



Saint Paul's Hospital Millennium Medical College

Department of Emergency and Critical Care Medicine

**PREVALENCE OF HYPOKALEMIA AND ASSOCIATED FACTORS
AMONG PATIENTS WITH DIABETIC KETOACIDOSIS VISITING
EMERGENCY DEPARTMENT AT ST. PAUL'S HOSPITAL
MILLENNIUM MEDICAL COLLEGE AND ADDIS ABABA, BURN AND
EMERGENCY AND TRAUMA HOSPITAL**

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Prevalence of Hypokalemia and Associated Factors
Among Diabetic Keto-Acidosis Patients Visiting Emergency
Department of Saint Paul's Hospital Millennium Medical College
and Addis Ababa Burn, Emergency and Trauma Hospital: Cross-
Sectional Study

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Approval sheet

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Abbreviations and Acronyms

AA	Addis Ababa
AaBET	Addis Ababa Burn, Emergency and Trauma Hospital
AOR	Adjusted odds ratio
BP	Blood pressure
COR	Crude odds ratio
CNS	Central Nervous System
CI	Confidence interval
DKA	Diabetic Keto Acidosis
DM	Diabetes Mellitus
ECF	Extracellular Fluid
EDHS	Ethiopian Demographic Health Survey
ECCM	Emergency and Critical Care Medicine
ED	Emergency Department
GCS	Glasgow Coma Scale
HHS	Hyper Osmolar State
ICD	International Classification of Disease
ICF	Intracellular Fluid
IDF	International Diabetes Federation
ODK	Open Data Kit
SPHMMC	Saint Paul's Hospital Millennium Medical College
SPSS	Statistical Package for Social Science
WHO	World Health Organization

Abstract

Background: Diabetes ketoacidosis (DKA) is one of the most serious acute complications of diabetes. Although diabetic ketoacidosis (DKA) patients are expected to have low total body potassium levels, measured levels may be low, normal, or elevated due to extracellular potassium shifts caused by acidosis or other factors.

Objective: The purpose of this study is to determine the prevalence of hypokalemia and its associated factors in diabetic ketoacidosis patients admitted to the Emergency Department at St. Paul's Hospital Millennium Medical College (SPHMMC) and AaBET Hospital in Addis Ababa, Ethiopia, from September 2020 to August 2023.

Methods: A facility-based cross-sectional study was conducted. A systematic random sampling technique was used to select 317 patients. Data were collected by electronic capture technique using an open data kit (ODK). SPSS version 20 was used for the analysis. Bivariate analysis was performed at a p-value < 0.25 of significance level to select candidate variables for multivariable analysis, and then in the final model, factors with p-value ≤ 0.05 were declared as significantly associated with hypokalemia in DKA patients.

Results: There were 317 charts reviewed in total, with 150 (47.3%) males and 167 (52.27%) females. The patient's average age was 36.18 ± 14.91 years. The mean potassium concentration was 4.12 (SD ± 0.682 mEq/L). Thirty-one (9.8%) of the 317 study participants had hypokalemia ($K^+ < 3.5$ mEq/l) at presentation. Among the 84 patients with repeated serum potassium levels, The mean level of repeated was 3.91 (SD ± 0.688 mEq/l). During treatment, 23 [7.3%] of the 83 patients with repeated potassium levels developed hypokalemia. Triage score, duration of diabetes, diarrhea, depressed mental status, severity of DKA, and insulin therapy all showed a significant association with hypokalemia after bivariable and multivariable logistic regression analyses.

Conclusion: In this study, hypokalemia was observed in 9.8% of patients with DKA at presentation and 7.3% during DKA treatment. More research is needed to better understand the risks and benefits of administering insulin and other associated factors before obtaining serum potassium levels.

Keywords: diabetic ketoacidosis, hypokalemia, Ethiopia

1. Introduction

1.1. Background of the study

Diabetic ketoacidosis (DKA) is a potentially fatal hyperglycemic emergency characterized by severe metabolic abnormalities such as ketone production, metabolic acidosis, and electrolyte disturbances. The most common electrolyte abnormality detected in DKA patients and a feared complication of DKA treatment is hypokalemia (serum potassium level 3.5 mEq/L) [1, 2]. DKA accounts for roughly 14-16% of all diabetic complications. It is usually caused by an increase in insulin counter-regulatory hormones. This includes increased catecholamine, cortisol, glucagon, and growth hormone production [3].

DKA patients are more likely to experience electrolyte disturbances as a result of hyperglycemia-induced osmotic fluid shifts or osmotic diuresis. Electrolyte abnormalities such as hypokalemia and hypernatremia can occur during DKA and cause significant morbidity, but they are relatively uncommon at the time of presentation before therapy is initiated. During DKA, potassium has an interesting outlook [4]. The most significant electrolyte disturbance in DKA patients is marked total body potassium deficiency. Even though the DKA treatment guidelines include specific potassium replacement protocols, the incidence of hypokalemia during DKA treatment remains high [5]. Serum potassium concentrations at presentation are either normal or high in more than 95% of diabetic ketoacidosis patients, according to studies. Hypokalemia at the time of initial assessment in diabetic ketoacidosis patients is an uncommon complication that occurs in 5% of patients and is caused by a combination of factors [5].

Hypokalemia in diabetic ketoacidosis patients is multifactorial, with increased renal losses (osmotic diuresis) possibly compounded by associated gastrointestinal losses (vomiting) and reduced oral intake. The use of intravenous fluids and insulin to treat DKA promotes additional potassium loss in urine and potassium shift into cells, resulting in a drop in serum potassium concentrations [1, 8]. Furthermore, because diabetics frequently use diuretics, diuretic-associated hypokalemia should be considered in this context [6].

Treatment of diabetic ketoacidosis is typically difficult due to its acute nature and associated medical problems [7]. Hypokalemia is common during acute DKA management and is often avoidable. The inclusion of potassium in IV fluids during hyperglycemia correction is the gold standard of care in the treatment of DKA. Without prompt and adequate potassium supplementation, hypokalemia can develop, with serious consequences such as respiratory muscle weakness, cardiac arrhythmias, and even death [8]. DKA management must also include an electrolyte profile test to monitor changes in electrolyte concentration to reduce the patient's risk of developing fatal complications. To avoid the complications of severe hypokalemia, the American Diabetes Association (ADA) treatment guidelines recommend that serum potassium levels be greater than 3.3 mEq/L before starting insulin treatment for DKA [9].

Cardiac arrhythmia in diabetic ketoacidosis (DKA) is a common complication caused by electrolyte imbalance. Hypokalemia is arrhythmogenic electrophysiologically because it increases both cardiac automaticity and the refractory period of action potential [8]. Diabetic subjects with hypertension, myocardial infarction/ischemia, or heart failure have a higher risk of hypokalemia-related complications [6].

1.2. Statement of the problem

The rising prevalence of diabetic ketoacidosis has a significant impact on health and social care services. According to the WHO global burden of disease, diabetic ketoacidosis and related disorders account for three to six percent of the leading causes of adjusted years lived with disability [10]. Electrolyte disturbances are common in DKA and can have serious consequences for people's lives. Hypokalemia can result in numerous cardiac arrhythmias, muscle necrosis/weakness, and respiratory depression [11]. It has been cited as an important cause to consider in resuscitation-refractory cardiac arrest [9].

While DKA inpatient mortality rates are generally low (5%) in most developed countries, they remain high in developing countries due to mismanagement or unaddressed precipitating factors [5]. The issue that requires immediate attention to improve the quality of DKA care is the higher in-hospital mortality rate in Ethiopia and other parts of the world [12]. Diabetes-related health

issues are on the rise in Ethiopia. Although studies in Ethiopia are limited, they consistently show inadequate metabolic monitoring and the development of hypokalemia in nearly half of treated patients [12]. In Ethiopia, hypokalemia (52%) was the most common reason among the known causes of in-hospital mortality as recorded on the patients' card, followed by hypoglycemia secondary to increased insulin dose (26%), and worsening of DKA (22%). Poor management of co-morbidity treatment, such as hypokalemia and hypoglycemia, has been identified as the most likely cause of such a high mortality rate[12].

According to various studies, even mild or moderate hypokalemia is associated with increased mortality and morbidity[1]. This mortality is unacceptable because it was primarily caused by poor potassium supplementation and insulin-induced hypoglycemia [12]. Even though knowing the status of electrolyte disorders and associated factors in DKA patients is critical, the issues are poorly researched, particularly in Ethiopia. Keeping all of the pieces of evidence in mind, the current study sought to determine the prevalence of hypokalemia and associated factors among DKA patients who visited Emergency Department at SPHMMC and AaBET Hospital [12].

1.3. Significance of the Study

The primary goal of this study is to fill gaps in different clinicians' opinions regarding the management of hypokalemia in DKA patients. It is also expected to increase health workers' knowledge and understanding of the patterns and factors that cause hypokalemia in DKA patients. Electrolyte disorders have a significant impact on patient outcomes, and while treating physicians typically focus on the underlying medical illness, electrolyte disorders are frequently overlooked.

Second, it may aid physicians working in remote areas of the country in making patient selection decisions in cases where serum electrolyte determination is not available. It may serve as a warning to clinicians and stakeholders to focus on modifiable factors (hypokalemia, urinary tract infection, and hypoglycemia) to reduce poor treatment outcomes/in-hospital mortality during DKA management [12]. Furthermore, the findings of this study may be used by local authorities to better understand the extent of hypokalemia in DKA patients and to implement long-term corrective measures as part of standard diabetic care.

2. Literature review

2.1. General prevalence

Diabetes is becoming more common in Ethiopia, as it has in other low-income countries around the world. A recent systematic review estimated the prevalence of diabetes in Ethiopia at 6.5%, with significant interregional variation [27]. According to a recent institution-based, cross-sectional study conducted at Hawassa University Comprehensive Specialized Hospital in Ethiopia, diabetic ketoacidosis was the most common acute complication of diabetes (77%), followed by hypoglycemia (14%), and hyperosmolar hyperglycemic state (9%).

Although hypokalemia has been reported to range from 24% to 81% in the context of DKA treatment [1], initial hypokalemia in the setting of DKA has historically been reported to occur in 4% of patients, with complications such as paralysis and dysrhythmia attributed to insulin administration due to an intracellular shift of potassium. This has historically been tolerated because the "classic" DKA patient is young, thin, and otherwise healthy. However, today's diabetic patient is older and has more co-morbidities [16].

According to one study, approximately 4% to 10% of DKA patients may have low serum potassium levels at first and require much higher amounts of parenteral potassium to prevent life-threatening hypokalemia. Following the initiation of appropriate therapy, serum potassium levels fall as a result of rehydration dilution, continued urinary potassium loss, acidosis correction, and potassium reentry into cells after insulin administration [29]. DKA patients who received supplemental potassium improved their treatment outcomes more than those who did not receive potassium replacement [27].

2.2. Prevalence of Hypokalemia and associated factors in DKA

In a prospective cross-sectional descriptive study conducted in the emergency department of Los Angeles County Hospital at the University of Southern California, 54 (10.7%) of 503 patients with hyperglycemia met all criteria for DKA. 3 (5.6%) of 54 DKA patients (95% confidence interval, 1.2-15.4) had hypokalemia. Hypokalemia was found in 5.6% of the subjects in this prospective sample of 54 DKA patients, which was higher than in previous studies performed at the time of admission or during therapy [17]. In Bangladesh, hypokalemia was present in 36% of the 115 diabetic patients who had both hypo and hyperkalemia on admission. Thiazide diuretics and vomiting were identified as the primary precipitating factors in this study [14]. Vomiting was found to be responsible for hypokalemia in 70% of diabetic hypokalemic study subjects, followed by diarrhea in 38.6%, inadequate intake in 11.4%, drug-induced in 11.4%, and diabetic ketoacidosis in 7.1% of hypokalemic patients in a similar study. In 5.8% of cases, there was no obvious cause of hypokalemia [13].

A retrospective chart review conducted to determine the prevalence of hypokalemia in 40 patients diagnosed with DKA between July 2012 and July 2013 found that the overall prevalence of hypokalemia observed initially presented to the emergency room was 5% and during DKA treatment was 38% (15/40), with 25% in type 1 diabetes and 56% in type 2 diabetes. Those who had hypokalemic episodes were more likely to be male (87% vs. 44%; $p=0.008$), older (48.0 vs. 31.0 years; $p=0.004$), and not yet diagnosed with diabetes (47% vs. 8%; $p=0.021$) [1]. Gavrielatos et al. also examined 56 DKA patients (19 males, 37 females) and discovered 10.7% hypokalemia at admission. According to his data analysis, patients with type 2 DM have moderate to severe DKA, and 6% develop hypokalemia, compared to 13% of patients with type 1 DM and hypokalemia [18]. Charoenpiriya et al. also report that patients with type 1 diabetes had a higher prevalence of severe DKA and hypokalemia after treatment [19].

In a multicenter retrospective study of 494 DKA patients at three urban academic EDs, only seven cases of serum potassium 3.5 mEq/L (none, 3.3) were found (an incidence of 1.4 percent) [8]. Swartzberg J et al. concluded that the incidence of hypokalemia among hyperglycemic patients presenting to the ED with or without DKA appears to be lower than previously estimated. Furthermore, the benefits of early insulin administration may outweigh the risk of causing severe

hypokalemia [8]. A similar multicenter retrospective, cross-sectional study that included 537 DKA patients diagnosed in the ED at participating institutions in the United States discovered a lower incidence of hypokalemia in DKA (1.3 vs. 4%). without any patients presenting with significant hypokalemia ($[K^+ < 3.3 \text{ mmol/L}]$) requiring potassium supplementation before insulin initiation [16].

In a Cross-Sectional Study on factors precipitating hypokalemia in Bangladeshi diabetic Patients, vomiting was found as a factor causing hypokalemia in 63.2% of cases. Other common factors precipitating hypokalemia were diarrhea (42.1%), inadequate diet (9.5%), severe hyperglycemia (3.2%), diabetic ketoacidosis (6.3%), and drugs especially diuretics (18.9%), bronchodilators (6.3%) and steroids (5.3%) [15]. The majority of hypokalemic patients were female and 60 years or older age group in this study [15]. The study at BIRDEM also revealed vomiting and thiazide diuretics as the main precipitating causes of hypokalemia in admitted diabetic subjects [7]

A retrospective cross-sectional study conducted in Saudi Arabia using a chart review to assess DKA treatment outcome and associated factors discovered that AKI and hypokalemia were the most common complications in 30 (13.45%) and 8 (3.59%) of the patients, respectively, in a total of 223 reviewed charts [20]. In one randomized controlled trial involving patients aged >16 years with moderate to severe DKA admitted to the emergency department, the most common adverse effects experienced during DKA treatment were hypokalemia [58 patients (54.7%)] and hypoglycemia [21 patients (19.8%)]. [21].

A retrospective study from a tertiary diabetes center in Thailand that aimed to examine DKA treatment outcomes over a decade reports that during ongoing management, 26.6% of 94 DKA patients developed hypokalemia, and supplementation was not prescribed as per protocol in those patients[23]. Y. Thewjitcharoen et al. concluded in this study that the occurrence of hypokalemia was related to poor adherence to protocol guidance on potassium supplementation [23].

A cross-sectional analytical study of 80 hospitalized DKA patients in Lusaka, Zambia discovered a 15% total prevalence of hypokalemia in these patients. In addition, the prevalence of hypokalemia was higher in comatose patients than in noncomatose patients [25]. Malnutrition, diuretic medication, and prolonged vomiting are also reported as major causes of severe hypokalemia by Marti et al [26].

A facility-based cross-sectional study of 256 patients admitted to Jimma Medical Center with metabolic syndrome found that 44.1% had at least one electrolyte disturbance, with hyponatremia 42.9% (95% CI:39.81-45.99) as the leading electrolyte disorder, followed by hypokalemia 20.7% (95% CI:18.17-23.23). In terms of precipitating factors for electrolyte disturbance, the majority of patients (25.4%) had sustained inadequate intake, followed by vomiting (22.6%). Diarrhea (14.4%), sweating (9.7%), and high-grade fever (pyrexia) (6.6%) were also reported as precipitating factors for electrolyte disturbance [31].

A comparative cross-sectional study of 130 diabetic patients was conducted to assess electrolyte imbalance and associated factors among adult diabetic patients attending the University of Gondar Comprehensive Specialized Hospital in Ethiopia. The prevalence of hypokalemia in diabetic patients was 22.3% [95% CI: 15.9-30.4]. Multiple factors, including inadequate nutrition, alcohol exposure, coexisting hypomagnesemia, insulin therapy, vomiting, and excessive diuretic use, are identified as causes in this study [28]. In a similar study, Keller et al reported that the incidence of hypokalemia was very common, with 23% of DKA cases having a low potassium level [30].

Finally, the reviewed literature demonstrates that DKA is associated with hypokalemia both at presentation and during DKA management. Because of factors such as clinico-demographic characteristics, management protocol, and quality of care, its patterns and responsible factors differ across settings. As a result, DKA management continues to be a source of concern, and factors related to poor adherence to protocol guidance should be addressed to improve DKA management outcomes. Furthermore, there is a dearth of context-specific, up-to-date data describing the clinical profile of diabetic patients presenting with DKA in the current study setting.

2.3. Conceptual Framework

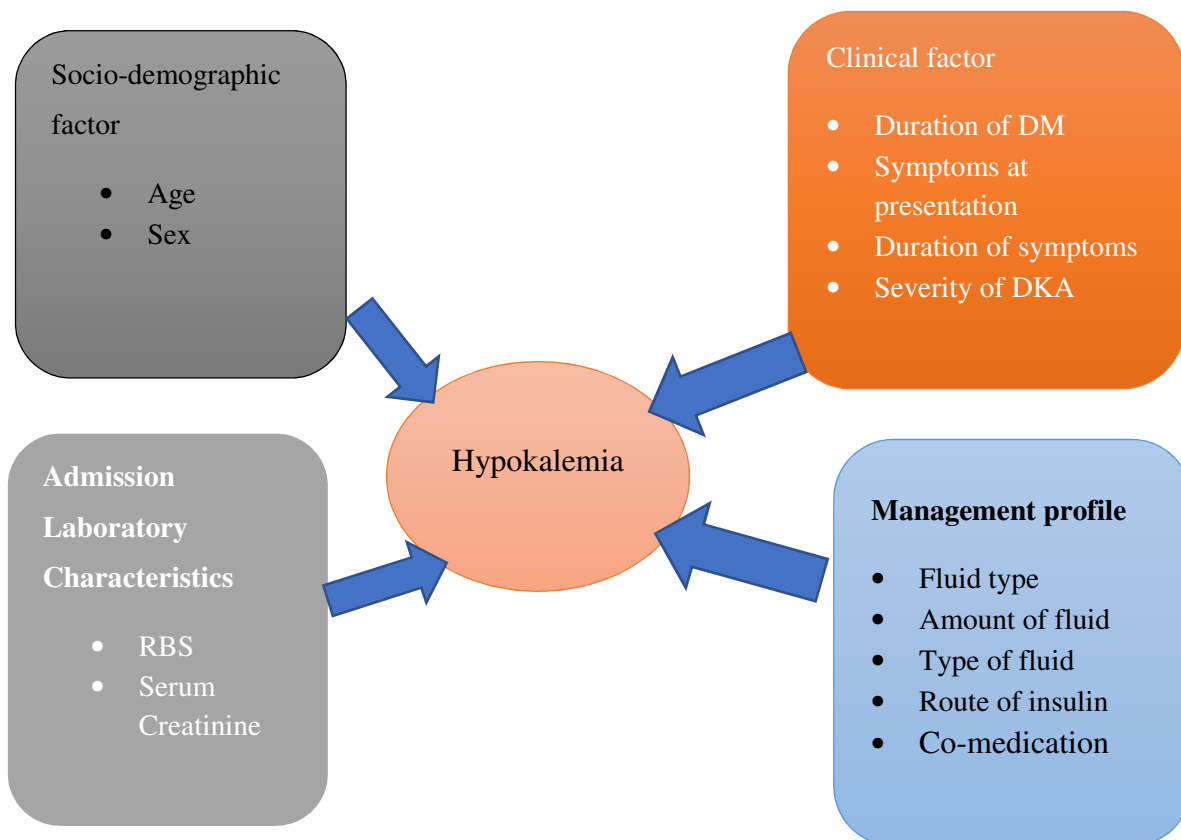


Figure 1. The conceptual framework of this study was developed based on cited studies to determine the prevalence of hypokalemia and related factors among adult patients with diabetic ketoacidosis who visit Emergency Department of Saint Paul's Millennium Medical College and AaBET Hospital in Addis Ababa, Ethiopia, 2023.

3. Objectives of the Study

3.1. General Objective

- To assess the prevalence of hypokalemia and associated factors among diabetic ketoacidosis patients visiting the Emergency Department at Saint Paul's Millennium Medical College and AaBET Hospital in Addis Ababa, Ethiopia, from September 2020 to August 2023.

3.2. Specific Objectives

- To determine the prevalence of hypokalemia among diabetic ketoacidosis patients visiting the Emergency Department patients at Saint Paul's Hospital Millennium Medical College and AaBET Hospital in Addis Ababa, Ethiopia, from September 2020 to August 2023.
- To identify the factors that contribute to hypokalemia among diabetic ketoacidosis patients visiting the Emergency Department at Saint Paul's Hospital Millennium Medical College and AaBET Hospital in Addis Ababa, Ethiopia, from September 2020 to August 2023.

4. Methodology

4.1. Study Setting

Saint Paul's Millennium Medical College is a specialized teaching hospital located in the northwestern part of Addis Ababa, Ethiopia's capital city. It has a catchment population of well over 7 million people, making it one of the country's largest referral centers. There are more than 28 beds in the emergency department. This unit serves approximately 9000 patients each year [32].

AaBET Hospital opened as a public hospital under SPHMMC in 2015, and it is one of the first in the health sector to have a full trauma and burn unit. It has a well-organized emergency and intensive care unit (ICU) with more than 50 beds in the ED.

4.2. Study Period

The study was conducted from September 2020 to August 2023.

4.3. Study Design

A facility-based cross-sectional study was conducted.

4.4. Source Population

All diabetic patients who visit the Emergency Department of SPHMMC & AaBET Hospital.

4.5. Study Population

All diabetic ketoacidosis patients who visit the Emergency Department of SPHMMC & AaBET Hospital.

4.6. Eligibility criteria

4.6.1. Inclusion criteria

- Patients with confirmed DKA
- Patients with determined potassium level at presentation
- Patient age ≥ 15 years

4.6.2. Exclusion criteria

- Decompensated CLD
- Acute heart failure

- ESRD on Hemodialysis
- Pregnant women
- Patients with malignancy

4.7. Sample Size Determination and Sampling Technique

4.7.1. Sample size determination

The single population proportion formula was used to calculate the minimum sample size required for this study. Because there has been no research on this topic in the study area, a prevalence of 50% was used as a guideline. A sample size of 384 diabetic patients was used, with a 95% confidence interval and 5% margin of error.

Using the single population formula, $n = \frac{z^2(1-p)}{d^2}$

n = the required sample size

p = proportion of hypokalemia among DKA 50%

$Z_{\alpha/2}$ = the critical value at 95% confidence level = 1.96

d = precision (margin of error) = 5%

$$n^0 = \frac{(1.96)^2 * 0.50(1 - 0.50)}{0.05^2}$$

$$n^0 = \frac{(1.96)^2 * 0.5(0.5)}{0.05^2}$$

$$n^0 = 384$$

Hence, to compute the final sample size using the correction formula, a 3-year source population was used i.e. **1539**.

$$n = \frac{n^0}{1+(n^0-1)/N}$$

$$n = \frac{384}{1+(384-1)/1539} = 307$$

Hence, adding 10% of the non-response rate, the final sample size becomes 338.

4.7.2. Sampling Technique

A systematic random sampling technique was employed to select 317 study patients after preparing a sampling frame. The study included all patients admitted as DKA cases between September 2020 and August 2023.

4.8. Study Variables

4.8.1 Dependent Variables

- Prevalence of hypokalemia

4.8.2 Independent Variables

- Socio-demographic (age and sex of the study participant)
- Diabetes-related variables/clinical and biochemical variables (type of DM, the severity of DKA, admission blood glucose level, duration of chief complaint, signs and symptoms, comorbidities, DKA precipitating factors)
- Treatment related-variables
- Medication-related variables (co-medication and a therapeutic class of co-medication)

4.9. Operational definitions

- **DKA:** admission blood glucose level >250 milligrams/dL (13.9 mmol/L), an anion gap >10 to 12 mEq/L (>10 mmol/L) a bicarbonate level <15 mEq/L (<15 mmol/L), and a pH <7.3 with moderate ketonuria or ketonemia [3]. In the absence of arterial blood gas analysis, RBS >250mg/dl with urine ketone of +2 and above is consistent with DKA and needs initiation of treatment [33]
- **Hyperglycemia:** RBS >200 mg/dL [3]
- **Hyperkalemia:** serum potassium level of > 5.5 mEq/l [34]
- **Hypokalemia:** serum potassium level less than 3.5mEq/l [34]
- **Impaired renal function** (serum creatinine $\geq$ 1.2 mg/dL [35])

4.10. Data collection

An English-language questionnaire adapted from cited literature was used to collect data for both independent and outcome variables. The collected data was checked for accuracy and completeness every day. The sociodemographics, comorbidities, precipitating factors, clinical presentation, biochemical tests, renal function, and DKA patient management were all covered in the checklist. The data gathered was then analyzed to determine the prevalence of hypokalemia and its associated factors in DKA patients. The primary outcome was the prevalence of overall hypokalemia.

4.11. Data Quality control

Before the data collection process began, the data collectors (two health professionals) received brief training on the data collection process. The principal investigator kept close supervision during data collection, and completed questionnaires were double-checked daily for consistency and completeness by data collectors and the principal investigator before analysis. During the chart review for initial RBS, serum creatinine, and potassium results, the date of admission, triage time, and time of sample collection were all checked. Before data collection, the checklist was tested on 10% of the total sample size to identify any potential issues.

4.12. Data processing and analysis

The data was collected electronically using an open data kit (ODK). It was then downloaded to XLS and exported to IBM_SPSS version 20 for coding and analysis. Frequency, percentages, mean, and standard deviation were used to summarize descriptive statistics. In DKA patients, bivariable and multivariable logistic regression analyses were used to determine the effect of factors on the outcome variable, hypokalemia. The regression model considered age, diabetes type, diabetes duration, diabetes treatment regimen, and comorbidities such as hypertension. The multivariable binary logistic regression analysis included variables with p-values less than 0.25. The Hosmer-Lemeshow tests were used to assess the goodness of fit of the model. Then, at a 95% confidence interval (CI), associations were shown using the adjusted odds ratio (AOR), and variables with p-values less than 0.05 were declared statistically significant.

4.14. Ethical Consideration

The study was conducted after receiving ethical approval from the Ethical Review Board of St. Paul's Millennium Medical College. The Board granted ethical approval with a referral number. Because the data used in this study was secondary, patients' informed consent was not required. After being collected, data was collected, stored, and used confidentially only for research purposes.

5. Results

5.1. Demographics and clinical characteristics

A total of 317 charts were reviewed, with 150 (47.3%) males and 167 (52.27%) females, and nearly half of the patients (167 (52.7%) being between the ages of 20 and 39. 160 (50.5%) of the patients reviewed had type 1 diabetes, while 157 (49.5%) had type 2 diabetes. 183 [57.7%] of patients had diabetes and were taking insulin (73 [23.0%]), oral medication (103 [32.5%]), or both oral and insulin (7 [2.2%]). More than half of the known diabetics (119 [65.0%]) had diabetes for less than five years, while 64 (35.0%) had diabetes for more than five years.

Although the majority of the patients (271 [85.5%]) had no other chronic comorbidities, 37 (11.7%) and 12 (3.8%) had hypertension and cardiac diseases, respectively. Three (0.9%) patients had liver disease, three (0.9%) had RVI, and two (0.6%) had other comorbidities. There was one ischemic stroke and one psychiatric disease discovered. In addition to their diabetes medications, 39 patients with comorbidities are taking other prescriptions. The socio-demographic profile of the study subjects (n=317) patients with DKA who visited the Emergency Department at St. Paul's Hospital Millennium Medical College and AaBET Hospital is shown in Table 1

Table 1. Socio-demographic profile of the study patients admitted to Emergency Department at St. Paul's Hospital, Millennium Medical College, and AaBET Hospital. (N=317)

Variables	Frequency (N)	Percentage (%)
Age (yrs.)		
< 20	35	11.0
20 – 39	167	52.7
40 – 60	94	29.7
> 60	21	6.6
Sex		
Male	150	47.3
Female	167	52.7
Diagnosis of DM		
Known diabetic	183	57.7
Newly diagnosed	134	42.3
Type of DM		
Type I	160	50.5
Type II	157	49.5
Duration of DM (yrs.)		
< 5	119	37.7
≥ 5	64	20.2
Anti-diabetic medications		
Oral medication	103	32.5
Insulin injection	73	23.0
Both oral & insulin	7	2.2
Co-existing comorbidities		
Yes	46	14.5
No	271	85.5
Co-medication		
Diuretics	14	38.9
Others	25	61.1
DKA diagnosed at triage		
Yes	131	41.3

No	186	58.7
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5.2. Clinical presentation and laboratory values of patients who were admitted with DKA

The most common symptoms of DKA were polyurea/polydipsia (259 [81.7%]) and vomiting (151[46.6%]). Furthermore, DKA patients reported fairly on appetite loss (25 [7.9%]), depressed mental status (11[3.5%]), sweating (4 [1.3%]), diarrhea (8 [2.5%]), and other symptoms such as fatiguability, abdominal pain (31 [13.90%]). The majority of patients (199 [62.8%]) presented within two days of the onset of symptoms.

Physical examination revealed that 314 (99.1%) of admitted patients with DKA were noncomatose, with GCS greater than 8/15. During the data review, there were three (0.9%) comatose patients (GCS $\leq$ 8/15). Random blood glucose, serum potassium, and serum creatine levels were 433.88 ± 108.852 mg/dl, 4.123 ± 0.682 mEq/L, and 0.72 ± 0.223 mg/dl, respectively. Severe DKA was found in 13 (4.1%) of the patients, 38 (12.0%) had moderate DKA, and 226 (83.9%) had mild DKA. Table 2 displays the clinical presentation and laboratory values of DKA patients who visited Emergency Department at St. Paul's Hospital, Millennium Medical College, and AaBET Hospital.

Table 2. Clinical presentation and laboratory value of DKA patients admitted to Emergency Department at St. Paul's Hospital, Millennium Medical College, and AaBET Hospital. (N=317)

Clinical presentations			Laboratory values	
Variables	Frequency	Percentage	Variables	Mean $\pm$ SD
Symptoms				
Polyurea/Polydipsia	259	81.7	Initial RBS (mg/dl)	433.88 $\pm$ 103.85
Vomiting	151	46.6	Initial potassium level (mEq/L)	4.123 $\pm$ 0.682
Inadequate intake	25	7.9	Serum creatinine level (mg/dl)	0.72 $\pm$ 0.223
Diarrhea	8	2.5	Repeated K+ level (mEq/dl)	3.91 $\pm$ 0.668
Sweating	4	1.3		
Depressed mental status	11	3.5		
Other symptoms	31	13.90		
GCS				
Comatose	3	0.9		
Non-comatose	314	99.1		
Severity of DKA				
Mild	266	83.9		
Moderate	38	12.0		
Severe	13	4.1		

Note: Coma indicates GCS $\leq$ 8/15

Abbreviations: GCS, Glasgow coma scale; DKA, Diabetic Ketoacidosis

5.3. Management of DKA patients

The most commonly used type of fluid bolus (314 [99.1%]) was 0.9% normal saline, with an average amount of 4.681.485 liters within 24 hours. The majority of fluid maintenance was done with 5% dextrose in normal saline (DNS) (275 [86.8%]). In all DKA patients, regular insulin was the only type of insulin used, with intermittent intravenous dose in 304 [95.9%], IV infusion in 17 [5.4%], intermittent SC in 1 [0.3%], and both IV and SC dose in 10 [3.6%].

The majority of the patients (289 [91.2%]) received intravenous potassium chloride. The majority of DKA patients (296 [74.4%]) recovered within 24 hours, with a mean hour of 10.45 ± 5.644 hrs. Almost 97 (43.50%) and 85 (38.12%) of the patients spent one to two days and three to five days in the hospital, respectively. Within 24 hours of treatment, 83 [26.2%] patients had their potassium levels checked again. The management profiles of DKA patients admitted to Emergency Department at St. Paul's Hospital, Millennium Medical College, and AaBET Hospital are shown in Table 3.

Table 3. Management profiles of DKA patients admitted to Emergency Department at St. Paul's Hospital, Millennium Medical College, and AaBET Hospital. (N=317)

Variable	Frequency	Percent
Fluid type		
0.9 % NS	314	99.1
RL	45	14.2
DNS	275	86.8
D5W	41	12.9
Fluid amount/24 hrs. (L)		
< 4	177	55.8
4 – 6	103	32.5
> 6	37	11.7
mean ± SD	4.68±1.485 ls.	
Insulin (Route)		
IV infusion	17	5.4
IV injection	304	95.9
SC injection	1	0.3
Both IV and SC injection	10	3.2
Potassium supplementation		
Yes	289	91.2
No	28	8.8
Time to DKA resolution (Negative urine ketone) (hr.)		
< 6	96	30.3
6 – 12	128	40.4
12 – 24	86	27.1
> 24	7	2.2
mean ± SD	10.45±5.644 hrs.	

5.4. Prevalence of hypokalemia among DKA patients

Thirty-one (9.8%) of the 317 study subjects had hypokalemia, and the mean serum potassium level among study participants was 4.1279 (SD±0.682 mEq/l). As a result, the prevalence of hypokalemia at ED presentation in this study was 9.8%.

In terms of hypokalemia severity, nearly two-thirds (22[71.0%]) of patients had a mild level. There were seven [22.6%] patients with moderate hypokalemia and two [6.5%] patients with severe hypokalemia.

Eighty-three patients (26.2%) had repeated potassium levels during DKA management; the mean repeated potassium level was 3.91 (SD±0.688 mEq/l). Of the 83 patients with repeated potassium levels, 22 (7.3%) had hypokalemia. Mild, moderate, and severe hypokalemia were observed in 16 [5.0%], 5[1.6%], and 1[0.3%] patients, respectively. Potassium profiles of DKA patients admitted to Emergency Department at St. Paul's Hospital, Millennium Medical College, and AaBET Hospital are shown in Fig. 1(N=317) and Fig. 2 (N=83) respectively. Table 4 shows the pattern of hypokalemia at presentation and during DKA treatment.

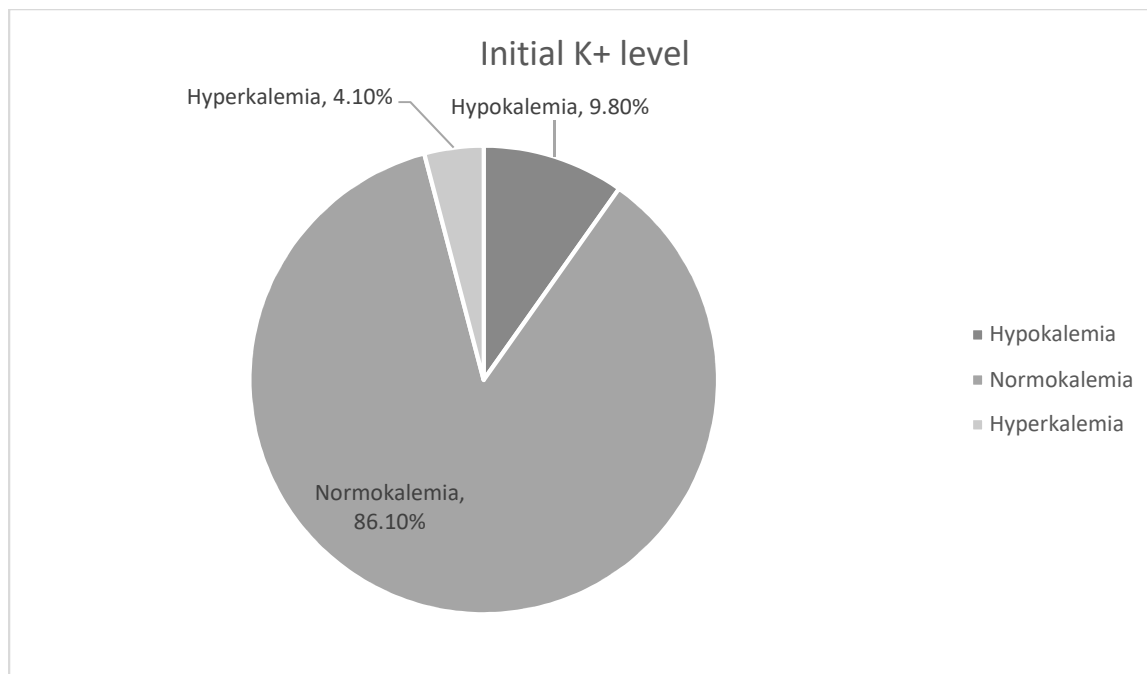


Fig. 2. Potassium profile of the DKA patients at presentation included in this study.

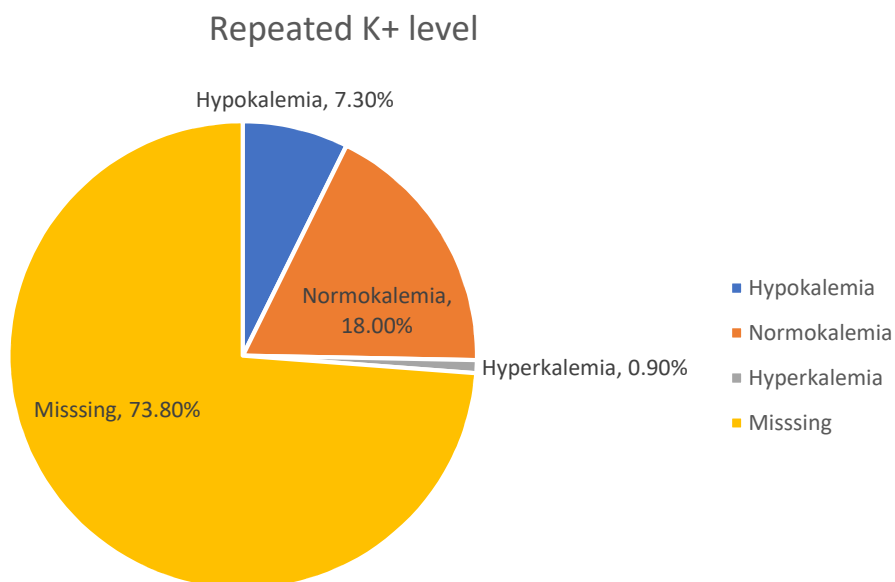


Fig. 2. Repeated potassium profile of the DKA patients during treatment included in this study. Note: Patients whose potassium levels were not rechecked are indicated by missing titles. Stated differently, the potassium level was repeated in 26.2% of patients during management.

Table 4. The severity of hypokalemia in DKA patients at admission and during treatment

Variable		Frequency	Percent	Valid percent
Initial hypokalemia (N=31)				
	Mild	22	6.9	71.0
	Moderate	7	2.2	22.6
	Severe	2	0.6	6.5
Repeated hypokalemia (N=22)				
	Mild	16	5.0	72.7
	Moderate	5	1.6	22.7
	Severe	1	.3	4.5

5.5. Factors associated with hypokalemia in DKA patients

With a P value of <0.25, binary logistic regression was applied to all variables in Table 5. In bivariable analysis, 12 variables were identified as potential candidates for multivariable analysis. After bivariable analysis, the results of multivariate logistic regression analysis revealed that triage score, duration of diabetes, diarrhea, depressed mental status, and severity of DKA at presentation all had a significant association with hypokalemia.

Patients who were triaged at red-orange were 20 times more likely to have hypokalemia at presentation [AOR: 20.491, 95% CI(8.596, 48.848) and p-value=0.000] than patients who were triaged at yellow-green. Diabetes patients who had the disease for more than five years were nearly three times more likely to develop hypokalemia [AOR: 3.725; 95%CI (1.206, 9.479) and p-value=0.031] than those who had it for less time.

Similarly, DKA patients presented with diarrhea [AOR: 3.348, 95%CI:(1.025, 10.931) and p-value=0.046] and/or depressed mental status [AOR: 29.365, 95% (9.325, 92.470) and p-value=0.000] were three and twenty-nine times more likely to develop hypokalemia respectively. Hypokalemia was also more common in patients with moderate [AOR: 5.714, 95%CI (1.342-24.332) and p-value=] to severe DKA [AOR:123.333, 95%CI(27.720-548.738) and p-value=0.000] than in patients with mild DKA.

Noncomatose DKA patients [AOR: 0.051; 95%CI (0.004, 0.578) and p-value=0.016] were 94.9% less likely to develop hypokalemia at presentation than comatose DKA patients [AOR: 0.051; 95%CI (0.004, 0.578) and p-value=0.016]. Additionally, in patients who underwent repeated potassium determinations during DKA management, insulin therapy, including IV infusion and IV injection [p value = 0.000], was found to be an independent predictor of hypokalemia. Compared to IV infusion and IV injection, patients on SC insulin have a lower risk of developing hypokalemia [AOR: 0.357; 95%CI (0.025, 5.109) and p-value=0.012].

Table 5 depicts Bivariate and multivariable logistic regression analysis of factors associated with hypokalemia among diabetic ketoacidosis patients admitted to the Emergency Department at St. Paul's Hospital Millennium Medical College (SPHMMC) and AaBET Hospital in Addis Ababa.

Table 5. Bivariate and multivariable logistic regression analysis of factors associated with hypokalemia among diabetic ketoacidosis patients admitted to the Emergency Department at St. Paul's Hospital Millennium Medical College (SPHMMC) & AaBET Hospital, Addis Ababa, Ethiopia, 2023. (n = 317)

Variables		Hypokalemia N: 31		COR (95% CI)	P- value	AOR (95% CI)	P- value
		Yes	No				
Sex	Male	11	139	0.582 (0.269 - 1.258)	0.169	2.52 (0.493– 12.791)	0.262
	Female	20	147	1		1	
Age (yrs.)	< 20	2	33	0.258 (0.043- 1.551)	0.139	2.076(0.626- 6.887)	0.232
	20 – 39	17	150	0.482 (0.145- 1.598)	0.232	3.882(0.645- 23.379)	0.139
	40 – 60	8	86	0.385 (0.107- 1.462)	0.164	2.529(0.684- 9.357)	0.164
	> 60	4	17	1		1	
Treatment is given at the referring center	Yes 124	14	110	0.598 (0.232- 1.544)	0.228	0.46 (0.17– 1.23)	0.126
	No 99	7	92	1		1	
Triage score	< 5 (Y/G)	16	270	1		1	
	≥ 5 (R/O)	17	16	0.049 (0.020- 0.116)	0.000	20.491(8.596 -48.848)	0.000*
Medication for coexisting diseases	Diuretics	8	3	0.236 (0.125- 2.545)	0.237	1.554(0.598- 4.038)	0.365
	Others	9	15	1		1	
	< 5 yrs.	9	110	1		1	
Duration of DM	≥ 5 yrs.	9	55	2.000 (0.751- 5.324)	0.165	2.725 (1.206- 9.479)	0.031*
Symptom at presentation	Polyurea/polydipsia	18	241	0.259 (0.118 – 0.565)	0.001	0.656 (0.067- 3.194)	0.407
	Vomiting	19	132	1.847 (0.0865- 3.947)	0.113	1.840(0.743- 4.560)	0.188
	Diarrhea	5	3	0.501 (0.284- 2.856)	0.000	3.348 (1.025– 10.931)	0.046*
	Depressed mental statues	14	7	0.030 (0.11- 0.085)	0.000	29.365 (9.325– 92.470)	0.000*
	Others			1		1	

Variables		Hypokalemia N: 31		COR (95% CI)	P- value	AOR (95% CI)	P- value
		Yes	No				
GCS	≤ 8 (comatose)	3	0	19.655 (1.729- 223.409)	0.016	0.051 (0.004– 0.578)	0.016*
	> 8 (Non-comatose)	28	286	1		1	
Severity of DKA	Mild	7	259	1		1	
	Moderate	14	24	0.175 (0.041- 0.745)	0.018	5.714(1.342– 24.332)	0.018*
	Severe	10	3	0.008(0.002- 0.036)	0.000	123.333(27.7 20-548.738)	0.000*
Admission RBS (mg/dl)	< 540	27	227	1.754 (0.591- 5.210)	0.311	2.52 (0.49– 12.79)	0.262
	≥ 540	4	59	1		1	
Admission creatinine level	Normal	27	273	0.321 (0.098- 1.055)	0.061	2.37 (0.41– 13.7)	0.332
	Impaired	4	13	1		1	
Insulin therapy	IV infusion	7	8	3.902 (0.964- 9.913)	0.058	0.108 (0.009- 1.297)	0.000*
	IV injection	17	53	0.513(0.148- 1.780)	0.293	0.357(0.025- 5.109)	0.012*
	SC injection	0	1	1		1	
	Both SC& IV injection	4	1	13.333(1.400 -126.975)	0.024	0.054(0.005- 0.530)	0.448

Note: *Significant association. Variables that had a p-value <0.05 in multivariable analysis.

Abbreviations: COR, Crude Odds Ratio; AOR, Adjusted Odds Ratio; CI, Confidence Interval; RBS, Random blood glucose; Y/G, yellow/green; R/O, Red/Orange; DM, Diabetes Mellitus; GCS, Glasgow coma scale; DKA, Diabetic Keto acidosis; 1, Reference category.

6. Discussion

Hypokalemia ($K^+ < 3.5$ mEq/L) has been recorded in 3 to 4% of diabetic ketoacidosis (DKA) patients [1]. To minimize the consequences of severe hypokalemia, the American Diabetes Association (ADA) treatment recommendations recommend ensuring blood potassium levels are 3.3 mEq/L before commencing insulin in the treatment of DKA [8]. The major purpose of this study was to investigate the prevalence and risk factors for hypokalemia in DKA patients hospitalized in the study area.

We identified a 9.8% prevalence of hypokalemia at presentation in this cross-sectional analysis of 317 DKA patients with blood potassium values. Other studies from around the world have found a wide range of prevalence [1, 16]. In one study, for example, a very low prevalence (1.3%) was described [16]. Another Kenyan research, on the other hand, found that roughly 22.7% of DKA patients have hypokalemia at the time of admission [35]. This disparity could be explained by differences in sociodemographics and living conditions among study participants, as well as the various treatment protocols provided by different medical institutions.

A recent study by Arora et al. from a US emergency department investigated the prevalence of hypokalemia in diabetic ketoacidosis patients at presentation and discovered a prevalence of 5.6% [17]. Hypokalemia is more common in our study, which could be because nearly two-thirds of our patients [223 (70.3%)] are referred and may begin DKA treatment before being referred to our center. Some patients may even inject insulin beforehand. Arora et al, unlike us, exclude insulin recipients and critically ill patients [17].

In a similar study, Gavrielatos et al. ^[18] examined 56 DKA patients (19 males, 37 females) and found 10.7% hypokalemia at admission, which is comparable to our findings (9.8%). According to his data analysis, patients with type 2 DM have moderate to severe DKA and 6% develop hypokalemia, compared to 13% of patients with type 1 DM and hypokalemia [18]. In our study, the type of diabetes had no significant (p -value = 0.588) association with hypokalemia at presentation.

In contrast to our findings, Kakusa et al. [25] discovered a higher prevalence of hypokalemia at admission (15%) in an 80-patient Zambian cross-sectional study. This study discovered that hypokalemia was more common in comatose patients than in noncomatose patients [25], which is consistent with our findings. Another similar study also reports hypokalemia may be associated with altered mental status [35]. In our study, patients with depressed mental status ($p = 0.001$) and comatose patients ($p = 0.000$) had a higher prevalence of hypokalemia. Three comatose (GCS ≤ 8 patients) patients were admitted during the study period, all of whom had hypokalemia.

According to Ahmed et al [13], growing older is associated with a significant increase in the incidence of hypokalemia. When compared to younger adults, an 80-year-old has more than triple the risk of having a K⁺ level of 3.0 mm/L. Gender is also a risk factor, with women having a lower K⁺ level than men [13]. A study of 58,167 hospital inpatients' biochemical data revealed a link between hypokalemia and female gender [36]. Ahmed et al. also conclude that the most common precipitating factor for hypokalemia is vomiting (78%) followed by diarrhea (38.6%)v[13]. The most common cause of hypokalemia, particularly in developing countries, is gastrointestinal loss due to infectious diarrhea, which is consistent with our findings. Diarrhea [AOR: 3.348 (1.025, 10.931) and p -value = 0.046] tripled the risk of hypokalemia in DKA patients in our study. However, in our study, age [AOR: 2.076(0.626-6.887) and p -value = 0.232], gender [AOR: 2.52 (0.493-12.791) and p -value = 0.262], and vomiting at presentation [AOR: 1.840(0.743-4.560) and p -value = 0.188] were not associated with hypokalemia.

In a similar study on the risk factors for hypokalemia, A retrospective analysis of biochemical data revealed that while diuretics were the most commonly associated with drug-related hypokalemia, it was also observed following the use of steroids and insulin in uncontrolled diabetes [36]. Diuretics, such as thiazide, used to treat comorbid conditions such as hypertension or congestive cardiac failure in diabetes can cause hypokalemia[37]. The BIRDEM study also revealed that vomiting and thiazide diuretics were the most common causes of hypokalemia in diabetic patients [7]. These were the most frequently identified factors in similar studies. [17, 18, 26, 28, 35, 37]. Diuretic or another drug use (COR: 1.554. 95%CI (0.598-4.038) and p -value = 0.365) was assessed but did not show a significant association in our study, which could be due to concomitant use of potassium-sparing diuretics although specific diuretics were not studied.

Following the initiation of appropriate therapy, serum potassium levels fall as a result of rehydration dilution, continued urinary potassium loss, acidosis correction, and potassium reentry into cells after insulin administration [29]. The most common adverse effects experienced during DKA treatment were hypokalemia [58 patients (54.7%)] and hypoglycemia [21 patients (19.8%)] in one randomized controlled trial involving patients aged >16 years with moderate to severe DKA admitted to the emergency department [21]. In our study, the prevalence of hypokalemia was 23 [7.3%] among 83 DKA patients who had repeated potassium levels during treatment. Hypokalemia occurred in 26.6% of DKA patients, according to Y. Thewjitcharoen et al. [23], and supplementation was not prescribed as per protocol in those patients. He concluded that the occurrence of hypokalemia was related to poor adherence to potassium supplementation protocol guidance [23]. Keller et al reported in a similar study that hypokalemia was very common, with 23% of DKA cases having a low potassium level [30]. In our study, the prevalence is lower (7.3% vs 23%) during or after treatment, possibly because the majority of patients (289 [91.2%] in our study) receive potassium supplementation as part of the protocol.

In one Saudi Arabian study, Alotaibi A et al discovered that 3.59% of patients were complicated with hypokalemia during DKA management, which is consistent with other studies reporting an incidence of hypokalemia in DKA patients ranging from 0% to 4% during various stages of DKA management [20]. This is a lower result than ours (3.59% vs 7.3%). Another study, Hela M, et al, discovered that 54.7% of DKA patients had hypokalemia [21]. Furthermore, a UK study found that 27.6% of DKA patients had hypoglycemia and 55% had hypokalemia during DKA treatment [38]. Both of the aforementioned studies show a significantly higher prevalence of hypokalemia than our or Alotabis et al^[20] findings. This could be due to delayed potassium supplementation during management, which accounts for half of the cases of this complication [38].

Taye et al.^[12] report a high prevalence of hypokalemia (n=14/27; 52%) as a DKA treatment outcome in one retrospective study Ethiopian study. He also concluded that potassium supplementation was given to only 28 (12.4%) of the patients [12], which is significantly lower than our finding (12.4% vs 91.2%). This could be an indication of proper DKA patient management in our hospital. Because of insulin or acidosis-induced potassium exchange between extracellular and intracellular [39], almost all patients require potassium supplementation.

Eshetu et al.^[28], conducted a cross-sectional study that assessed electrolyte imbalance and associated factors and reported a prevalence of hypokalemia of 22.3% [95% CI: 15.9-30.4] in diabetic patients in Ethiopia, a finding that is comparable to Otieno's (22%) findings but higher than our study [35]. Inadequate nutrition, alcohol exposure, coexisting hypomagnesemia, insulin therapy, vomiting, and excessive diuretic use are all identified as causes of hypokalemia in this study [28]. Malnutrition, diuretic medication, and prolonged vomiting are also reported as major causes of severe hypokalemia by Marti et al [26]. Insulin therapy was associated with an increased risk of hypokalemia in our study [AOR: 0.108 (0.009-1.297) 0.000], which is consistent with previous research [1,12, 20, 23, 28, 39]. However, as previously discussed, factors such as vomiting and diuretic use (1.554(0.598-4.038) and p-value = 0.365) were assessed but did not show a significant association. Other factors, such as nutrition status, alcohol consumption, and hypomagnesemia, were not assessed because they were not documented during the chart review.

7. Strengths and Limitations of the Study

7.1. Strength

The fact that our study offers current information on the variables linked to hypokalemia in DKA patients is one of its strong points. The study considered as many significant variables as it could that could affect the outcome. Another strength of this study is that, as it was the first in the field in the study setting, it can serve as a model for similar studies in the future. Additionally, this study uses an electronic tool (ODK) to collect data, which could enhance the quality of the data and be considered a strength.

7.2. Limitations

Each study has its own set of limitations. One limitation of our study is that our study was limited to one hospital (SPMMC & AaBET) and could not be generalized to other hospitals in Ethiopia. Because each institution used a different insulin and intravenous fluid regimen, it was thought impossible to draw meaningful management conclusions from admission and serial potassium levels.

Our study's retrospective design is also a limitation. Furthermore, it would have been impossible to know if patients took their insulin before the laboratory tests were drawn in a retrospective design. Although the precision would improve, such a retrospective approach would raise concerns about the findings' validity.

Finally, if we had used a different definition for DKA, the cases identified could have been different. To diagnose DKA, we chose to use laboratory criteria established by Ethiopian national guidelines rather than ADA criteria. Although ADA criteria are the most well-established and widely used, ABG analysis is not routinely performed due to cost concerns or a lack of test machine availability. Although our findings show that 9.8% of our DKA patients had hypokalemia, we have no idea what would have happened if these patients had received insulin before potassium repletion.

8. Conclusion and Recommendations

8.1. Conclusion

In our study, hypokalemia was observed in 9.8% of patients with DKA at presentation and 7.3% during treatment. Based on these findings, we conclude that the ADA recommendation to obtain a serum potassium level before starting insulin therapy in a patient with DKA is valid and clinically prudent if an electrolyte test machine is available. The level of hypokalemia is an especially important factor in determining the initial treatment for patients with DKA. If potassium determinations are unavailable, subcutaneous or low-dose intravenous insulin therapy may be used as a treatment option in conjunction with potassium administration.

Multiple factors (the benefits of early insulin administration, the risk of insulin causing severe hypokalemia, and potassium supplementation in the absence of serum potassium leading to death as a result of hyperkalemia or cardiac complication) should be considered in developing countries such as Ethiopia, where routine blood chemistry machines for plasma electrolyte study to determine the level of serum potassium are scarce). More research is needed to better understand the risks and benefits of administering insulin before measuring serum potassium levels.

8.2. Recommendations

8.2.1. For hospital administrators and the Ministry of Health

To develop an institution-based standard DKA management protocol

To place a premium on the availability of ABG machines and routine blood chemistry machines for plasma electrolyte testing.

To implement a computerized information and data entry system at ED

To reduce morbidity and mortality associated with acute diabetes complications by providing training on updated DKA management and the standard of diabetic care.

8.2.2. For health care providers

To practice a habit of proper documentation.

To emphasize easily avoidable associated factors during DKA management.

8.2.3. Institutions/ Researchers

To conduct a prospective study to identify the challenges and risk factors of hypokalemia to properly manage patients and analyze their level of significance with the outcomes

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English version checklist

St. Paul's Hospital Millennium Medical College

Department of Emergency and Critical Care Medicine

1. Serial number _____

2. Card number _____

Section 1: Demographic data		
S.N.	Question item	Possible answer
101	Age in years?	
102	Sex	☐ Male ☐ Female
103	Patient referred?	☐ Yes ☐ No

104	Treatment is given from a referral hospital/health center.	☐ Yes ☐ No		
105	Triage score	☐ < 5 (Yellow/Green) ☐ ≥ 5 (Red/Orange)		
106	Pre-existing comorbid condition	☐ Hypertension ☐ Cardiac disease ☐ Liver diseases ☐ HIV/AIDS ☐ Other _____		
107	Co-mediation	☐ Yes ☐ No		
108	If the patient is on medication	☐ Diuretics ☐ Others		
Section 2: Clinical data of the patient				
201	Type of DM	☐ Type 1 ☐ Type 2		
202	Diagnosis of DM	☐ Known Diabetic ☐ Newly diagnosed		
203	If the above is known, the duration of DM in years	☐ < 5 yrs. ☐ ≥ 5 yrs.		
204	Anti-diabetic medications used for the treatment	☐ Oral medication ☐ Insulin ☐ Mixed medication		
205	Is DKA diagnosis at triage	☐ Yes ☐ No		
206	Previous admissions with DKA?	☐ Yes ☐ No		
207	Symptoms at presentation	☐ Polyurea ☐ Polydipsia ☐ Polyphagia ☐ Vomiting ☐ Inadequate intake (Appetite loss)		

		☐ Diarrhea ☐ Fever ☐ Excessive sweating ☐ Depressed mental status
208	Duration of symptoms in days	☐ 1 day ☐ 2 day ☐ ≥ 3 days
209	Severity of DKA	☐ Mild ☐ Moderate ☐ Severe
210	GCS	☐ ≤ 8 (Comatose) ☐ > 8 (Noncomatose)
Section 3: Laboratory characteristics at the initial visit		
301	Initial Blood glucose levels (mg/dL)?	
302	Initial Urinary ketones?	☐ +1 ☐ +2 ☐ +3 ☐ +4
303	Initial potassium level	
304	Is insulin given before initial potassium determination?	☐ Yes ☐ No ☐ Unknown
305	Is any potassium given before initial potassium determination?	☐ Yes ☐ No ☐ Unknown
306	Serum creatinine level?	
Section 4: Precipitating factors		
401	Identified precipitating factor	☐ Yes ☐ No
402	Documented precipitating factor	☐ Missed insulin dose (noncompliance) ☐ Inadequate dose of insulin ☐ Infection ☐ Stroke ☐ Myocardial infarction

		☐ Trauma ☐ Diet abuse ☐ Substance abuse ☐ Other (specify) _____
Section 5: Management profile		
501	Fluid requirement during DKA management (in L)/24 hours	☐
502	The type of fluid given	☐ NS ☐ DNS ☐ D5w ☐ RL ☐ Mannitol
503	How long does it take for urine ketone to become trace or negative?	☐
504	Route of insulin administration in the first 24 hours	☐ IV infusion ☐ IV injection ☐ SC injection ☐ IV injection + SC injection
505	Patients are given any KCL supplementation	☐ Yes ☐ No
506	Potassium level determined during or after management?	☐ Yes ☐ No
507	If yes. level of repeated potassium?	☐