (27 years versus 38 years, \( p = 0.002 \)). There was no relationship between LOS and the biochemical markers of DKA severity, collected on admission. (See below for details of these biochemical markers).

**Registrar intervention: estimated impact on length of stay (LOS)**—The registrar reviewed 55 (78%) of the 71 DKA admissions. The mean number of registrar visits per reviewed admission was 1.8 and the mean amount of time spent by the registrar on each reviewed admission was 2.5 hours.

Typical tasks undertaken by the registrar include assistance in the transition between variable intravenous insulin infusion and subcutaneous insulin treatment in 41 (58%) admissions, provision of new insulin prescriptions on 26 (37%) occasions and provision of ketone testing strips on 22 (31%) occasions.

New blood glucose meters were provided during 16 (23%) admissions. The registrar estimated the amount of time saved on LOS per admission receiving registrar input, to average 3.3 hours.

**Clinical and biochemical assessment of diabetic ketoacidosis (DKA) severity**—Three (4%) DKA admissions were initially managed by the Intensive Care Unit due to the severity of presentation and were later transferred to General Medicine teams. Two (3%) admissions had mild DKA and were managed with subcutaneous insulin injections without the need for intravenous insulin infusion. Capillary and plasma beta-hydroxybutyrate measurements on discharge were obtained for 44 (62%) and 21 (30%) admissions respectively and the majority of these results showed evidence of mild ketosis (see Table 2). DKA biochemical markers are summarised in Table 2.

### Table 2. Biochemical results at admission and discharge (n=71)

<table>
<thead>
<tr>
<th>Biochemical marker</th>
<th>Admission biochemistry</th>
<th>% admissions</th>
<th>Median (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma glucose (mmol/L)</td>
<td>100%</td>
<td>30.8 (12.5–75.1)</td>
<td></td>
</tr>
<tr>
<td>Arterial pH‡</td>
<td>27%</td>
<td>7.16 (6.86–7.35)</td>
<td></td>
</tr>
<tr>
<td>Venous pH‡</td>
<td>89%</td>
<td>7.23 (6.80–7.34)</td>
<td></td>
</tr>
<tr>
<td>Plasma β-OH (mmol/L)</td>
<td>88%</td>
<td>7.18 (0.03–11.5)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biochemical marker</th>
<th>Discharge biochemistry</th>
<th>% admissions</th>
<th>Median (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial pH</td>
<td>16%</td>
<td>7.35 (7.28–7.43)</td>
<td></td>
</tr>
<tr>
<td>Venous pH</td>
<td>55%</td>
<td>7.35 (7.26–7.47)</td>
<td></td>
</tr>
<tr>
<td>Plasma β-OH (mmol/L)</td>
<td>30%</td>
<td>0.86 (0.03–4.74)</td>
<td></td>
</tr>
<tr>
<td>Capillary β-OH (mmol/L)</td>
<td>62%</td>
<td>0.10 (0–2.0)</td>
<td></td>
</tr>
<tr>
<td>HbA1c (mmol/mol)§</td>
<td>79%</td>
<td>108 (57–156)</td>
<td></td>
</tr>
</tbody>
</table>

Note: β-OH=beta-hydroxybutyrate; ‡ Either an arterial pH and / or a venous pH was available for all 71 admissions; §HbA1c expressed in % units is 12.0% (7.4–16.4%).

**Triggers for the development of diabetic ketoacidosis (DKA)**—A single trigger was identified for 47 (66%) admissions, while 24 (34%) admissions had more than one trigger. Omitting or stopping insulin was the major factor in 46 (65%) admissions and in 24 (34%) admissions infection was a factor.

Alcohol was implicated in 9 (13%) admissions, 5 (7%) admissions were for the first presentation of diabetes and 2 (3%) admissions were related to recreational drugs. Triggering factors were unable to be identified in 7 (10%) of the admissions.
Discussion

The study was designed as a feasibility study to ascertain whether it might be possible to reduce DKA LOS with a facilitated discharge model of care. A multicentre randomised controlled trial (RCT) designed to minimise contamination bias (that is, the effect of the intervention ‘spilling over’ into the control group), would then have been the next logical step to investigate the effectiveness of this care model. However, since no statistically significant reduction in LOS was found, the study then focussed on a description of the clinical findings of patients admitted with DKA, including descriptions of DKA severity and triggering factors.

The estimated amount of time saved on length of stay by the registrar intervention was 3.5 hours per reviewed patient. The median LOS during the 9 month study of facilitated discharge was 2 days. This median LOS is shorter than the 3 days (range 1 to 21 days) obtained retrospectively from the 101 DKA admissions from the previous year (2009 LOS data from Coding Department, not analysed for potential miscoding/misclassification), however this study’s mean LOS of 3.7 (±1.0) days is little different from the 2009 mean LOS of 3.1 (±0.5) days.

This lack of overt temporal difference in overall results and also the short median and mean LOS implies that; a) the registrar intervention had only a weak or no effect on overall LOS and that b) we are near the limits for reducing LOS for DKA admissions. Although the facilitated discharge intervention had minimal impact on LOS, it may have offered other benefits that were not measured in this study, such as a reduced amount of time spent on patient care by the admitting team and better patient self-care in the period immediately following discharge.

Patients’ admission biochemical profiles described in the current study are similar to that of earlier studies, thus the trend towards shorter LOS is unlikely to be due to secular differences in biochemical severity of DKA presentation. It was of passing interest to note that younger patients tended to have short overnight stays. This relationship between age and LOS has been described previously.

Secondary analyses showed that insulin omission was the major precipitant for DKA admissions. This was in contrast to the findings from some retrospective studies where infection was the most commonly cited cause. Our findings were however in keeping with two other prospective studies which also found missed insulin injections to be the major factor for admission.

In contrast to a recent Australian report, recreational drugs did not feature prominently as a DKA trigger in our study. It is not known whether this represents a true difference in precipitating factors, reflecting differences in prevalence of substance abuse between Australian and New Zealand populations studied, or whether it represents under-reporting by the patients in our study.

Another secondary finding was that discharges were occurring at a time ketosis was settling, as judged by median plasma beta-hydroxybutyrate level at discharge of 0.86 mmol/L and median capillary beta-hydroxybutyrate of 0.1 mmol/L, rather than when patients showed complete metabolic recovery.

This study has several limitations. The time saved on LOS by the intervention was estimated by the registrar performing the intervention, rather than by an independent third party.
Another study limitation relates to a system limitation associated with the recording of LOS. The current study estimated LOS in number of days. In theory, measurement of LOS could have been undertaken in hours but it would have been difficult to interpret this measurement; the electronic patient management system allows LOS to be calculated in hours but it is based on the discharge summary completion timing rather than the time the patient left hospital. In our local hospital it is not uncommon for patients to leave some time after completion of their discharge summary, for example due to delays in arranging transportation or in arranging review by allied health personnel. The converse is also true, with some patients leaving the hospital when medically stable, prior to formal completion of the discharge summary.

Finally, the study focused on saving bed days (LOS) once admission had occurred, as the diabetes team thought that the later part of the admission was associated with the greatest modifiable delays. Maximal reduction in LOS is however dependent on effective management of the patient journey through all stages of hospital admission process. It may be possible for selected patients with minor DKA to be discharged on the same day as admission, if this event is planned for at the very beginning of the admission process, i.e. in the Emergency Department. However, as DKA admission volumes are low relative to overall admission numbers and as most DKA admissions are brief overnight stays, arguably there is limited incentive to focus on additional interventions aimed at reducing DKA bed day stay, when it is already very short.

**Conclusions**

The LOS for DKA admissions has fallen over the last two decades and we are probably now close to the limits for a safe LOS, with little capacity for any further reduction in LOS. The current study suggests that the commonest precipitant for DKA is insulin omission. Future resources might therefore best be directed towards reducing admissions and particularly reducing recurrent admissions, rather than trying to reduce further the number of days in hospital.

**Competing interests:** Nil.

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