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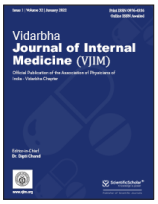

Original Article

Clinical Profile and Outcome of Diabetic Ketoacidosis in Type 1 and Type 2 Diabetes: A Comparative Study

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ABSTRACT

Objectives: To Compare the Clinical and Biochemical Profile of DKA in Type 1 and Type 2 DM in terms of various complications and Mortality.

Material and Methods: In this comparative study, a total of 95 patients admitted to tertiary care centres with DKA from October 2018 to December 2020, were enrolled. They were analysed for clinical profile and outcome in both groups.

Results: Out of 95 patients, Type 1 DM was 18 (18.95%) and 77 (81.05%) were Type 2 DM. Among the clinical presentations, abdominal pain (61.11%) and breathlessness (55.55%) were common in Type 1 DM while breathlessness (40.25%) was the predominant presentation seen in Type 2 DM. There was no significant difference in the biochemical profile of patients in both groups with DKA. The mortality rate was higher in Type 2 DM (12.63%) than Type 1 DM (3.15%). Septicaemic shock (40%) was the most common cause of mortality and the next common was pneumonia in 33%. Severe acidosis, low Glasgow Coma Scale (GCS), high doses and longer duration of insulin therapy, higher acute physiology, and chronic health evaluation II (APACHE-II) score, and high serum osmolality had a bad outcome and were associated with high mortality.

Conclusion: DKA is commonly observed in Type 2 DM also. Infection is the most common precipitating factor for DKA. Type 2 DM had the more severe presentation of DKA as compared to Type 1 DM with DKA. Increased APACHE-II, the requirement of insulin, and length of hospital stay are a predictor of mortality. However, GCS, APACHE-II score, and ABG parameters can predict outcomes in DKA.

Keywords: Type 1 diabetes mellitus, Type 2 diabetes mellitus, Diabetic ketoacidosis, GCS, APACHE2

INTRODUCTION

Diabetic ketoacidosis (DKA) is an acute complication of diabetes mellitus (DM) that can be life threatening if not treated properly.[1,2] This is one of the most common medical emergencies in the world. The annual incidence ranges from 4.6 to 8 cases per 1000 diabetic patients. DKA is associated with a mortality rate of 2–10%.[2] However, DKA is characterised by a triad of hyperglycaemia, metabolic acidosis, and ketonaemia and represents a state of insulin deficiency and concurrent elevation in counterregulatory hormones.[2] The patient may present with a wide range of manifestations such as ketosis, ketoacidosis, ketoacidosis pre-coma, and coma but often these manifestations are submerged in the clinical presentation of precipitating illnesses.[3]

Most patients with DKA have Type 1 diabetes; however, patients with Type 2 diabetes are also at risk during an acute illness such as trauma, surgery, myocardial infarction, or infection. Among these patients, clinical presentation and outcome are diverse.[4]

DKA is classified as mild, moderate, and severe as per the American Diabetic Association. However, there are limited data on the correlation between the severity of DKA and its outcomes using this classification.

Of all the available guidelines, DKA continues to be inadequately managed, even in teaching hospitals.[5,6]

A lot of improvements have been made in early detection and management of both ketoacidosis and the comorbidities to the extent of making changes in the natural history of this illness would certainly, be interesting to look into the present-day scenario of clinical presentation of DKA and the course of illness in the hospitalised patients. Hence, the present study was undertaken to compare the clinical features and biochemical profile in Type 1 and Type 2 DM with ketoacidosis in terms of various complications and mortality.

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MATERIAL AND METHODS

After obtaining the Institutional Ethical Committee approval and written informed consents from all the patients or their relatives, this prospective comparative study was conducted in the department of general medicine at tertiary care hospital in Central India for the period of 2 years from October 2018 to December 2020. A total of 95 consecutive patients of age more than 16 years, who were known diabetics either Type 1 or Type 2 presenting with DKA and those patients with accidental detection of DKA but primarily admitted for other diseases were included in the study. Patients with gestational DM, alcoholic or starvation ketosis, diabetics <16 years of age and non-willingness to participate in the study were excluded from the study.

Diagnosis of DKA was made on the basis of the following criteria such as hyperglycaemia (blood glucose >11 mmol/l); metabolic acidosis (venous pH <7.3 OR serum bicarbonate <15 mEq/L) and urine positive for ketones (>2+ on standard urine sticks). DKA was classified as mild, moderate, and severe based on severity as per the American Diabetes Association.[7]

Definitions of the severity of diabetic ketoacidosis[7]

Parameters	Mild DKA	Moderate DKA	Severe DKA
Plasma glucose (mg/dl)	>250	>250l	>250
Arterial pH	7.25–7.3	7.0–<7.24	<7
Serum bicarbonate (mmol/L)	15–18	10–<15	<10
Anion gap	>10	>12	>12
Mental status	Alert	Alert/drowsy	Stupor/coma

On admission, all the patients were evaluated clinically thoroughly. Biochemical tests such as complete blood counts, liver and renal function tests, serum electrolytes, serum creatinine, and serum osmolality were done. Other tests such as random blood sugar, blood urea, blood pH, and serum bicarbonate estimation were done. Urine albumin and urine ketone body were also estimated. Additional investigations such as electrocardiography, urine microscopy, and culture sensitivity, blood culture and sensitivity, sputum culture and sensitivity (as when needed), and chest X-ray were done to know the source of trigger for ketoacidosis and complications.

After initial patient evaluation and investigations, the patients were graded according to the Glasgow Coma Scale (GCS) [8] and acute physiology and chronic health evaluation II (APACHE-II) scoring systems.[9] Patients were managed with standard care that included insulin, intravenous fluids, and appropriate supportive care. Serial assays of serum electrolytes, glucose, and blood pH were analysed and correlated with clinical outcomes of either discharge to home or death.

Statistical analysis

Continuous variables were presented as mean ± SD whereas categorical variables were expressed in frequency and percentages. Continuous variables were compared between Type 1 and Type 2 diabetes groups performing independent *t*-test and Mann–Whitney U-test while categorical variables were compared between Type 1 and Type 2 diabetes groups by performing Chi-square tests. Multivariate logistic regression was performed to determine independent predictors of diabetes. Adjusted odds ratio and 95% confidence intervals were calculated to find the association of different factors associated with mortality. $P < 0.05$ was considered as statistical significance. Statistical software STATA version 14.0 was used for statistical analysis.

RESULTS

A total of 95 DKA patients were enrolled during the study. Of them, Type 1 DM was 18 (18.95%) and 77 (81.05%) were Type 2 DM. The frequency of DKA was more in males than females 1.87:1. The duration of diabetes and incidence of DKA did not show any statistically significant correlation ($P = 0.861$, NS) in both groups. In overall DKA patients, they were mostly on OHA (45.26%) and 18.94% of cases were not on any treatment since detected for the 1st time as diabetic as DKA presentation [Table 1].

Among the clinical presentations, abdominal pain and breathlessness were most common in Type 1 DM while breathlessness, fever, and vomiting were common in Type 2 DM [Figure 1].

Non-compliance with the treatment and pancreatitis was the most common precipitating factors for DKA in Type 1 DM in 08/18 and 02/18 cases, respectively, and no cause was detected in the remaining eight cases.

Among Type 2 DM with DKA group, lower respiratory tract infection (LRTI) was observed as the most common precipitating factor that is, 20/77 cases. The next common factor was non-compliance for the treatment of DM in 13/77 cases. Stroke and IHD were seen in 07/77 and 06/77 cases, respectively [Table 2].

No comorbidity was detected in Type 1 DM patients with DKA while in Type 2 DM with DKA, hypertension was the most common comorbidity in 31/77 (40.25%) cases followed by ischaemic heart disease 8/77 (10.38%) cases. Nephropathy was the most common complication in Type 2 DM in 14/77(18.18%) cases and only in 3/18 (16.66%) cases in the Type 1 DM group.

On clinical examination, the mean pulse rate was 113.89 in the Type 1 DM DKA group as compared to 99.14 in the

Table 1: Baseline charters of DKA patients in both groups.

Parameters	Type-1 DM (*n*=18)	Type-2 DM (*n*=77)	*P*-value
Demographic data			
Mean age±SD	21.27±7.82	50.50±13.24	<0.0001s
Height (cm)	151.94±10.36	158.83±6.54	0.0006 s
Weight (kg)	45.55±11.73	57.37±7.50	<0.0001s
BMI (kg/m^2)	19.45±3.37	22.71±2.42	<0.0001s
Male	12 (19.35%)	50 (80.64%)	0.890
Female	06 (18.18%)	27 (81.81%)	
Duration of diabetes in years			
0–≤5	12 (20.68%)	46 (79.31%)	
5–10	03 (16.66%)	15 (83.33%)	0.861
≥10	03 (15.78%)	16 (84.21%)	
Treatment			
OHA	00 (0.0%)	43 (100%)	<0.001 s
Insulin+OHA	00 (0.0%)	13 (100%)	0.120
Insulin only	11 (52.38%)	10 (47.61%)	<0.001s
Not on treatment detected 1st time as DM in DKA	07 (38.88%)	11 (61.11%)	0.039

S: Significant, HS: Highly significant

Table 2: Distribution of the study population according to the precipitating factor for DKA.

Precipitating factors	Type-I DM	Type-II DM	*P*-value
Infections (39)			
Lower respiratory tract infection	0	20	0.011
Diabetic foot	0	4	1.000
Urinary tract infection	0	6	0.591
CNS			
Mucormycosis	0	1	1.000
Meningitis	0	1	
AIDP	0	1	
Acute gastroenteritis	1	0	0.189
Skin			
Pemphigus vulgaris	0	1	0.472
Psoriasis	0	1	
SLE	0	1	
Pancreatitis	2	0	0.034
Irregular treatment	8	13	0.023
New onset	4	6	0.091
Others (25)			
Acute coronary syndrome	0	6	0.591
Stroke	0	7	0.218
Seizure	2	1	0.091
Organophosphorus poisoning	0	1	0.811
Cause not found	1	7	0.529

S: Significant, HS: Highly significant

Type 2 DM DKA group which was statistically significant, $P = 0.0026$.

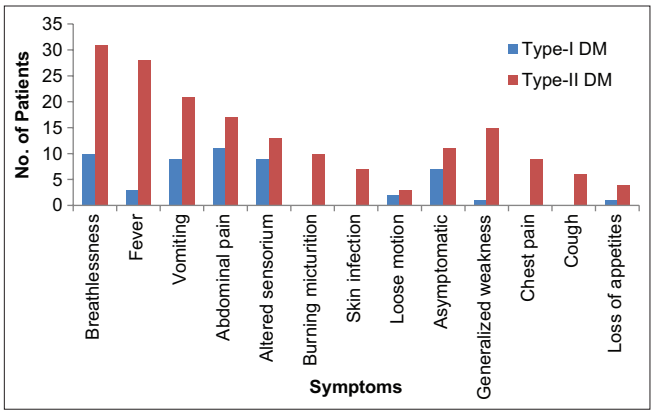

Figure 1: Distribution of the study population according to the symptoms at the time of presentation ($n = 95$).

Mean systolic blood pressure (SBP) revealed a statistically significant difference in both the groups with DKA ($P = 0.0161$). Mean SBP in Type1 DM with DKA was 108.88 and 121.81 in Type 2 DM with DKA group. The parameters such as respiratory rate and diastolic blood pressure did not show a significant difference in both groups.

The biochemical parameters such as serum sodium, total protein, and anion gap showed a significant difference between Type 1 and Type 2 DM with DKA ($P < 0.05$) [Table 3].

In the majority of patients, required insulin doses to clear urinary ketone bodies were 25–50 units, and the duration of intensive insulin therapy was 13–24 h which was not statistically significant in both the groups ($P = 0.462$ and $P = 0.961$, respectively).

Poor (low) GCS score, higher APACHE-II score, and low pH (acidemia) were significantly associated with high mortality in patients of Type 2 DM as compared to Type 1 DM. Low bicarbonate levels and higher anion gap were associated with higher mortality in both Type 1 DM and Type 2 DM but results were statistically not significant [Table 4].

Out of 95 patients, 80 (84.22%) patients were completely recovered from DKA and 15 (15.78%) patients died due to complications. The most common cause of death was septicaemia (40%) followed by pneumonia (33%), then cardiogenic shock (20%), and CVA (6%). The mortality rate in Type 1 DM DKA was 3.15% and in Type 2 DM DKA was 12.63%.

Table 3: Comparison of biochemical parameters with DKA patients in both the groups, *n*=95.

Variables	Type 1 DM (n=18)	Type-2 DM (n=77)	P Value
TLC (*10^3/cumm)	13,012.78±8647.67	11,048.18±5333.90	0.2199
Hb (g/dl)	10.25±1.84	10.08±2.27	0.7715
PLT (*10^3/cumm)	186± (47–510)	207± (75–465)	0.9773
Haematocrit (%)	34.55±11.07	31.69±7.68	0.1975
Na (mmo;/dl)	138±6.51	134.46±6.46	0.0398 s
K (mmol/dl)	3.65±0.81	4.10±0.93	0.0592
Serum urea (Mg/dl)	33.27±22.77	47.47±39.41	0.1238
Serum creatinine (mg/dl)	1.06±0.53	2.00±5.54	0.2332
Total protein (g/dl)	5.62±0.83	6.05±0.71	0.0290 s
Total bilirubin (mg/dl)	0.66±0.39	0.89±0.96	0.1256
ALP (IU/L)	170.83±136.07	149.42±103.30	0.4981
SGOT (IU/L)	49.83±56.24	58.76±97.67	0.6307
SGPT (IU/L)	44.55±55.31	45.59±67.72	0.9521
Serum OSM (mmol/Kg)	312.77±17.04	305.89±16.09	0.1097
Anion GAP (mmol/L)	26.72±8.28	21.87±9.06	0.0409s

S: Significant, HS: Highly significant

Table 4: Correlation between GCS, APACHE-II score, and ABG parameters in both the groups and mortality, *n*=95.

Variables	Score	Total cases (*n*-95)		No. of deaths (%)		Comparing % mortality according to the severity of GCS and APACHE-II and ABG parameters	
		Type-1 DM (*n*=18)	Type-2 DM (*n*=77)	Type-1 DM (*n*=18)	Type-2 DM (*n*=77)	Type-1 DM (*n*=18)	Type-2 DM (*n*=77)
GCS	13–15	10	66	0 (0.0)	7 (10.6)	*P*=0.081	P=0.002,
Mean	9–12	6	8	2 (33.3)	2 (25)	NS	HS
(13.83)	<9	2	3	1 (50)	3 (100)		
APACHE-II	0–10	9	45	0 (0.0)	2 (4.4)	P=0.147	P<0.001
Mean	11–20	8	25	3 (37.5)	4 (16)	NS	HS
(10.97)	21–30	1	5	0 (0.0)	4 (80)		
	>30	0	2	0 (0.0)	2 (100)		
PH	7.3–7.2	7	40	0 (0.0)	6 (15)	0.073	0.001
Mean	7.19–7.1	2	3	0 (0.0)	0 (0.0)	NS	HS
(7.26)	<7.1	6	8	3 (50)	6 (75)		
HCO3	>18	2	23	1 (50)	4 (17.4)	0.183	0.583
Mean	16–18	2	7	0 (0.0)	0 (0.0)	NS	NS
(13.41)	10–15	4	25	1 (25)	3 (12)		
	<10	10	22	1 (10)	5 (22.7)		
Anion gap	>30	7	13	2 (28.5)	3 (23.1)	0.760,	0.767
Mean	21–30	7	30	1 (14.2)	5 (16.6)	NS	NS
(22.79)	10–20	4	28	0 (0.0)	4 (14.3)		
	<10	0	6	0 (0.0)	0 (0.0)		

S: Significant, HS: Highly significant

Out of the total 95 cases of DKA, 38 (40%) cases were in the mild category, 24 (25.26%) cases were in the moderate category and 33 (34.74%) were accounting for the severe category. Category-wise intergroup analysis for all clinical and biochemical parameters could not be done due to the non-comparable sample size in both the groups (Type 1 DM 18 and Type 2 DM 77).

Hence, among intragroup analysis of total DKA patients (95 cases) young age, the presence of nephropathy and high APACHE-II score was significantly associated with severe DKA.

Similarly, parameters such as severe metabolic acidosis (low PH, low bicarbonate, and high anion gap), low GCS score, and need for invasive ventilation were also significantly associated with the severe DKA category. *P*-value was statistically highly significant [Table 5].

Various parameters such as low pH, high serum osmolality, high APACHE-II score, low GCS scale, high requirement of insulin dose for clearance of UKB, and short hospital stay were significantly associated with high mortality [Table 6].

In multivariate analysis, variables such as APACHE-II score, the requirement of insulin dose, and hospital stay emerged as significant independent predictors [Table 7] of mortality in the patient of DKA.

DISCUSSION

DKA is a life-threatening metabolic complication in patients with DM.

Table 5: Demographic, clinical, and biochemical characteristics of DKA patients. as per severity.

Parameters	Mild DKA		Moderate DKA		Severe DKA		*P*-value
	n	%	*n*	%	*n*	%	
No. of patients	38		24		33		
Gender							
Male	14	36.84	8	33.33	11	33.33	0.940, NS
Female	24	63.16	16	66.67	22	66.67	
Duration of DM							
<5	27	71.05	14	58.33	19	57.58	0.460, NS
5–<10	7	18.42	4	16.67	5	15.15	
>10	4	10.53	6	25.00	9	27.27	
Plasma glucose on admission	397.42	109.18	430.95	123.00	435.39	125.66	0.3486, NS
PH	7.39	0.06	7.17	0.05	6.48	0.30	<0.0001, HS
Serum bicarbonate	22.65	5.26	12.83	1.48	5.48	2.72	<0.0001, HS
Age at diagnosis of DM (years)							
<40	11	28.95	9	37.50	14	42.42	0.488, NS
≥40	27	71.05	15	62.50	19	57.58	
Type of DM							
1	5	13.16	3	12.50	11	33.33	0.060, NS
2	33	86.84	21	87.50	22	66.67	
Sodium	135.86	6.50	133.5	6.32	135.47	6.86	0.3648, NS
Haemoglobin	10.13	2.12	9.74	1.95	10.35	2.45	0.5815, NS
Potassium	3.98	0.86	4.14	0.93	3.97	1.02	0.7663, NS
Systemic hypertension	13	34.21	7	29.17	11	33.33	0.913, NS
CTB	5	13.16	6	25	6	18.18	0.495, NS
Retinopathy	5	13.16	2	8.33	3	9.09	0.789, NS
Neuropathy	3	7.89	2	8.33	5	15.15	0.562, NS
Nephropathy	3	7.89	9	37.50	5	15.15	0.011, S
IHD	4	10.53	3	12.50	2	6.06	0.686, NS
CKD	1	2.63	1	4.17	1	3.03	0.944, NS
CAD	3	8.33	0	0	0	0	0.090, NS
Stroke	3	7.89	1	4.17	6	9.09	0.771, NS
GCS	14.47	1.67	14.16	1.71	12.84	3.01	0.0086, HS
APACHE-II	9.52	5.77	10.25	5.41	13.18	7.00	0.0395, S
S. osmolarity	307.5	15.15	306.5	17.00	307.36	17.82	0.9712, NS
Anion gap	20.17	8.72	17.87	6.56	29.4	7.18	<0.0001, HS
Invasive ventilation	0	0	4	16.67	12	36.36	<0.0001, HS
Non-invasive	0	0	2	8.33	4	12.12	0.066, NS

S: Significant, HS: Highly significant

Table 6: Comparison of biochemical parameters on admission, doses of insulin, and duration of hospital stay in survivors and non-survivors of DKA.

Parameters	Survivors	Non-survivors	*P*-value
Age in years	44.01±16.13	50.06±20.38	0.2045
pH (on admission)	7.27±0.16	7.1±0.42	0.0061
HCO3 (on admission)	15.71±9.11	14.86±8.87	0.7711
Random blood sugar (on admission)	420.48±108.74	374.06±107.58	0.1148
Anion gap (on admission)	20.47±8.85	24.07±11.31	0.1703
Serum osmolarity (on admission)	305.51±15.27	316.2±19.71	0.0198
APACHE-II (on admission)	9.33±4.66	19.73±6.79	<0.0001 s
GCS (on admission)	14.31±1.68	11.26±3.49	<0.0001 s
Sodium (on admission)	134.87±5.80	136.53±9.94	0.3731
Potassium (on admission)	3.96±0.87	4.33±1.14	0.1567
TLC (on admission)	11371.88±6029.08	11679.33±6638.73	0.8588
Requirement of insulin in unit	57.56±16.05	98.4±26.49	<0.0001s
Hospital stays in days	7.08±3.77	4.60±2.79	0.0055

S: Significant, HS: Highly significant

Table 7: Multiple logistic regression analysis showing independent predictors of mortality.

Predictor	Adjusted odds ratio	95% confidence interval	*P*-value
Requirement insulin	1.14	1.04–1.24	0.002, HS
APACHE-II	1.49	1.04–2.14	0.028, S
Hospital stays in days	0.46	0.22–0.98	0.044, S

S: Significant, HS: Highly significant

The present study provides an evidence-based clinical status of patients with DKA. Results at the end of the study revealed that the APACHE-II score, requirement of insulin dose to clear UKB, and length of hospital stay are the independent predictor of mortality in a patient of DKA which can be used to triage patients for intensive monitoring and timely institution of critical care support.

It is conceptualised that DKA occurs most often in patients with Type 1 diabetes but this is not true. DKA is also reported in Type 2 diabetes; however, it rarely occurs without a precipitating event. Moreover, in a developing country like India, due to poor socioeconomic status, many patients with Type 2 DM tend to have poor compliance and poor control of blood sugar levels so any precipitating factor tends to land them in a state of DKA.

The present study showed more frequency of DKA in Type 2 DM as compared to Type 1 DM. Similar kind of results showing a high incidence of DKA in Type 2 DM came from the previous studies[10,11] while the results of the study conducted by Kitabchi *et al.* revealed a high incidence of DKA in Type 1 DM.[12]

In the present study, infection, especially lower respiratory tract, was observed as the most common precipitating factor in 39 (41.05%) cases followed by non-compliance to the medication of DM in 21 (22.1%) patients. These findings were well correlating with others.[13,14]

Among infections, LRTI (pneumonia) was the most common infection precipitating DKA in 20 (51.28%) of patients followed by urinary tract infection which accounts for 6 (15.38%), and diabetic foot in 4 (10.25%) cases. Similarly, treatment omission/irregular treatment was a major precipitating factor in Type 1 DM.

As previously reported in the literature, 'infection' was the most common precipitating factor for DKA.[15,16] Pneumonia and urinary tract infection account for the majority of infections, which supported the results of this study. However, reports from a few studies showed non-compliance to the treatment.[17-19]

The duration of diabetes and incidence of DKA did not have any correlation ($P = 0.861$, NS) as similar to a study conducted by Maskey *et al.*[11] A significant number of patients that were presented in DKA were on OHA and not on insulin which is comparable with the previous studies.[20,21]

Among symptomatology, abdominal pain was the most common presenting symptom followed by breathlessness in Type 1 DM with DKA while patients of Type 2 DM with DKA presented mostly with symptoms related to respiratory tract infection and breathlessness. These findings were consistent with the results from the previous studies.[16,22,23]

There was no significant difference found in the biochemical profile of Type 1 and Type 2 DM patients ($P > 0.05$) which is comparable with the other studies.[19,24] In non-survivors, the total dose of insulin required was >100 units, suggesting that increasing doses of insulin are associated with high mortality. In non-survivors, the duration required to clear

UKB was >72 h which suggests that a longer duration of insulin therapy is associated with a worse prognosis. Similar results are reported by Efstathiou *et al*.[25] The mortality rate in Type 1 DM was 3.15% and in Type 2 DM was 12.63%. Thus, DKA in patients with Type 2 DM was more severe with worse outcomes compared with Type 1 DM. Similar results were found in other studies.[10,15,22] Factors that contributed to higher mortality in our study could be due to more severe acidosis due to underlying complications of DM and associated infections.

Increased duration of hospital stay was associated with a good outcome. However, low GCS score and high APACHE-II score were significantly associated with poor outcomes in patients of Type 2 DM as compared to Type 1 DM patients with DKA. Hence, GCS and APACHE-II score can be used as important predictor of mortality. There is a plethora of articles supporting this finding.[24,25] Severe acidemia, low serum bicarbonate, and high anion gap were significantly associated with poor outcome. In both Type1 DM and Type 2 DM, but in the present study, a high anion gap did not show any statistically significant association with high mortality in both the groups.[10]

In multiple logistic regression analysis, high APACHE-II score, high doses insulin requirement, and less duration of hospital stay emerged as independent predictors of mortality in DKA patients. We should have an ABG facility while managing the patients of DKA to avoid complications and to have better outcomes

CONCLUSION

DKA is commonly observed in Type 2 DM also. Infection is the most common precipitating factor for DKA. Type 2 DM has a more severe presentation of DKA as compared to Type 1 DM with DKA. APACHE-II score, the requirement of insulin dose, and length of hospital stay are independent predictors of mortality. However, GCS, APACHE-II score, and ABG parameters can predict outcomes in DKA.

Limitations

Our study had a relatively smaller number of patients with Type 1 DM. Studies with more sample size should be undertaken to strengthen the study.

Declaration of patient consent

Consent of Patient/Legally authorised Representative have been taken.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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