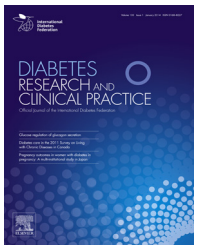
Contents available at ScienceDirect

Diabetes Research and Clinical Practice

journal homepage: www.elsevier.com/locate/diabres

International Diabetes Federation



Brief report

Use of a standardised diabetic ketoacidosis management protocol improved clinical outcomes

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ARTICLE INFO

Article history:
Received 19 August 2013
Received in revised form
13 January 2014
Accepted 14 January 2014
Available online 19 January 2014

Keywords:
Diabetic ketoacidosis
DKA
Management
Protocol
Outcomes

ABSTRACT

We analysed the clinical outcomes of using a standardised protocol in the management of diabetic ketoacidosis. Of 71 admissions, the protocol group ($n = 35$) had significantly shorter length of hospitalisation, shorter time to normalise bicarbonate, fewer incidence of hypokalaemia and hypoglycaemia compared with the control group ($n = 36$).

1. Introduction

Diabetic ketoacidosis (DKA) is a common, acute metabolic complication of diabetes mellitus and can lead to significant morbidity and mortality if not effectively managed. Mortality in the last decade is reported to be 0.2–2% in developed countries [1–3]. Management of DKA includes rehydration, insulin, replacement of electrolytes especially potassium, correction of acidosis and treatment of the precipitating factor [1,4]. Several health professionals are usually involved in the management of DKA especially after hours using variable regimens. Over the last decade, efforts to standardise DKA management have been shown in other countries to have a positive impact on patient care [5–7] but it has not been reported in an Australian setting.

We aimed to analyse whether using a standardised protocol improves clinical outcomes in the acute management of DKA at a tertiary teaching hospital in Australia.

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0168-8227/$ – see front matter.
http://dx.doi.org/10.1016/j.diabres.2014.01.016

2. Patients and methods

Admissions with DKA in patients aged ≥16 year for the period January 2008–March 2012 were identified from the Townsville Hospital medical records. 40 consecutive admissions managed according to the protocol (January 2010–March 2012) and another 40 admissions managed by non-standardised practice between January 2008 and December 2009 who served as control were reviewed using medical notes and electronic pathology results. Patients who self-discharged against medical advice before resolution of acidosis and those who stayed in hospital for more than 96 h without ongoing issues with DKA (5 in the protocol group and 4 in the control group) were excluded.

The protocol was adapted from the Scottish National DKA protocol [8] and modified to meet local practice need. It involved fluid resuscitation with 0.9% sodium chloride and an initial fixed rate (6 units/h) of intravenous insulin. When blood glucose level (BGL) became <14 mmol/L, 10% dextrose (100 ml/h) was introduced and the IV insulin rate was reduced to 3 units/h to maintain BGL 9–14 mmol/L. Potassium replacement was commenced when serum potassium was <5 mmol/L. Subcutaneous insulin was given at least 2 h before cessation of IV insulin when serum bicarbonate was ≥20 mmol/L and patient tolerated oral food. Patients could be discharged if stable for at least 4 h on subcutaneous insulin.

The main parameters that were compared between the protocol and control groups included mean time taken to normalise serum bicarbonate (time between the start of IV insulin and the time at which the serum bicarbonate was first measured as ≥20 mmol/L), mean length of hospitalisation (recorded time at emergency triage to the time of discharge), incidence of hypoglycaemia, incidence of hypokalaemia, mean total IV insulin dose, mean duration of IV insulin, average BGL reduction in first 3 h, and mean amount of IV fluid.

Data were compared using two-tailed Student's *t*-test, Chi-square and Mann–Whitney *U* tests as applicable. Quantitative data were expressed as mean ± SD.

3. Results

A total of 35 and 36 admissions were included in the protocol and control groups respectively for analysis. The baseline characteristics between the two groups were comparable (Table 1). Compared with the control group, the protocol group had significantly shorter mean time taken to normalise serum bicarbonate (15.1 h in protocol vs. 24.6 h in control) ($P = 0.01$), and mean length of hospitalisation (37.9 h vs. 49.2 h) ($P = 0.01$). Subgroup analysis of mean time taken to normalise serum bicarbonate in patients with initial bicarbonate ≤10 mmol/L showed that the protocol group took 11.4 h less than the control group ($P = 0.05$). Incidence of hypokalaemia and hypoglycaemia were significantly lower in the protocol group; 28.6% in the protocol group vs. 52.8% in the control group for hypokalaemia ($P = 0.038$), and 8.6% in the protocol group vs. 28% in the control group for hypoglycaemia ($P = 0.036$). There was no significant difference in the mean total IV insulin dose, total amount of IV fluid or average BGL reduction (Table 2).

Table 1 – Baseline characteristics.

Characteristics	Protocol ($n = 35$)	Control ($n = 36$)	P value
Mean age (yrs)	30 ± 13	27 ± 8	P = 0.19
Gender	*n* (%)	*n* (%)	P = 0.73
Male	15 (43%)	14 (39%)	
Female	20 (57%)	22 (61%)	
Aetiology	*n* (%)	*n* (%)	P = 0.30
Missed insulin	14 (40%)	17 (47%)	
Infection	10 (29%)	13 (36%)	
New diagnosis of DM	2 (6%)	3 (8.5%)	
Alcohol	6 (17%)	3 (8.5%)	
Other	3 (8%)*	–	
Type of DM	*n* (%)	*n* (%)	P = 0.1
Type 1	34 (97.1%)	34 (94.5%)	
Type 2	1 (2.9%)	2 (5.5%)	
Mean blood glucose on presentation	28.68 ± 11.93 mmol/L	28.61 ± 9.6 mmol/L	P = 0.98
Ketones on presentation	*n* (%)	*n* (%)	P = 0.16
Small	4 (2%)	1 (3%)	
Moderate	2 (6%)	1 (3%)	
Large	29 (82%)	31(86%)	
No record	–	3 (8%)	
Serum bicarbonate (mmol/L) on presentation	*n* (%)	*n* (%)	P = 0.64
10 or less	16 (46%)	18 (50%)	
10.1–15	10 (29%)	12 (33%)	
More than 15	9 (25%)	6 (17%)	
Mean level	11.6 ± 6.06 mmol/L	10.5 ± 5.25 mmol/L	P = 0.42

* Blocked insulin pump in 1, unknown precipitant in 2 admissions.

Table 2 – Summary of clinical outcomes.

Outcomes	Protocol	Control	P value
Mean time taken to normalise serum bicarbonate	15.1 ± 11.85 h	24.6 ± 17.6 h	P = 0.01*
Mean time taken to normalise serum bicarbonate in patients with initial bicarb ≤10 mmol/L	20.4 ± 11.08 h	31.08 ± 17 h	P = 0.05
Mean length of hospitalisation	37.9 ± 15.9 h	49.2 ± 17.67 h	P = 0.01*
Incidence of hypoglycaemia	8.6%	28%	P = 0.036*
Incidence of hypokalaemia	28.6%	52.8%	P = 0.038*
Mean total dose of IV insulin	77.28 ± 44.2 units	84 ± 49.04 units	P = 0.56
Mean duration of IV insulin	21.97 ± 13.18 h	29.8 ± 16.91 h	P = 0.03*
Average BGL reduction	3.52 ± 2.78 mmol/L/h	3.9 ± 2.81 mmol/L/h	P = 0.57
Mean total amount of IV fluid	7.33 ± 3.20 L	8.16 ± 3.17 L	P = 0.28

* Denotes statistically significant P value.

4. Discussion

To our knowledge, this is the first study to show in an Australian setting that using a standardised low-dose-insulin protocol in the management of DKA results in better clinical outcomes. Although approximately 50% of our patients had severe DKA, the mean length of hospitalisation was shorter than the Australian national average of 3–5 days [9]. Using the protocol in our patients shortened hospital stay by 11.3 h and took 9.5 h less for resolution of acidosis in keeping with a recent study using American Diabetes Association protocol [7]. The cost of DKA management is high, averaging USD 13,000 per patient per hospitalisation [10]. Our study suggests that implementation of the standardised protocol could reduce these costs.

In line with other reports [7,11], we observed a high incidence of hypokalaemia in our control group before the introduction of the DKA protocol. Similarly, the incidence of hypoglycaemia in our control group (28%) was comparable to previous reports [6,12–14]. The introduction of the protocol in our institution significantly lowered incidence of hypokalaemia and hypoglycaemia.

The underlying differences in clinical practice leading to the better outcomes in the protocol group could be extrapolated from our data as follows. Although there was no statistically significant difference in the total IV insulin dose between the two groups, the mean rate of insulin infused was higher in the protocol group (3.5 U/h) compared with the control group (2.8 U/h). This could explain the more rapid resolution of acidosis achieved in the protocol group. Timely appropriate initiation of dextrose and potassium supplements in the protocol group could have allowed continuation of insulin at a reasonable rate and reduction in incidence of hypoglycaemia and hypokalaemia. Less hypoglycaemia could have also reduced rebound ketosis from a surge in counter-regulatory hormones.

We acknowledge the general limitations of retrospective studies. Nevertheless, our results are generally consistent with other reports [5–7,12–14].

In conclusion, using the standardised protocol improved several clinical outcomes in the management of DKA with significantly shorter time taken to resolution of acidosis, shorter duration of hospitalisation, lower incidence of hypokalaemia and hypoglycaemia. A multi-centre study has been planned.

Conflict of interest

None.

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