Diabetic Ketoacidosis Treatment Outcomes and Associated Characteristics: Comparison between Type I and Type II Diabetes Mellitus

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ABSTRACT

Diabetic ketoacidosis (DKA) is a serious, life-threatening complication of both type I and type II diabetes mellitus (DM). Differences in the clinical presentation, severity (need for intensive care unit), treatment protocol, and general outcomes (hospital stay, mortality, and hospital costs) of DKA between type I and type II DM groups must be understood to establish a better approach to patient care and clinical outcomes, not only in general but based on specific patient characteristics. Unlike previous studies in which patients with type I and type II DM were studied as one population, this study was conducted to assess DKA outcomes and associated characteristics among patients with type I and type II DM at King Abdelaziz Medical City, Riyadh, Saudi Arabia. A 2017- 2022 retrospective cohort study of DKA in type I and type II diabetes was conducted at a tertiary hospital in Saudi Arabia. All DKA cases were included except those with incomplete medical charts or those <14 years of age. The data were then divided into two groups, type I and type II DM. Each dataset was analyzed using SAS version 9.4 (SAS Institution, Cary, North Carolina, USA). A total of 223 diabetic patients presented to ER with DKA were included in the study, comprising 166 (74.44%) patients with type I DM and 57 (25%.56%) with type II DM. Most of the type I DM group did not have other comorbidities, whereas in the type II DM group, 34 (59.65%) patients had hypertension, 31 (54.39%) had dyslipidemia, seven (12.28%) had chronic kidney disease, six (10.53%) had acute coronary syndrome, and six (10.53%) had heart failure. The frequency of recurrence of DKA per year and clinical presentation of DKA were mostly similar between the two groups. In The most common precipitating factor for DKA in the type I DM group was inappropriate insulin therapy in 87 (52.41%) patients, whereas that of the type II DM group was infection in 22 (38.60%) patients. 54 (32.53%) patients with type I DM required ICU admission, as compared to 17 (29.87%) patients with type II DM. Type I diabetics tended to require a hospital stay of >3 days at 89 (64.91%) patients, as compared to 37 (55.62%) patients with type I DM. Finally, the mortality rate was higher among the type II DM group compared to the type I DM group at three (5.26%) patients and one (0.60%) patient, respectively. The findings of this study demonstrate the importance of studying DKA populations in terms of DM type and creating an evidence-based approach for DKA treatment protocols based on individual patient characteristics. For example, patients who are at increased risk of volume overload such as heart failure, or hemodialysis patients require a special treatment protocol, different from that of the general population, in terms of fluid resuscitation. Understanding the unique characteristics of these populations will help to develop individualized treatment protocols, which will result in significant improvement in clinical outcomes, including decreases in hospital stay, costs, and mortality.

Keywords: diabetic ketoacidosis, type I diabetes mellitus, type II diabetes mellitus, clinical characteristic, hospital stay, cost, mortality, treatment protocol

INTRODUCTION

Diabetic ketoacidosis (DKA) is a life-threatening acute hyperglycemic crisis that results as a complication of diabetes mellitus (DM), with high morbidity and mortality rates among type I and type II diabetics. The condition is well recognized by a triad of significant hyperglycemia, acidosis, and high serum ketones[1]. The most common precipitating factor worldwide is infection followed by insulin non-compliance and less commonly stroke, myocardial infarction, trauma, acute pancreatitis, and sometimes as a first presentation of type I DM[1-3].

DKA can cause critical volume depletion and severe acidosis, which eventually leads to acute kidney injury (AKI) and rarely cardiac arrest if not treated; therefore, prompt diagnosis and initiation of intensive treatment protocol are essential to prevent DKA complications, followed by serial monitoring to avoid the occurrence of iatrogenic complications such as hypoglycemia, hyperchloremic non-anion gap metabolic acidosis, hypokalemia, and cerebral edema[3,4]. DKA can be successfully managed within 1–2 days with an appropriate treatment protocol, with which complications and mortality can be avoided effectively[5-8].

DKA treatment outcomes and clinical characteristics among those with type I *vs*. II DM have not yet been identified in Saudi Arabia. In our previous study conducted at King Abdulaziz Medical City (KAMC), we noticed that 26% of the patients were type II diabetics, representing a good sample for conducting another study to evaluate major differences between type I *vs,* type II DM[9]. A recent study comparing DKA clinical presentation, severity, including need for intensive care unit (ICU), and general outcomes among those with type I *vs.* type II DM found that the type II DM group exhibited a longer hospital stay, higher hospital cost, and increased mortality rate compared to the type I DM group[10]. The aim of the current study is to build a uniform approach to assessing DKA outcomes and associated characteristics not only among DM in general but also among type I and type II DM. To achieve this aim, we assessed DKA outcomes and associated characteristics among patients

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with type I *vs*. type II DM at KAMC, Riyadh, Saudi Arabia.

MATERIALS & METHODS

A 2017- 2022 retrospective cohort study of DKA in type I *and* type II diabetes conducted at a tertiary hospital, KAMC, located in Riyadh, the capital city of Saudi Arabia. All patient data were collected by using the BESTCare HIS System. All DKA cases admitted during the study period were included except those with an incomplete chart or <14 years of age. The data checklist was adapted from our previous study [9]. The data were divided into two groups, type I DM (166, 74.44%) and type II DM (57, 25.56%). The data were collected by the co-authors, and checked for accuracy and completeness by the principal investigator. Before the actual data collection, the data checklist was tested on 15% of the total sample size to ensure its ease of use, and some modifications were made accordingly. The data checklist included socio-demographic information, comorbidities, precipitating factors, frequency or recurrence, clinical presentation, biochemical tests, and DKA treatment protocol.

Categorical variables were presented as frequencies and percentages, whereas continuous variables were presented as means ± standard deviations. Fisher's exact test and the chi-squared test were performed to compare categorical variables. We used the Wilcoxon test for associations between continues variables and two-level categorical variables. Multinomial logistic regression analysis was used to examine the relationship between recurrence of DKA per year, time within which the patient got out of DKA, hospital stay, ICU admission as dependent variables, and DM type as an independent variable. All statistical tests were considered significant at *p*-values of <0.05. Data were analyzed using the statistical software SAS version 9.4 (SAS Institution, Cary, North Carolina, USA).

Ethical approval (Number: NRC22R-621-12) was obtained from the Institutional Review Board at King Abdullah International Medical Research Center.

RESULTS

Demographics and DKA recurrence per year among Type I DM *vs*. Type II DM

We obtained electronic medical records for 223 study subjects, of which 166 (74.44%) had type I DM and 57 (25.56%) had type II DM. In the type I DM group, most patients, 132 (79.52%), were between the ages of 14–30, followed by 20 (12.05%) in the 30–40 age group, nine (5.42%) in the 40–50 age group, three (1.81%) in the 50–60 age group, and two (1.2%) in the >60 age group. The sample was relatively evenly distributed in terms of gender, with 76 (45.78%) male and 90 (54.22%) female patients. Regarding duration of DM, the majority of patients, 98 (59.04%), had DM for >5 years, followed by 35 (21.08%) with DM for 1–5 years, 13 (7.83%) who were newly diagnosed, and 20 (12.05%) not documented in the system. For treatment regimens, 155 (93%) were on insulin only, two (1.2%) were on oral medications only, three (1.81%) used both insulin and oral medications, and six (3.61%) were not on any medications.

In the type II DM group, the majority of patients, 26 (45.61%), were >60 years of age, followed by 16 (28.07%) in the 50–60 age group, seven (12.28%) in the 40–50 age group, five (8.77%) in the 30–40 age group, and three (5.26%) in the 14–30 age group. The sample was relatively evenly distributed in terms of gender, with 30 (52.63%) male and 27 (47.37%) female patients. Regarding duration of DM, the majority, 27 (47.37%), had DM for >5 years, followed by nine (15.79%) with DM for 1–5 years, one (1.75%) who was newly diagnosed, and 20 (35.09%) not documented in the system. For treatment regimens, 29 (50.88%) used insulin only, 16 (28.07%) used both insulin and oral medications, 11 (19.3%) were on oral medications only, and one (1.75%) was not on any medications.

The most common comorbidities in the type I DM group were dyslipidemia, which was found in 19 (11.45%) patients, followed by hypertension in 18 (10.84%) patients, chronic kidney disease (CKD) in five (3.01%) patients, and heart failure in two (1.2%) patients. In contrast, the most common comorbidities in the type II DM group were hypertension, which was found in 34 (59.65%) patients, followed by dyslipidemia in 31 (54.39%) patients, CKD in seven (12.28%) patients, acute coronary syndrome (ACS) in six (10.53%) patients, and heart failure in six (10.53%) patients. Frequency of recurrence of DKA per year was assessed in both populations. In the type I DM group DKA recurrence was once per year in 92 (55.42%) patients, twice per year in 46 (27.71%) patients, and three or more times per year 28 (16.87%) patients. In the type II DM group, DKA recurrence was once per year in 34 (59.65%) patients, twice per year in 15 (26.32%) patients, and three or more times per year in eight (14.04%) patients. Table 1 summarizes the differences between the type I DM and type II DM groups based on age, gender, duration of DM, treatment regimen, comorbidities, and frequency of recurrence per year.

DKA clinical presentation among type I DM and type II DM groups

The most common symptoms among type I DM patients were abdominal pain in 120 (72.29%) patients, followed by vomiting in 109 (65.66%), nausea in 72 (43.37%), polyuria/polydipsia in 31 (18.67%), malaise in 21 (12.65%), anorexia in 10 (6.02%), changes in level of consciousness in nine (5.42%), and weight loss in six (3.61%) patients; and the most common sign of DM was dehydration signs in 109 (65.66%) patients, including dry mucus, poor skin turgor, sunken eyes, tachycardia, and hypotension. In contrast, the most common symptoms among type II DM patients were vomiting in 30 (52.63%), abdominal pain in 23 (40.35%), nausea in 17 (29.82%), polyuria/polydipsia in 11 (19.30%), malaise in 10 (17.54%), anorexia in 10 (17.54%), changes in level of consciousness in eight (14.04%), and weight loss in one (1.75%) patient; and the most common signs were dehydration features in 32 (56.14%) and altered mental status in 12 (21.05%) patients. In the type I DM group, average values for random blood glucose, serum creatinine, serum bicarbonate, and urinary ketones were 26.71 ± 9.88 mmol/L, 115.94 ± 86.19 µmol/L, 12.1 ± 5.73 mEq/L, and 123.07 ± 82.83 mg/dL, whereas those for the type II DM group were 30.39 ± 9.09 mmol/L, 171.47± 131.80 µmol/L, 15.70 ± 8.03 mEq/L, and 79.02 ± 59.26 mg/dL, respectively. Table 2 summarizes the variations in DKA clinical characteristics of the sample among the type I DM and type II DM groups.

DKA precipitating factors among type 1 DM and type 2 DM groups

The most common precipitating factor among type I DM patients was inappropriate insulin therapy in 87 (52.41%) patients, followed by infection in 48 (28.92%), first presentation of DM in nine (5.42%), inappropriate diet in five (3.01%), acute renal failure in three (1.81%), emotional stress in three (1.81%), pancreatitis in one (0.6%), sepsis in one (0.6%), and drug use in one (0.6%) patient. In contrast, the most common precipitating factor among type II DM patients was infection in 22 (38.60%) patients, followed by inappropriate insulin therapy in 17 (29.82%), sepsis in three (5.26%), acute renal failure in three (5.26%), inappropriate diet in three

Table 1. Differences between type I diabetes mellitus and type II diabetes mellitus groups based on age, gender, duration of DM, treatment regimen, comorbidities, and frequency of recurrence per year.

Variable	Type I DM (n=166)	Type II DM (n=57)	*p*-value
Age of the patient (years)	-	-	<0.0001
14–30	132 (79.52%)	3 (5.26%)	-
30.1–40	20 (12.05%)	5 (8.77%)	-
40.1–50	9 (5.42%)	7 (12.28%)	-
50.1–60	3 (1.81%)	16 (28.07%)	-
>60	2 (1.20%)	26 (45.61%)	-
Sex of the patient	-	-	0.3717
Male	76 (45.78%)	30 (52.63%)	-
Female	90 (54.22%)	27 (47.37%)	-
Duration of DM (years)	-	-	0.0008
1–5 years	35 (21.08%)	9 (15.79%)	-
>5 years	98 (59.04%)	27 (47.37%)	-
Newly diagnosed	13 (7.83%)	1 (1.75%)	-
Not documented	20 (12.05%)	20 (35.09%)	-
Treatment regimen for DM	-	-	<0.0001
Insulin	155 (93.37%)	29 (50.88%)	-
Oral medications	2 (1.20%)	11 (19.30%)	-
Both	3 (1.81%)	16 (28.07%)	-
Not on any medications	6 (3.61%)	1 (1.75%)	-
Comorbidities			
Hypertension	-	-	<0.0001
No	148 (89.16%)	23 (40.35%)	-
Yes	18 (10.84%)	34 (59.65%)	-
Dyslipidemia	-	-	<0.0001
No	147 (88.55%)	26 (45.61%)	-
Yes	19 (11.45%)	31 (54.39%)	-
Heart failure	-	-	0.0041
No	164 (98.80%)	51 (89.47%)	-
Yes	2 (1.20%)	6 (10.53%)	-
ACS	-	-	0.0002
No	166 (100.00%)	51 (89.47%)	-
Yes	0 (0.00%)	6 (10.53%)	-
CKD	-	-	0.0137
No	161 (96.99%)	50 (87.72%)	-
Yes	5 (3.01%)	7 (12.28%)	-
Frequency of recurrent DKA per year	-	-	0.8289
Once	92 (55.42%)	34 (59.65%)	-
Twice	46 (27.71%)	15 (26.32%)	-
≥3 times	28 (16.87%)	8 (14.04%)	-

DM: diabetes mellitus, ACS: acute coronary syndrome, CKD: chronic kidney disease. Data are reported as frequency (percentage).

Table 2. Differences in clinical characteristics of diabetic ketoacidosis between type I diabetes mellitus and type II diabetes mellitus groups.

Variable	Type I DM (n=166)	Type II DM (n=57)	*p*-value
Polyuria/Polydipsia	-	-	0.9173
No	135 (81.33%)	46 (80.70%)	-
Yes	31 (18.67%)	11 (19.30%)	-
Nausea	-	-	0.0715
No	94 (56.63%)	40 (70.18%)	-
Yes	72 (43.37%)	17 (29.82%)	-
Vomiting	-	-	0.0798
No	57 (34.34%)	27 (47.37%)	-
Yes	109 (65.66%)	30 (52.63%)	-
Weight loss	-	-	0.6811
No	160 (96.39%)	56 (98.25%)	-
Yes	6 (3.61%)	1 (1.75%)	-

Malaise	-	-	0.3569
No	145 (87.35%)	47 (82.46%)	-
Yes	21 (12.65%)	10 (17.54%)	-
Abdominal pain	-	-	<0.0001
No	46 (27.71%)	34 (59.65%)	-
Yes	120 (72.29%)	23 (40.35%)	-
Anorexia	-	-	0.0086
No	156 (93.98%)	47 (82.46%)	-
Yes	10 (6.02%)	10 (17.54%)	-
SOB	-	-	0.1339
No	147 (88.55%)	46 (80.70%)	-
Yes	19 (11.45%)	11 (19.30%)	-
Changes in LOC	-	-	0.0443
No	157 (94.58%)	49 (85.96%)	-
Yes	9 (5.42%)	8 (14.04%)	-
Weakness	-	-	0.0809
No	160 (96.39%)	51 (89.47%)	-
Yes	6 (3.61%)	6 (10.53%)	-
Looking ill	-	-	0.7405
No	60 (36.14%)	22 (38.60%)	-
Yes	106 (63.86%)	35 (61.40%)	-
Dehydration signs (dry mucous – poor skin turgor – sunken eyes – tachycardia - hypotension)	-	-	0.1983
No	57 (34.34%)	25 (43.86%)	-
Yes	109 (65.66%)	32 (56.14%)	-
Constitutional signs	-	-	0.5919
No	144 (86.75%)	51 (89.47%)	-
Yes	22 (13.25%)	6 (10.53%)	-
Kussmaul respiration	-	-	0.2970
No	156 (93.98%)	56 (98.25%)	-
Yes	10 (6.02%)	1 (1.75%)	-
Ketone breath	-	-	0.5719
No	163 (98.19%)	57 (100.00%)	-
Yes	3 (1.81%)	0 (0.00%)	-
Altered mental status	-	-	0.0037
No	154 (92.77%)	45 (78.95%)	-
Yes	12 (7.23%)	12 (21.05%)	-
	Mean ±STD		***p*-value**
Temperature	36.92±0.48	36.87±0.46	0.8998
Systolic	119.85±15.56	120.39±21.28	0.4434
Diastolic	68.14±12.09	67.12±13.91	0.3961
Pulse rate (beats/min)	107.54±22.06	96.12±21.26	<0.0001
Random blood glucose level (mmol/L)	26.71±9.88	30.39±9.09	0.0096
Serum creatinine (µmol/L)	115.94±86.19	171.47±131.80	<0.0001
serum BUN (mmol/L)	5.89±3.24	11.41±8.98	<0.0001
Serum sodium (mmol/L)	132.33±3.78	132.68±8.64	0.2608
Serum potassium (mmol/L)	4.97±0.82	4.85±0.93	0.2712
Anion gap calculation (mmol/L)	26.90±6.45	26.47±6.51	0.6127
Serum bicarbonate (mEq/L)	12.10±5.73	15.70±8.03	0.0033
Urinary ketones (mg/dL)	123.07±82.83	79.02±59.26	<0.0001
Serum amylase (U/L)	35.05±88.64	26.28±40.41	0.5722
WBC count (x10^9/L)	13.03±5.98	13.99±7.60	0.6106
RBC count (x10^12/L)	5.08±0.71	4.66±0.88	0.0002
Hemoglobin (gm/L)	141.02±24.62	129.00±24.25	0.0002
Platelets (x10^9/L)	355.40±129.20	310.77±126.73	0.0135

DM: diabetes mellitus, SOB: xxx, LOC: level of consciousness, BUN: blood urea nitrogen, WBC: white blood cell, RBC: red blood cell. Data are reported as frequency (percentage).

(5.26%), ACS in two (3.51%), pancreatitis in one (1.75%), cerebral vascular accident in one (1.75%), drug use in one (1.75%), and first presentation of DM in one (1.75%) patient. Table 3 summarizes the precipitating factors and complications of DKA among the type I DM and type II DM groups.

Table 3: Precipitating factors and complications of diabetic ketoacidosis among type I diabetes mellitus and type II diabetes mellitus groups.

Variable	Type I DM (n=166)	Type II DM (n=57)
Inappropriate insulin therapy	87 (52.41%)	17 (29.82%)
Infection	48 (28.92%)	22 (38.60%)
ACS	0 (0.00%)	2 (3.51%)
Sepsis of any origin	1 (0.60%)	3 (5.26%)
Pancreatitis	1 (0.60%)	1 (1.75%)
CVA	0 (0.00%)	1 (1.75%)
Drug induced	1 (0.60%)	1 (1.75%)
Emotional Stress	3 (1.81%)	0 (0.00%)
Any recent surgical intervention (<1 month)	2 (1.20%)	0 (0.00%)
Acute renal failure	3 (1.81%)	3 (5.26%)
Inappropriate diet	5 (3.01%)	3 (5.26%)
Unknown/not documented	6 (3.62%)	3 (5.26%)
First presentation of DM	9 (5.42%)	1 (1.75%)

DM: diabetes mellitus, ACS: acute coronary syndrome, CVA: cerebrovascular accident. Data are reported as frequency (percentage).

DKA outcome among type I DM and type II DM groups

In the type I DM group, the majority of patients, 90 (54.22%), got out of the DKA protocol between 24 and 72 hours, whereas 61 (36.75%) got out of DKA within 24 hours, and 15 (9.04%) got out of DKA after >72 hours. 54 (32.53%) patients needed to be admitted to the ICU, whereas 112 (67.47%) were managed in the medical floor. Regarding hospital stay, 77 (46.39%) patients stayed for 1–2 days, 65 (39.16%) stayed for 3–5 days, and 24 (16.46%) stayed for >5 days. The mortality rate among type I DM patients admitted as a case of DKA was one (0.60%) patient.

In the type II DM group, the majority of patients, 30 (52.63%), got out of the DKA protocol between 24 and 72 hours, whereas 15 (26.32%) got out of DKA within 24 hours, and 12 (21.05%) got out of DKA after >72 hours. 17 (29.87%) patients needed to be admitted to the ICU, whereas 40 (70.18%) were managed in the medical floor. Regarding hospital stay, 20 (35.09%) patients stayed for 1–2 days, 20 (35.09%) stayed for 3–5 days, and 17 (29.82%) stayed for >5 days. The mortality rate among type II DM patients admitted as a case of DKA was three (5.26%) patients.

In the type I DM group, the most common complication in DKA treatment was AKI in 16 (9.64%) patients, followed by hypokalemia in six (3.61%) patients. In contrast, in the type II DM group, the most common complication in DKA treatment was AKI in 14 (24.56%) patients, followed by cardiac arrest in two (3.51%) and hypokalemia in two (3.51%) patients. Table 4 summarizes DKA outcomes among the type I DM and type II DM groups.

Table 4. Diabetic ketoacidosis outcomes among type I DM and type II DM groups.

Variable	Type I DM (n=166)	Type II DM (n=57)	*p*-value
Time within which patient got out of DKA	-	-	0.0401
<24 h	61 (36.75%)	15 (26.32%)	-
24–72 h	90 (54.22%)	30 (52.63%)	-
>72 h	15 (9.04%)	12 (21.05%)	-
Admitted to ICU	-	-	0.7445
No	112 (67.47%)	40 (70.18%)	-
Yes	54 (32.53%)	17 (29.82%)	-
Hospital Stay (days)	-	-	0.0386
1–2	77 (46.39%)	20 (35.09%)	-
3–5	65 (39.16%)	20 (35.09%)	-
>5	24 (14.46%)	17 (29.82%)	-
General treatment outcomes of DKA patients	-	-	0.0524
Showed improvement and discharged	165 (99.40%)	54 (94.74%)	-
Showed no improvement (referred or died)	1 (0.60%)	3 (5.26%)	-
Complications of DKA	-	-	0.0280
No complication	134 (80.72%)	36 (63.16%)	-
Hypoglycemia	4 (2.41%)	1 (1.75%)	-
Hypokaemia	6 (3.61%)	2 (3.51%)	-
Non-anion gap hyperchloremic acidosis	2 (1.20%)	1 (1.75%)	-
Cerebral edema/ brain injury	0 (0.00%)	1 (1.75%)	-
Acute respiratory distress syndrome	1 (0.60%)	0 (0.00%)	-
Acute renal failure	16 (9.64%)	14 (24.56%)	-
Cardiac arrest	1 (0.60%)	2 (3.51%)	-
Other	2 (1.20%)	0 (0.00%)	-

DM: diabetes mellitus, DKA: diabetic ketoacidosis, ICU: intensive care unit.

Relationship between recurrence of DKA per year, time within which the patient got out of DKA, hospital stay, and ICU admission among type I DM and type II DM groups

Multinomial logistic regression analysis showed a significant association between the time within which the patient got out of DKA and DM type. Our reference was type II DM patients who got out of DKA between 24 and 72 hours. We found that type I DM patients were less likely to get out of DKA after >72 hours (p=0.0471). In addition, there was a significant association between hospital stay and DM type. Our reference was type II DM patients who stayed at the hospital for 1–2 days. We found that type I patients were less likely to stay >5 days (p = 0.0131). However, there was no significant association between frequency of DKA recurrence per year, ICU admission, and DM type (p>0.05). Table 5 shows the results of the multinomial logistic

regression analysis, examining the relationship between recurrence of DKA per year, time within which the patient got out of DKA, hospital stay, ICU admission, and DM type.

Table 5. Multinomial logistic regression analysis examining the relationship between recurrence of diabetic ketoacidosis per year, time within which the patient got out of diabetic ketoacidosis, hospital stay, intensive care unit admission, and diabetes mellitus type.

Dependent variable	Independent variable	Odds ratio	95%CI for adjusted odds ratio		*p*-value
			Lower	Upper	
Frequency of recurrent DKA per year = twice	Type I vs. Type II	1.133	0.561	2.289	0.7272
Frequency of recurrent DKA per year ≥ 3	Type I vs. Type II	1.293	0.537	3.114	0.5660
Time within which patient got out of DKA ≤ 24 h	Type I vs. Type II	1.356	0.673	2.729	0.3942
Time within which patient got out of DKA > 72 h	Type I vs. Type II	0.417	0.176	0.989	0.0471
Admitted to ICU = Yes	Type I vs. Type II	1.134	0.590	2.181	0.7053
Hospital Stay = 3-5 days	Type I vs. Type II	0.844	0.418	1.704	0.6363
Hospital Stay > 5 days	Type I vs. Type II	0.367	0.166	0.810	0.0131

DKA: diabetic ketoacidosis, ICU: intensive care unit.

DISCUSSION

Out of 223 patients admitted with DKA in our study, 166 (74.4%) had type I DM and 57 (25.56%) had type II DM. This distribution is comparable that of the general populations of Europe and the Unites States, as reported in two previous retrospective cross-sectional studies, where type I DM was the leading cause of DKA across all age groups, whereas type II DM only accounted for 598 (12%) and 30 (21.7%) cases, respectively[11,12]. This percentage for DKA in type I DM is higher than that of a retrospective study done in 15 tertiary medical centers around China, in which 308 (47.9%) type I DM and 294 (45.7%) type II DM patients experienced DKA, representing similar proportions among groups[13]. In the Chinese study, type I DM was predominant among those <40 years of age, whereas type II DM was predominant among those >40 years of age, which increased with age[13]. Similarly, our results showed that most type I DM patients, 132 (79.52%), were between the ages of 14 and 30, whereas approximately half of type 2 DM patients, 26 (45.61%), were ≥60 years of age.

Clinical presentation for patients with DKA on admission included abdominal pain, which was the most common presenting symptom among those with type I DM at 120 (72.29%) patients, followed by nausea and vomiting. Patients with type II DM mostly presented with vomiting at 30 (52.63%) patients, followed by abdominal pain in 23 (40.35%) patients. Polyuria and polydipsia were similar in both groups but less common than acute gastrointestinal manifestation, which was observed in 31 (18.67%) and 11 (19.30%) type I and type II DM patients, respectively. The most common sign of illness upon presentation was dehydration, which was present in more than half of the patients in both groups. Similarly, the above-mentioned Chinese study found that polyuria and polydipsia were similar in both groups, whereas acute gastrointestinal manifestation was more common among type I diabetics[13].

In our study, the most common precipitating factors for DKA were inappropriate insulin therapy in the type I DM group and infection in the type II DM group, followed by other causes such as first presentation of DM, inappropriate diet, AKI, and emotional stress. Among the type I DM group, inappropriate insulin therapy was the most common precipitating factor, which was found in 87 (52.41%) patients. In contrast, infection was the most common precipitating factor among the type II DM group, which was found in 22 (38.6%) patients. These findings were consistent with those of a large cohort study that was conducted in China comprising 643 patients across 15 tertiary centers, which found that infection was the most common precipitating factor among type II DM patients, representing 133 (44.2%) cases[13].

Regarding complications among DKA patients in our study, acute renal failure was found to be the most common complication among both groups, affecting 16 (9.64%) patients in the type I DM group and 14 (24.56%) patients in the type II DM group. Most patients did not have significant complications. Furthermore, hypokalemia was a common complication, affecting six (3.61%) patients in the type I DM group and three (3.51%) patients in the type II DM group. In a cross-sectional study conducted in the United Arab Emirates (UAE) in which data were collected for 220 diabetic patients admitted with DKA[15], hypokalemia was the most common complication, affecting 37 (16.8%) patients; consistent with our study, most patients, 163 (74.1%), had no complications. These findings raise questions regarding the effect of age, immune status, and other comorbidities in causing more vulnerability to some precipitating factors. As found in Type II DM patients who are likely older and have comorbid conditions would probably be more susceptible to infections compared to Type I DM patients.

Concerning DKA outcomes, the rate of ICU admission in our cohort was almost the same between the type 1 DM and type II DM groups at 54 (32.53%) and 17 (29.82%) patients, respectively. Other studies in Spain and the United Arab Emirates showed higher rates of ICU admission due to severe DKA: 50%–70% for type I DM and 45%–85% for type II DM. These differences can be explained by multiple factors, mainly, early presentation to the emergency room, rapid and aggressive initiation of DKA protocol, and different admission criteria to the ICU[14,15]. Regarding hospital stay, our results showed that most DKA patients required <5 days in the hospital. Nevertheless, 17 (29.82%) DKA patients with type II DM required >5 days. The relatively long period of admission for these patients can be understood from multiple points of view. First, most patients with type 2 DM were in older age groups, of which 42 (73.68%) patients were >50 years old. Furthermore, this population had multiple microvascular and macrovascular complications of DM, in addition to other comorbidities, as shown in Table 1. Our results for hospital stay duration were consistent with those of other studies[13,14].

In more than one-third of DKA patients with type II DM, 21 (36.84%), their hospital stay featured major complications, most commonly AKI, hypokalemia, and cardiac arrest at 14 (24.56%), two (3.51%), and two (3.51%) patients, respectively. Complications also were seen in the type I DM group but to a much lesser extent at 32 (19.28%) patients. Similar to the type II DM group, AKI and hypokalemia were the most common complications, affecting 16 (9.64%) and six (3.61%) patients, respectively. Although other studies in the literature showed similar results, many did not specify the rate of complications[13,14,15].

Study limitations: This study did have some limitations. The majority of the patients in this study had type I DM, which may affect the overall comparison between the two groups. It was also difficult to assess types of IV fluids, rate, and initial bolus requirements due to poor electronic charting and documentation as well as the design of the data sheet. Conducting a large study that includes multiple centers and more patients, as well as modification of the data sheet based on this current study, will help to better evaluate DKA treatment outcomes and associated characteristics among the two DM type groups.

CONCLUSION

The findings of this study demonstrate the importance of studying DKA among type I DM and type II DM patients, and creating an evidence-based approach for DKA treatment protocols based on patient characteristics. Other populations that deserve special focus include overloaded patients such as those with heart failure, or hemodialysis patients presenting with DKA. Further investigation of the characteristics of these populations will support the creation of individualized treatment protocols, which will result in significant improvement in clinical outcomes, including decreases in hospital stay, cost, and mortality.

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