



MOST COMMON ECG CHANGES IN DIAGNOSED CASE OF DIABETIC KETOACIDOSIS

Emergency Medicine

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ABSTRACT

Introduction: Diabetic Ketoacidosis (DKA) is a severe complication of diabetes mellitus. Despite advances in care, managing DKA remains challenging due to potential complications and varied clinical presentations. Electrocardiogram (ECG) changes in DKA are of growing interest as potential prognostic indicators, given their association with electrolyte imbalances and cardiac dysfunction. **Methods:** This retrospective observational study analysed ECG findings from DKA patients at KIMS, Bangalore, India. Inclusion criteria comprised diagnosed DKA cases meeting predefined criteria, excluding those with predisposing conditions or medications affecting ECG. Ethical clearance was obtained, and sample size calculated based on previous studies. Data collection includes demographic, clinical and ECG parameters, analysed using statistical tools. **Results:** A total of 35 patients were included, with a gender distribution of 57.1% females and 42.9% males. Most patients (83.0%) exhibited sinus tachycardia, with normal sinus rhythm (NSR) in 14.0% and sinus bradycardia in 3.0%. The prevalence of ECG abnormalities included normal P waves (85.0%), narrow QRS complexes (94.0%), and flat T waves (43.0%). Associations between ECG parameters and patient outcomes were assessed, revealing no significant associations between rate/rhythm, P wave changes, QRS complex changes, T wave changes, PR interval changes, QTc interval changes, and patient outcomes ($p > 0.05$ for all). **Conclusion:** Despite the prevalence of ECG abnormalities in DKA patients, no significant associations were found between these parameters and patient outcomes. These findings highlight the complexity of DKA management and the need for further research to elucidate the role of ECG changes as prognostic indicators. Understanding these relationships may lead to improved risk assessment and management strategies for DKA patients, ultimately enhancing clinical outcomes and reducing mortality.

KEYWORDS

Diabetic Ketoacidosis (DKA), Electrocardiogram (ECG), Patient outcomes, Prognostic indicators, Retrospective observational study, Cardiac abnormalities, Clinical management.

INTRODUCTION

Diabetic Ketoacidosis (DKA) is a potentially life-threatening complication of diabetes mellitus characterized by a triad of hyperglycemia, ketosis, and acidosis. DKA arises predominantly due to insulin deficiency, leading to unchecked gluconeogenesis and ketogenesis, culminating in metabolic derangements^{1,2} and may lead to potential complication. Various factors precipitate DKA. Early recognition and prompt intervention are crucial in mitigating the complications and improving patient outcomes^{3,4}. Electrolyte imbalances commonly seen in DKA can manifest as ECG alterations, predisposing patients to arrhythmias and worsening outcomes. Understanding the spectrum of ECG changes in DKA and their association with patient outcomes could offer valuable insights for risk stratification and management⁵.

Therefore, this retrospective observational study aims to investigate the prevalence and patterns of ECG changes in diagnosed cases of DKA. This research initiative holds promise in enhancing our understanding of DKA pathophysiology and refining risk assessment strategies, ultimately contributing to more effective patient care and outcomes⁶. Notably, DKA can manifest discernible alterations in the electrocardiogram (ECG), often reflecting the systemic metabolic derangements inherent to the condition [2]. Among the most frequently observed ECG changes in DKA are transient ST-segment depression, QT interval prolongation, alterations in T wave morphology, and the emergence of U waves [2]. These changes typically stem from fluctuations in serum electrolytes levels, among other metabolic abnormalities^{11,12}.

Methodologically, the study involves the retrospective analysis of ECGs from a cohort of DKA patients meeting predefined inclusion criteria. Data collection and analysis will adhere to rigorous statistical methodologies, including the assessment of associations between categorical variables using appropriate tests. By leveraging modern analytical tools, we aim to derive meaningful insights from the

collected data, shedding light on the intricate interplay between DKA, electrolyte imbalances, and cardiac function^{14,15}.

Aim And Objectives

1. To study the ECG changes in diagnosed cases of Diabetic Ketoacidosis;
2. To identify the most common ECG changes in diagnosed cases of Diabetic Ketoacidosis;

MATERIALS AND METHODOLOGY

Study Design: This research employs a retrospective observational study design. The study was conducted at KIMS, Bangalore, India. Ethical clearance is obtained from the college ethical committee before commencing the study. All patients meeting the inclusion and exclusion criteria are included in the study.

Inclusion Criteria: Participants included in the study meet the following criteria: 1. Diagnosed with Diabetic Ketoacidosis (DKA) of either sex. 2. Age above 18 years old. 3. Diagnosis of DKA based on the following criteria: Blood Glucose level greater than 250 mg/dl, Presence of Ketonuria, Arterial pH of less than or equal to 7.30, Bicarbonate level of less than or equal to 18 mEq/l, Anion gap of more than 12 (adjusted for albumin).

Exclusion Criteria: Participants are excluded from the study if they have: 1. Underlying conditions predisposing to ECG changes, such as, Structural heart diseases, Heart failure, Myocardial ischemia, Endocrinopathies like Cushing's Syndrome, Hyperpituitarism, Hyperthyroidism, Chronic Kidney Disease. 2. Been taking medications known to affect ECG, including but not limited to: Fluoroquinolones, Macrolides, Trimethoprim, Pentamidine, Azoles, Haloperidol, Droperidol, Thioridazine, Pimozide, Ondansetron, Granisetron, Metoclopramide. Antiarrhythmics including Class 1A (Quinidine, Procainamide, Disopyramide) and Class 3 (Amiodarone, Sotalol, Dofetilide, Ibutilide, Dronedarone).

Sample Size Calculation: The sample size is calculated based on data obtained from a previous study using the formula: $n = Z^2 pq / d^2$, where Z is the standard normal deviate at 95% confidence interval, p is the proportion in the target population, q is $100 - p$, and d is the fixed precision (taken as 15%).

Data Collection: ECGs of the patients are studied for rate and rhythm, P wave, QRS complex, T wave, PR interval, QTc interval, and entered into a master chart. Additional patient information including gender, age, duration of hospital stay, and outcome are also recorded.

Statistical Analysis: Data collected is analyzed using Microsoft 365 Excel and SPSS v21.0. The normality test (Shapiro-Wilk Test) is performed, and results are expressed as frequency with percentage, mean with standard deviation, or median with interquartile range. Associations between categorical variables are assessed using Chi-square test or Fisher's exact test, with statistical significance set at $p < 0.05^{18-22}$.

RESULT & ANALYSIS

Gender Distribution

The study population comprised 35 patients, with 57.1% being females and 42.9% males, who met the specified inclusion and exclusion criteria over a span of 6 months. This gender distribution provided a diverse sample for analysis.

Table 1 Gender Distribution

Gender	Frequency	Percentage
Males	15	42.9
Females	20	57.1

Through a comprehensive investigation of ECG changes in DKA patients, this study seeks to advance our understanding of cardiac involvement in DKA, refine diagnostic and prognostic approaches, and ultimately optimize patient care and outcomes in this critical metabolic disorder^{16,17}.

Age Distribution

The study included patients across various age groups, with the majority falling between 60 to 70 years old, constituting 26% of the total sample. While patients aged 80 to 90 years comprised 3% of the total sample.

Table 2 Age Distribution

AGE GROUP IN (yrs)	FREQUENCY	PERCENTAGE
18 – 20	1	3.0
20 – 30	3	9.0
30 – 40	6	17.0
40 – 50	7	20.0
50 – 60	4	11.0
60 - 70	9	26.0
70 - 80	4	11.0
80 - 90	1	3.0

Rate And Rhythm of ECG

The distribution of rate and rhythm observed in the ECGs of patients diagnosed with diabetic ketoacidosis. These findings underscore the significance of cardiac dysrhythmias as a common manifestation of diabetic ketoacidosis, with sinus tachycardia being the predominant ECG abnormality observed likely in response to the metabolic stress associated with diabetic ketoacidosis.

Table 3 Rate And Rhythm of ECG

Rate and rhythm	Frequency	Percentage
NSR	5	14.0
Sinus tachycardia	29	83.0
Sinus bradycardia	1	3.0

P Wave

The analysis of P wave morphology among patients diagnosed with diabetic ketoacidosis suggest that while a normal P wave morphology is most common, variations such as flat, tall, and polymorphic P waves may also be present in a subset of individuals with diabetic ketoacidosis.

Table 4 Pwave

P WAVE	FREQUENCY	PERCENTAGE
Normal	30	85%

Flat	2	6%
Tall	2	6%
Polymorph	1	3%

QRS Morphology

The analysis of QRS morphology in these patients suggest that narrow QRS complexes are far more prevalent among individuals with diabetic ketoacidosis, indicating relatively normal ventricular depolarization, while a small proportion exhibit broad QRS complexes, potentially indicative of underlying conduction abnormalities or other cardiac pathology.

Table 5 QRS Morphology

QRS MORPHOLOGY	FREQUENCY	PERCENTAGE
Narrow	33	94.0
Broad	2	6.0

T Wave Morphology

The evaluation of T wave morphology among these patients underscore the diversity of T wave abnormalities present in individuals with diabetic ketoacidosis, with flat and normal T waves being the most prevalent patterns, followed by tall and inverted T waves in a smaller subset of patients.

Table 6 T Wave Morphology

T WAVE MORPH	FREQUENCY	PERCENTAGE
Normal	14	40%
Flat	15	43%
Tall	3	8%
Inverted	3	9%

Pr Interval

The analysis findings of PR interval among the patients suggest that a normal PR interval is the most common pattern in individuals with diabetic ketoacidosis, with only a small proportion exhibiting prolongation, potentially indicating atrioventricular conduction abnormalities.

Table 7 Pr Interval

PR INTERVAL	FREQUENCY	PERCENTAGE
Normal	33	94.0
Prolonged	2	6%
Shortening	0	0%

QTc Interval

The assessment of QTc interval among the patients in our study highlight the diverse QTc interval abnormalities present in individuals with diabetic ketoacidosis, with a significant proportion demonstrating prolongation or shortening compared to the normal range. Such deviations in QTc interval may predispose patients to cardiac arrhythmias.

Table 8 QTc Interval

QTc INTERVAL	FREQUENCY	PERCENTAGE
Normal	16	45.7
Prolonged	10	28.5
Short	9	25.7

Duration Of Stay In Hospital And Final Outcome Of The Patients.

In evaluating the outcomes among patients diagnosed with diabetic ketoacidosis, the majority, comprising 77%, experienced a favorable outcome. This indicates that the management and treatment provided resulted in successful recovery or stabilization of their condition. In contrast, 23% of patients had an unfavorable outcome, suggesting complications, deterioration, or potentially fatal outcomes despite medical intervention. The duration of hospital stay varied among patients and was likely influenced by the severity of DKA and any associated complications. This highlights the importance of prompt diagnosis, appropriate management, and vigilant monitoring in optimizing outcomes for individuals with diabetic ketoacidosis.

Table 9 Final Outcome Of The Patients

OUTCOME	FREQUENCY	PERCENTAGE
Favourable	27	77%
Unfavourable	8	23%

The duration of hospital stay among patients diagnosed with diabetic ketoacidosis varied significantly and is as follows

Table 10 Duration Of Stay

DURATION	FREQUENCY	PROPORTION
1 - 3 DAYS	22	63%
4 - 7 DAYS	9	26%
> 7 DAYS	4	11%

Ecg In Dka Patients

Based on the provided data, a qualitative analysis of ECG findings among diabetic ketoacidosis (DKA) patients reveals diverse abnormalities in multiple parameters. The qualitative assessment involves identifying the presence or absence of abnormalities, such as increased or decreased rates, altered wave morphologies, and intervals. For example, sinus tachycardia was the most common rate abnormality observed in 83% of cases, indicating a qualitative assessment of increased heart rates. Similarly, abnormalities in P wave, QRS complex, T wave, PR interval, and QTc interval were identified qualitatively based on the presence of normal or abnormal patterns.

Conversely, a quantitative analysis involves quantifying the frequency or proportion of each abnormality observed in the dataset. For instance, in the quantitative analysis, the percentage of patients exhibiting increased heart rates (83%) compared to normal (14%) or decreased (3%) rates is calculated. Similarly, the proportion of patients with abnormal P wave, QRS complex, T wave, PR interval, and QTc interval are quantified based on the provided data.

In summary, qualitative analysis involves identifying the presence or absence of abnormalities, while quantitative analysis quantifies the frequency or proportion of these abnormalities observed in the dataset. Both types of analysis provide valuable insights into the prevalence and nature of ECG abnormalities among DKA patients, aiding in better understanding and management of this condition.

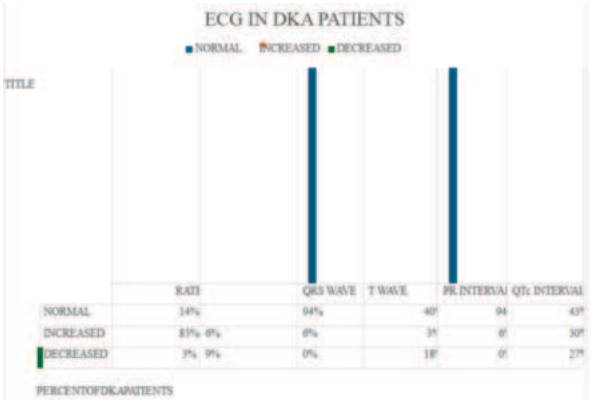


Figure 11 Ecg In Dka Patients

Ecg In Dka Patients With Unfavourable Outcome

The analysis of ECG findings among diabetic ketoacidosis (DKA) patients with unfavorable outcomes reveals distinct patterns both qualitatively and quantitatively. Qualitatively, all patients in this subgroup exhibited increased heart rates, indicative of tachycardia. While the majority demonstrated normal P wave morphology, a portion displayed alterations in P wave amplitude, with 12.50% showing increased amplitude and another 12.50% exhibiting decreased amplitude. However, all patients had normal QRS complexes and PR intervals. In terms of T wave morphology, a significant proportion of patients (37.50%) showed decreased T wave amplitude, although the majority (62.50%) displayed a normal pattern. Quantitatively, these findings are further elucidated, with 100% of patients showing increased heart rates, 75% displaying a normal P wave morphology, and the remaining showing alterations in amplitude. Moreover, all patients had normal QRS complexes and PR intervals. Regarding T wave morphology, the quantitative analysis reaffirms that 62.50% had normal patterns, while 37.50% exhibited decreased T wave amplitude. Additionally, only 25% of patients had a normal QTc interval, with the majority displaying either prolongation or shortening. These comprehensive analyses underscore the significance of ECG monitoring in identifying specific abnormalities associated with unfavorable outcomes in DKA patients, thereby guiding appropriate interventions and management strategies.

Ecg In Dka Cases With Favourable/Unfavourable Outcome

The comparison of ECG findings between diabetic ketoacidosis

(DKA) cases with favorable and unfavorable outcomes reveals distinct patterns. In cases with a favorable outcome, all patients exhibited a normal sinus rhythm, while sinus tachycardia was observed in 72% of cases, indicating an increased heart rate. Most patients displayed a normal P wave morphology (80%), with some showing tall or flat P waves. Additionally, the majority had a narrow QRS complex (75.80%) and normal T waves (64.30%). However, cases with an unfavorable outcome also exhibited normal sinus rhythm, with sinus tachycardia observed in 28% of cases. A lower percentage of patients displayed a normal P wave morphology (20%), with an equal proportion showing tall or flat P waves. All patients had a narrow QRS complex (100%), and abnormal T wave morphologies were more prevalent, with only 35.70% showing normal T waves and none displaying tall T waves. These findings underscore the importance of ECG assessment in predicting outcomes and guiding management strategies for DKA patients, with variations in ECG patterns potentially indicative of different prognoses.

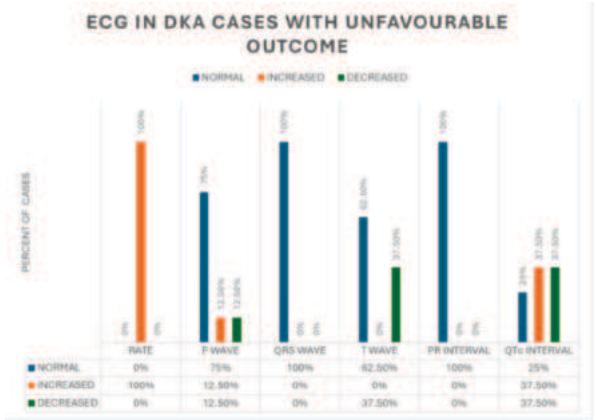


Figure 12 ECG IN DKA PATIENTS WITH UNFAVOURABLE

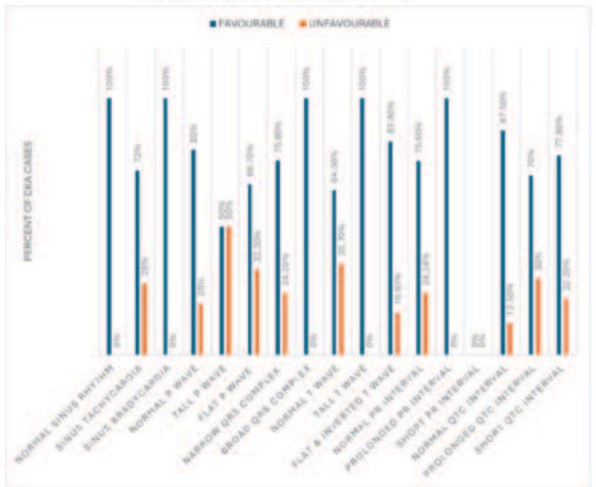


Figure 13 Ecg In Dka Cases With Favourable/ Unfavourable Outcome

Table 11 Ecg In Dka Cases With Favourable/ Unfavourable Outcome

ECG	FAVOURABLE	UNFAVOURABLE
NORMAL SINUS RHYTHM	100%	0%
SINUS TACHYCARDIA	72%	28%
SINUS BRADYCARDIA	100%	0%
NORMAL P WAVE	80%	20%
TALL P WAVE	50%	50%
FLAT P WAVE	66.70%	33.30%
NARROW QRS COMPLEX	75.80%	24.20%
BROAD QRS COMPLEX	100%	0%
NORMAL T WAVE	64.30%	35.70%
TALL T WAVE	100%	0%
FLAT & INVERTED T WAVE	83.40%	16.60%
NORMAL PR INTERVAL	75.60%	24.24%
PROLONGED PR INTERVAL	100%	0%
SHORT PR INTERVAL	0%	0%

NORMAL QTc INTERVAL	87.50%	12.50%
PROLONGED QTc INTERVAL	70%	30%
SHORT QTc INTERVAL	77.80%	22.20%

Association between rate and rhythm of ECG and outcome of the patient

Table 12 Association between rate and rhythm of ECG and outcome of the patient

Rate and rhythm	Favourable (%)	Unfavourable (%)	P value
NSR	5 (100.0)	0 (0.0)	0.342
Sinus bradycardia	1 (100.0)	0 (0.0)	
Sinus tachycardia	21 (72.4)	8 (27.6)	

There was no significant association between rate and rhythm of ECG and outcome of the patient as the p value was found to be >0.05.

Association between changes in p wave and outcome of the patient

Table 13 Association Between Changes In P Wave And Outcome Of The Patient

P wave	Favourable (%)	Unfavourable (%)	P value
Different	0 (0.0)	1 (100.0)	0.176
Flat	1 (50.0)	1 (50.0)	
Normal	24 (80.0)	6 (20.0)	
Tall	2 (100.0)	0 (0.0)	

No significant association was found between p wave changes and outcome of the patient

Association between changes in QRS complex and outcome of the patient

Table 14 Association between changes in QRS complex and outcome of the patient

QRS complex	Favourable (%)	Unfavourable (%)	P value
Broad	1 (100.0)	0 (0.0)	0.730
Narrow	25 (75.8)	8 (24.2)	
Wide	1 (100.0)	0 (0.0)	

There was no significant association between changes in QRS complex and outcome of the patient.

Association between changes in T wave and outcome of the patient

Table 15 Association between changes in T wave and outcome of the patient

T wave	Favourable (%)	Unfavourable (%)	P value
Flat	13 (86.7)	2 (13.3)	0.368
Inversion	2 (66.7)	1 (33.3)	
Normal	9 (64.3)	5 (35.7)	
Tall	3 (100.0)	0 (0.0)	

No significant association was found between T wave changes and outcome of the patient.

Association between changes in PR interval and outcome of the patient

Table 16 Association between changes in PR interval and outcome of the patient

PR interval	Favourable (%)	Unfavourable (%)	P value
Normal	25 (75.8)	8 (24.2)	0.637
Prolonged	2 (100.0)	0 (0.0)	

There was no significant association between length of PR interval and outcome of the patient.

Association between changes in QTC interval and outcome of the patient

Table 17 Association between changes in QTC Interval And Outcome Of The Patient

QTC interval	Favourable (%)	Unfavourable (%)	P value
Normal	14 (87.5)	2 (12.5)	0.402
Prolonged	7 (70.0)	3 (30.0)	
Short	6 (66.7)	3 (33.3)	

No significant association was found between length of QTC interval and outcome of the patient.

The study delved into the intricate association between various

electrocardiogram (ECG) parameters and the outcomes of patients afflicted with diabetic ketoacidosis (DKA). With meticulous attention to detail, researchers meticulously analyzed the relationship between ECG characteristics and the prognostic indicators of individuals grappling with this severe metabolic derangement.

Beginning with the rate and rhythm of the ECG, the investigation uncovered intriguing insights. Despite the diverse manifestations observed, encompassing normal sinus rhythm (NSR), sinus bradycardia, and sinus tachycardia, the analysis discerned no significant association between these rhythmic patterns and the eventual clinical outcomes of the patients ($p > 0.05$). This observation sheds light on the complex interplay between cardiac dynamics and the trajectory of DKA, suggesting that while rhythm irregularities may be prevalent, they do not inherently dictate the course of the disease.

Similarly, the study scrutinized alterations in P wave morphology, QRS complex width, T wave morphology, PR interval duration, and QTc interval length in relation to patient outcomes. Despite the diverse array of electrocardiographic abnormalities observed, ranging from flat or tall P waves to prolonged QTc intervals, no statistically significant associations emerged between these parameters and the favorable or unfavorable outcomes of individuals grappling with DKA ($p > 0.05$ for all).

These findings unveil a nuanced perspective on the utility of ECG parameters as prognostic markers in DKA cases. While the ECG serves as a vital tool for assessing cardiac function and identifying potential abnormalities, its ability to predict the clinical trajectory of DKA patients appears to be limited. Yet, amidst this complexity, lies an opportunity for further exploration and inquiry. Future research endeavors, bolstered by larger sample sizes and enhanced methodologies, may unveil novel insights into the intricate interplay between cardiac dynamics and the clinical course of DKA, paving the way for more targeted and effective interventions in the management of this debilitating condition.

DISCUSSION

The comprehensive investigation into the association between various electrocardiogram (ECG) parameters and outcomes in patients with diabetic ketoacidosis (DKA) provides valuable insights into the cardiac manifestations of this metabolic disorder. The study meticulously analysed various ECG characteristics in relation to patient outcomes. The findings shed light on the potential prognostic value of ECG parameters in DKA management, offering nuanced perspectives on their clinical significance.

Beginning with the assessment of rate and rhythm, the study observed a predominance of sinus tachycardia (83%), followed by normal sinus rhythm (14%) and sinus bradycardia (3%). However, no significant association was found between these rhythmic patterns and patient outcomes ($p > 0.05$). Despite the prevalence of sinus tachycardia, often attributed to the metabolic stress of DKA, its presence did not correlate with unfavorable outcomes, highlighting the complex interplay between cardiac dynamics and DKA prognosis.

Similarly, alterations in P wave morphology, QRS complex width, T wave morphology, PR interval duration, and QTc interval length were scrutinized. While diverse electrocardiographic abnormalities were identified, including flat or tall P waves, prolonged QTc intervals, and variations in T wave morphology, no statistically significant associations were observed with patient outcomes ($p > 0.05$ for all). These findings suggest that while ECG abnormalities are prevalent in DKA patients, they do not independently predict clinical outcomes, emphasizing the multifactorial nature of DKA pathophysiology.

Notably, the study provides detailed quantitative data on the prevalence of specific ECG abnormalities among DKA patients. For instance, 85% of patients exhibited a normal P wave morphology, while 94% had a narrow QRS complex. Additionally, 45.7% of patients had a normal QTc interval, with 28.5% showing prolongation and 25.7% demonstrating shortening. These quantitative analyses offer a comprehensive overview of the spectrum and frequency of ECG changes in DKA, facilitating a deeper understanding of cardiac involvement in this metabolic disorder.

Furthermore, the study highlights the importance of ECG monitoring in DKA management, particularly in identifying early signs of cardiac

dysfunction. While ECG parameters may not independently predict outcomes, they serve as valuable tools for assessing cardiac function and guiding clinical decision-making. Close monitoring of ECG changes can aid in the timely detection of arrhythmias, electrolyte imbalances, and other cardiac complications, enabling prompt intervention and potentially improving patient outcomes.

CONCLUSION

The study underscores the complex relationship between ECG parameters and outcomes in DKA patients. While no significant associations were found between specific ECG abnormalities and patient outcomes, the detailed analyses provide valuable insights into cardiac manifestations in DKA. Future research endeavors should continue to explore the prognostic value of ECG parameters, considering larger sample sizes and more robust methodologies, to further elucidate their role in DKA management. Ultimately, integrating ECG monitoring into clinical practice can enhance risk assessment and optimize care for individuals with DKA, potentially reducing morbidity and mortality associated with this challenging metabolic disorder.

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