Original Article

Management of diabetic ketosis and ketoacidosis with intramuscular regular insulin in a low-resource family medicine setting

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Abstract

Background: India is facing an epidemic of diabetes mellitus (DM). Effective management of complications of DM is a challenge in resource-poor areas of India. This study addresses the need to explore low-cost methods to manage diabetic ketosis (DK) and diabetic ketoacidosis (DKA). **Objectives:** To demonstrate the use of intramuscular (IM) regular insulin as a safe alternative method to control DK and DKA in a family practice setting. **Materials and Methods:** A retrospective chart review was done for 34 patients admitted with DK and DKA in a family medicine unit for the urban poor over 5 years. Data on age, sex, precipitating factors, blood pressure, number of days of hospitalization, amount of insulin, and time required to control blood glucose (BG) and to correct acidosis were entered into EpiData version 3.1 and analyzed using SPSS software version 17. **Results:** Administration of IM regular insulin was effective in reducing the BG to <250 mg/dL in patients with DK and DKA. The mean time required for this in the ketosis group was 3.8 h and in the ketoacidosis group was 3.9 h. The mean amount of insulin required for correction of acidosis in the ketoacidosis group was 72.3 units and the mean time to achieve this was 33 h. Of the 34 patients, only one in the ketoacidosis group had hypoglycemia. There was no fatality or referral of any patient. **Conclusion:** This study demonstrates that IM regular insulin is a safe alternative method in managing DK and DKA in a family medicine setting.

Keywords: Diabetic ketoacidosis, diabetic ketosis, intramuscular insulin

Introduction

Diabetes mellitus (DM) is becoming an epidemic in many countries. Its prevalence is increasing globally, especially in low- and middle-income countries. In the year 2000, India had 31.7 million people with diabetes which was predicted to become 79.4 million by the year 2030.[1] Worldwide, the prevalence of diabetes was 171 million in 2000, and it is expected to be 366 million worldwide by the year 2030.[1]

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The common life-threatening emergencies seen in diabetes are diabetic ketoacidosis (DKA), hyperglycemic hyperosmolar state, and hypoglycemia. A population-based study done in the USA reported the annual incidence of DKA as 4.6/100,000 in the diabetic population.[2] It accounted for more than 100,000 hospitalizations in a year in the USA.[3]

DKA consists of the metabolic triad of hyperglycemia, metabolic acidosis, and increased concentration in ketones. Although DKA is most common in type 1 DM, it can also be seen in type 2 DM when associated with underlying precipitating factors. A study done in a tertiary hospital identified the most common

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precipitating factor to be infections followed by medication noncompliance.[4] The severity of DKA is classified based on blood glucose (BG), bicarbonate level, and sensorium into mild, moderate, and severe [Table 1].[5]

The recommended mode of treatment of DKA is bolus intravenous (IV) or intramuscular (IM) short-acting insulin followed by continuous IV infusion. The IV therapy has the advantage of rapid onset of action and maintenance of a steady level of insulin in the blood. The IV route, however, has the challenges of equipment and workforce, particularly in developing countries and low-resource units. The intermittent IM route has been reported to have good outcomes.[6] The IM route will be a more practical option in low-resource units.

We have been managing mild and moderate DKA with IM insulin therapy in our urban health center. The objective of this study is to document the outcomes of IM insulin route.

Materials and Methods

This study was done in an urban secondary health center which is a 46-bedded hospital equipped with labor room and operation theater serving nearly 200,000 urban poor population. This center is 2 km away from a tertiary health-care center which is the referral unit and run by a group of family physicians, community medicine doctors, and medical officers. There are daily ambulatory clinics where approximately 49,000 consultations are done every year of which 31.2% were for DM.[7]

The inpatient unit does not have intensive care facilities; therefore, management of moderate and mild DKA is by intermittent IM insulin. Severe DKA is referred to the referral unit. This protocol was designed for discussion with endocrine specialists of a referral hospital. On admission, hydration is corrected using normal saline and blood samples are taken to check electrolytes and bicarbonate levels. The diagnosis of DKA is made, if blood sugar is more than 250 mg/dL, urine ketones are positive, and serum bicarbonate level is below 15. A diagnosis of diabetic ketosis (DK) was made, if blood sugar was more than 250 mg/dL, urine ketones were positive, but serum bicarbonate level was normal. The results of serum electrolytes and bicarbonate levels are available after 3 h of sending the sample.

The IM insulin regimen was initiated with a bolus dose of 0.3 units/kg, half of which was given intravenously and half intramuscularly.[8] The intravenous insulin dose was added into the normal saline. The intramuscular insulin dose was administered using tuberculin glass syringe with disposable one-inch long needle into deltoid or gluteal muscle. The blood glucose was monitored every hour by capillary prick using glucometer. Insulin was administered hourly by IM route at the dosage 0.1 units/kg with the aim of achieving a 50–70 mg/dL fall in BG level per hour. If this was not achieved, the dose was doubled. When the BG level fell below 250 mg/dL, the patient was started on dextrose saline infusion with 8 units insulin. The hourly monitoring of glucose was continued for 24 h. The route of insulin administration was changed to subcutaneous route after 24 h. The plasma electrolytes were monitored 6 hourly.

We reviewed inpatient charts where the diagnosis of DKA was made. It was done retrospectively from January 2011 to July 2015. During this period, 44 patients were admitted with the diagnosis of DKA or DK. However, only 34 patients' records were included in this study as the rest of the records had incomplete data. Data on age, sex, BG, electrolytes, precipitating factor, and blood pressure were entered using EpiData version 3.1 (The EpiData Association, Odense Denmark) and analyzed using SPSS version 17 (Chicago, IL). The outcomes that were considered in this study are the mean amount of insulin and mean time required to bring BG <250 mg/dL in both DKA and DK groups. We also

Table 1: Diagnostic criteria for diabetic ketoacidosis

	Mild DKA	Moderate DKA	Severe DKA
Plasma glucose (mg/dl)	>250	>250	>250
Arterial pH	7.25-7.30	7.00-7.24	<7.00
Serum bicarbonate	15-18	10-<15	<10
Urine ketones	Positive	Positive	Positive
Serum ketones	Positive	Positive	Positive
Sensorium	Alert	Alert/drowsy	Stupor/coma

DKA: Diabetic ketoacidosis

Table 2: Clinical characteristics of the patients

	n=17	
	DK	DKA
Age		
Mean (SD)	53.24 (13.75)	48.35 (10.43)
Range	28-80	34-65
Sex, *n* (%)		
Male	8 (47.1)	8 (47.1)
Female	9 (52.9)	9 (52.9)
Glucose		
Mean (SD)	448 (85.11)	458.94 (70.19)
Range	284-596	375-600
SBP		
Mean (SD)	129.38 (24.07)	116.12 (20.20)
Range	90-180	90-178
DBP		
Mean (SD)	78.12 (8.34)	75.00 (8.94)
Range	60-90	60-90
Sodium		
Mean (SD)	131.19 (4.75)	128.88 (4.45)
Range	119-139	118-136
Potassium		
Mean (SD)	4.10 (0.45)	4.38 (0.66)
Range	3.2-5.2	3.0-5.6
Bicarbonate		
Mean (SD)	23.06 (2.78)	15.35 (2.90)
Range	19-27	6-18
Precipitating factor, *n* (%)		
Yes	8 (47.1)	10 (58.8)
No	9 (52.9)	7 (41.2)

SD: Standard deviation; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; DK: Diabetic ketosis; DKA: Diabetic ketoacidosis

calculated the mean amount of insulin and mean time required to correct acidosis in the DKA group. *T*-test was used to compare the means of outcomes in between above two groups.

Results

The mean age of patients admitted with DKA was 48 [Table 2]. The mean BG at admission for patients with DKA was 458 mg/dL. The mean amount of insulin and mean time required to bring BG <250 mg/dL in both DK and DKA patients were similar (P = 0.23 and 0.29, respectively). The mean number of days of hospital stay was 4.18 and 5.29 in the DK and DKA groups, respectively. The BG was brought down to below 250 mg/dL within 4 h approximately [Table 3].

There was no difference in the outcomes of patients admitted with precipitating factors and without precipitating factors among the patients with DKA. The mean duration of hospital stay in patients with DKA was 5.29 [Table 4].

During the course of treatment in the urban health center, only one patient out of the 34 patients had two episodes of hypoglycemia in the DKA group. There were no referrals or deaths among these patients.

Discussion

The management of DKA involves correction of dehydration, hyperglycemia, and electrolyte imbalance. The correction of hyperglycemia is with insulin. Over the years, various routes, doses, and timing of administration have been reported. The efficiency of any one route or dose is decided by the time needed to correct hyperglycemia and the ketoacidosis along with any side effects. Most guidelines recommend low-dose continuous IV insulin by infusion pump.[5] Frequent subcutaneous or IM injection has also been recommended.[9]

The best route of insulin administration is still under debate. Studies done by Fisher *et al.* and Soler *et al.* have demonstrated that when patients with DKA were treated with IV insulin therapy, they have a more rapid fall in plasma glucose, particularly in the 1st h.[9,10] However, after the initial fall, there were no significant differences in the rate of fall of glucose or blood ketones.[9]

In our study, the time by which BG was brought to below 250 mg/dL in patients' with DKA and DK was approximately 4 h. This is similar to the study done in Nigeria, wherein the time required for BG to reach 250 mg/dL in DKA was between 4 and 5 h.[11] In the Nigerian study, this time was same whether the administration was by IV or IM route. The mean amount of insulin required to bring the BG to below 250 mg/dL in our study was 32.8 units which is comparable to the study in Nigeria.[11] There was no mortality or severe complications in our study.

It has been noted that the IM insulin therapy produces more gradual changes in the BG level. The more rapid fall in glucose level in IV insulin therapy can result in severe hypoglycemia if not adjusted correctly. In situations where infusion pumps are not available or feasible, IM insulin would be safer. As noted IM insulin therapy has good outcomes and does not require infusion pumps or complex calculation of infusion rates. The cost of treating DKA with IV insulin is higher as patients are usually admitted in intensive care units to receive IV infusion of insulin.[12]

Conclusion

We conclude that IM insulin therapy is safe and provides similar outcomes though at a slower rate than IV insulin therapy in DKA. The dose of IM insulin therapy can be easily calculated and is flexible and less prone for error. These characteristics recommend the IM route to the nonspecialist clinicians practicing in low-resource rural or urban health centers. Further comparative studies in the Indian scenario will throw more light into its cost-effectiveness in comparison to IV insulin therapy.

Table 3: Treatment outcomes of patients with diabetic ketoacidosis and diabetic ketosis

	n=17		*P*
	DK	DKA	
Insulin (international units) required to bring BG <250 (mg/dl)			
Mean (SD)	24.47 (11.01)	32.81 (15.14)	0.23
Range	0-48	20-74	
Time (h) required to bring BG <250 (mg/dl)			
Mean (SD)	3.88 (3.95)	3.94 (3.02)	0.29
Range	1-18	1-12	
Number of days of hospital stay			
Mean (SD)	4.18 (2.63)	5.29 (3.04)	0.57
Range	1-11	2-15	

BG: Blood glucose; SD: Standard deviation; DK: Diabetic ketosis; DKA: Diabetic ketoacidosis

Table 4: Comparison of treatment outcomes in patients with precipitating factor versus without precipitating factor

	Precipitating factor present (*n*=18)	Precipitating factor absent (*n*=16)	*P*
Number of days of hospital stay	5.56 (3.43)	3.81 (1.68)	0.06
Insulin (international units) required to bring BG <250 (mg/dl)	32.06 (15.87)	24.75 (9.93)	0.12
Time (h) required to bring BG <250 (mg/dl)	4.58 (4.40)	3.18 (2.00)	0.25
Insulin (international units) required to bring bicarbonate>18	83.43 (48.57)	56.80 (17.69)	0.22
Time (h) required to bring bicarbonate >18	34.75 (30.16)	30.125 (8.29)	0.71

BG: Blood glucose

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Conflicts of interest

There are no conflicts of interest.

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