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Original research article

EFFICACY, SAFETY, AND PATIENT OUTCOMES OF EMERGENCY TREATMENT WITH IV INSULIN-DEXTROSE IN PATIENTS WITH HYPERKALEMIA

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Abstract: *Hyperkalemia is a potentially life-threatening condition often encountered in emergency settings. Insulin-dextrose infusion is a common treatment to rapidly lower serum potassium levels, but this approach carries risks, particularly related to glucose imbalances.* ***Objective:*** *To evaluate the efficacy, safety, and clinical outcomes of insulin-dextrose infusion in the emergency treatment of patients with hyperkalemia.* ***Methods:*** *This retrospective study was conducted in the Emergency Department of Shifa International Hospital Islamabad from June 2023 to June 2024. The study included 400 patients with recorded potassium levels. Patients were categorized into non-hyperkalemic (K+ <5.5 mmol/L) and hyperkalemic (K+ ≥ 5.5 mmol/L) groups. Hyperkalemic patients received an insulin-dextrose infusion consisting of an average of 10 units of Actrapid insulin and 50 milliliters of 50% dextrose. Clinical outcomes, including efficacy and safety, were compared between treated hyperkalemic patients and those with moderate-severe hyperkalemia who did not receive the treatment. Statistical analysis was performed using odds ratios (OR) and 95% confidence intervals (CI) to assess the association between treatment variables and outcomes.* ***Results:*** *Glucose imbalances were observed in 60% of patients treated with insulin, with 50% developing hyperglycemia and 20% experiencing hypoglycemia, including 5% with severe hypoglycemia six hours post-treatment. Factors significantly associated with hypoglycemia included multiple insulin doses (OR: 2.9, 95% CI: 2.0-3.9), chronic kidney disease (CKD) (OR: 1.3, 95% CI: 1.0-2.1), and baseline glucose levels below seven mmol/L (OR: 3.0, 95% CI: 2.2-4.2). Hypoglycemic patients had a higher risk of mortality (OR: 1.49, 95% CI: 1.11-2.11). ICU admission occurred in three patients treated with insulin, with a higher risk associated with multiple doses (OR: 1.8, 95% CI: 1.4-2.9) and insulin doses greater than ten units (OR: 5.3, 95% CI: 2.9-10).* ***Conclusion:*** *The use of insulin-dextrose infusion in the emergency management of hyperkalemia is associated with a significant risk of hypoglycemia, ICU admission, and prolonged hospital stay. These findings suggest the need for improved treatment protocols to enhance patient safety in emergency settings.*

Keywords: Emergency Treatment, Hyperkalemia, Hypoglycemia, Insulin, Retrospective Studies, Safety.

Introduction

Hyperkalemia is a frequent, severe emergency condition occurring in 10% of acute hospital-admitted patients caused by electrolyte imbalance. (1). However, its occurrence is more than 10% in patients with hypertension, diabetic kidney disease, and those administered RAAS-blocking treatment for heart failure, whereas, in chronic kidney disease patients, hyperkalemia occurs in more than 20% of patients. (2). If left untreated, it can result in life-threatening arrhythmias.

The primary treatment and course of action of hyperkalemia are inconsistent despite its high morbidity and prevalence. (3). However, a combination of insulin and dextrose has been seen to improve the condition. significantly (4). In a multi-center study, individual or combined infusion of insulin and dextrose was effective in 64% of patients. (5). In Pakistan, insulin, calcium, glucose, diuretics, cation exchange resins, and adrenergic blockers are widely used to treat hyperkalemia. (6, 7).

The recommended emergency treatment for reducing potassium is a combination of insulin and dextrose. The treatment was first proposed in 1944 when it effectively lowered potassium levels in crash victims. Repeated infusing and close monitoring are required due to the recurrence of hyperkalemia after the redistribution of potassium. Emergency management is also done by administering IV calcium, sodium bicarbonate, loop diuretics, salbutamol, potassium-binding resins, and renal replacement therapy.

This study evaluated the efficacy, safety, and clinical outcomes of emergency insulin-dextrose infusion treatment in patients with hyperkalemia.

Methodology

A retrospective study was conducted in the Emergency Department of Shifa International Hospital Islamabad from June 2023 to June 2024. A total of 400 patients who attended the emergency department and had a potassium result recorded in their medical records during follow-up were included in the study by convenience sampling. Patients younger than 16 and without recorded potassium results were excluded. All patients provided their informed consent to be included in the study. The hospital's ethical committee approved the study.

The patients were divided into non-hyperkalemic patients with K+ <5.5 mmol/L, hyperkalemic with K+ ≥ 5.5 mmol/L, and severe hyperkalemic with K+ ≥ 6.5 mmol/L.

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Selected hyperkalemic patients were administered insulin-dextrose infusion containing ten units (mean) of Actrapid insulin and 50 milliliters of 50% dextrose. Clinical outcomes, including efficacy and safety of insulin-dextrose treatment, were compared between hyperkalemic patients who were administered treatment and moderate-severe hyperkalemic patients who were not administered treatment. Secondary outcomes were also recorded, including repeated treatment, glucose imbalance during treatment, length of hospital stay, and ICU stay.

Patient data were recorded, including demographic features, medical history, medications, creatinine levels, potassium levels, and glucose levels. Baseline characteristics, including age, gender, chronic comorbidities, drugs disrupting potassium homeostasis, and laboratory results, were also noted. Age-adjusted Charlson co-morbidity score was calculated by confirming diagnoses according to ICD-10 codes. eGFR was calculated by creatinine levels.

All data was evaluated by Stata version 15. The chi-squared test was used to compare categorical parameters presented by percentages. T-test or Wilcoxon rank test were used to compare continuous parameters presented by mean± SD or median & IQR. Logistic regression analysis was done to evaluate the association of variables with hyperkalemia. The variables included age, gender, comorbidities, and medications affecting hyperkalemia. A p-value of 0.05 or higher was taken significantly.

Results

A total of 400 patients visiting the emergency department were included, among which 36 patients (9%) had hyperkalemia, 12 patients (3%) had moderate hyperkalemia, and eight patients (2%) had severe hyperkalemia. The mean potassium level of all patients was 4.19 ± 0.68 mmol/L. The patients' characteristics according to potassium levels are shown in Table I. Non-hyperkalemic patients were younger, had a lower prevalence of diabetes and CKD, and had better Charlson co-morbidity scores and a reduced mortality rate (p<0.001).

The logistic regression analysis showed that mortality risk was higher in the hyperkalemic group after adjustment of age, gender, and co-morbidities (OR: 2.9 (3.0-3.2)). The presence of CKD (3.9 (3.5-4.0), diabetes (1.8 (1.9-2.1)), and administration of potassium-sparing diuretics (2.7 (2.5-2.9)) were strong predictors of hyperkalemia (Table II).

Ten hyperkalemic patients were treated with insulin-dextrose infusion for a mean of 20.1 hours, whose mean age was 71 years; six patients (60%) were men, and 60% survived after the treatment. Four patients (60 %) were treated with IV calcium salts. The median eGFR was 42.1. As compared to patients not treated with IDEx, patients treated were elderly (71 (57-82) vs 69 (52-81)), had a higher incidence of CKD (40% vs 29.3%), and had a high incidence of comorbidities (P<0.001). eGFR was lower in treated patients (42.6 vs 60.4). The median hyperkalemic index of nonIDEx-treated patients was 6.2 (5.9-6.5), and the median potassium level after subsequent tests was 4.2 (4.0-4.9).

The need for IDex treatment was significantly related to the presence of CKD (OR: 1.6, 1.0-1.8), male gender (OR: 1.6, 1.4-1.9), administration of potassium-sparing diuretics (OR: 1.6, 1.0-2.0) and presence of hypertension (1.0, 0.8-1.3). At follow-up, 40% of patients in the IDEx group and 33.3% of patients in the non-IDEx group died. Mortality risk was higher in the calcium group when adjusted for age, gender, and presence of co-morbidities (OR: 1.3, 1.1-2.0). We did not evaluate the cause of mortality.

Figure I shows that the mean potassium levels 1 hour or less before treatment was 6.22 ± 1.0, and the median time for treatment to take effect was 50 minutes (20-100). Excluding RRT patients, the mean reduction in K+ levels 4 hours after treatment was 0.90 ± 0.96 mmol/L. Patients with CKD, cardiac failure, and administered ACE inhibitors were most likely to require multiple doses, among which CKD was a significant predictor (p=0.002). However, various insulin doses were directly related to high mortality risk after adjusting co-variates (OR: 1.5, 0.9-2.0). Hospital stay was significantly more in insulin-treated patients (12.1 days) as compared to non-insulin treatment patients (7 days) (P<0.001).

Glucose imbalance was noted in 60% of patients given insulin, 50% were hyperglycemic, and 20% were hypoglycemic (5% severe hypoglycemia) 6 hours post-treatment. Multiple insulin doses (OR: 2.9,2.0-3.9), CKD (OR: 1.3, 1.0-2.1), and baseline glucose less than 7 (OR: 3.0, 2.2-4.2) were significantly associated with hypoglycemia and diabetes, and older age decreased risk of hyperglycemia. Hypoglycemic patients were also at high risk of mortality (OR: 1.49, 1.11-2.11). Three patients treated with insulin were admitted to ICU; ICU admission was associated with multiple doses (OR: 1.8, 1.4-2.9) and higher insulin dose >10 units (OR: 5.3, 2.9-10).

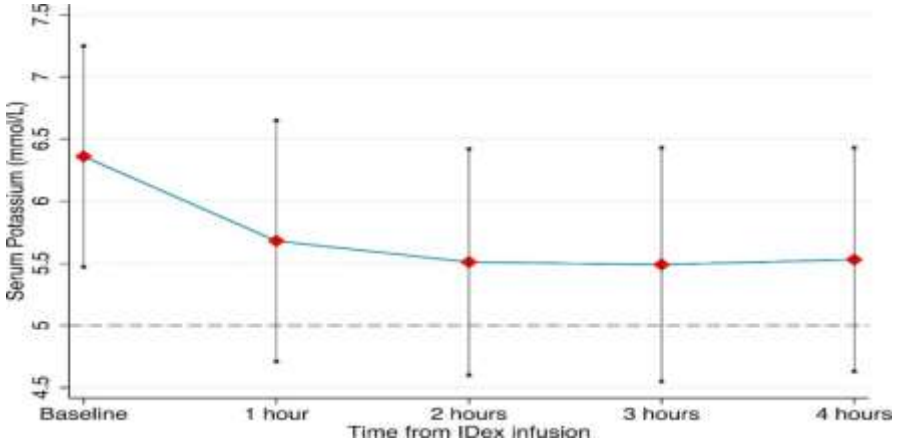

Figure I: Potassium levels after insulin-dextrose treatment

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Table I: Patient Characteristics According to Potassium Level Stratification

	Non-hyperkalemic (N= 364)	Hyperkalemic (N= 36)	P
Age	51 (35-70)	71 (55-85)	<0.001
Female gender	202 (55.5%)	18 (50%)	<0.001
Survived after treatment	349 (95.9%)	26 (72.2%)	<0.001
Charlson Co-Morbidity Index	2 (0-5)	5 (3-7)	<0.001
eGFR	94.9 (80.2-110.8)	71.1 (45.3-91.7)	<0.001
Comorbidities			
CKD	11 (3%)	8 (22.4%)	<0.001
End-stage kidney disease	1 (0.2%)	2 (5.5%)	<0.001
Diabetes mellitus	25 (6.8%)	10 (27.8%)	<0.001
Hypertension	80 (22%)	18 (50%)	<0.001
Congestive cardiac failure	11 (3%)	5 (14%)	<0.001
Ischemic heart disease	29 (7.9%)	8 (22.3%)	<0.001
Medication			
ACE inhibitors	33 (9%)	9 (25%)	<0.001
Angiotensin 2 Receptor Blockers	14 (3.8%)	4 (11.1%)	<0.001
Potassium-sparing diuretics	8 (2.2%)	4 (11%)	<0.001
NSAIDs	109 (30%)	9 (25%)	<0.001
Beta-blockers	37 (10.1%)	12 (33.4%)	<0.001
Trimethoprim	5 (1.4%)	2 (5.5%)	<0.001

Table II: Risk factors of Hyperkalemia

Co-variates	OR (95% CI)
Age > 65	1.5 (1.4-1.6)
Male gender	1.1 (1.0-1.1)
CKD	3.9 (3.5-4.0)
Diabetes	1.8 (1.9-2.1)
Hypertension	1.5 (0.9-1.5)
CHF	1.1 (0.9-1.6)
IHD	0.9 (0.8-1.0)
Angiotensin-converting enzyme inhibitors	1.6 (1.4-1.5)
ARBs	0.9 (0.8-1.1)
Potassium-sparing diuretics	2.7 (2.5-2.9)
Non-steroidal anti-inflammatory drugs	0.9 (0.9-1.0)
B-blockers	1.4 (1.3-1.6)
Trimethoprim	2.0 (1.8-2.2)

Table III: Predictors of Mortality Post IDEx Treatment

Co-variates	OR (95% CI)
Age >65 years	2.78 (2.20,3.69)
Male gender	0.79 (0.65,1.05)
Hypoglycemia 4 hours post-treatment	1.62 (1.20-2.11)
Diabetes	1.12 (0.80,1.37)
CKD	0.88 (0.68,1.13)
Heart failure	1.59 (1.22,2.17)
Hypertension	0.70 (0.57,1.0)
IHD	1.76 (1.42,2.40)

Discussion

This study was conducted to evaluate patient outcomes after emergency treatment with IV insulin-dextrose infusion. The results showed that IDex treatment was required in multiple doses in the majority of patients, lengthened the hospital stay, and increased the risk of hypoglycemia compared to non-IDEx treatment.

The incidence of hyperkalemia in our study was 9%, with 3% of patients having moderate and 2% having severe hyperkalemia. This complies with literature that has reported an incidence of 1-10% hyperkalemia in admitted patients.(8). Old age, male gender, CKD, and diabetes were strong predictors of hyperkalemia. Other studies have also supported this association.on (9, 10). The risk of hyperkalemia was also high in patients administered RAAS inhibitors, potassium-sparing diuretics, and beta blockers that are administered to diabetics, heart failure, and chronic kidney disease patients. (11, 12).

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The insulin treatment was effective in managing potassium levels up to 1 hour after treatment, but 1/3rd of the hyperkalemic patients required repeated treatment, which increased the likelihood of hypoglycemia, which increased morbidity and mortality risk. (13). As shown in the results, patients having hypoglycemia 6 hours post-treatment were more likely to die by the end of the study duration. 5% of patients developed severe hypoglycemia after 6 hours; similar results have been reported by previous research (13, 14). This indicates that glucose levels should be closely monitored for at least 6 hours after treatment to manage low sugar levels promptly. (13).

IDEx treatment lengthened hospital stay to 12 days on average compared to 7 days in non-IDEx patients; ICU admission was also more common in these patients. ICU admission was more likely in patients receiving retreatment and also in patients administered more than ten units of insulin. To prevent this, IDEx is now administered with oral potassium binders for emergency management of patients with severe hyperkalemia. (15).

Our study has some limitations. The study design limited the evaluation of causation factors and only enabled the assessment of association between variables. Secondly, we did not evaluate the impact of K+ and treatment on patient's ECG, but calcium salts were administered to some patients as caution. Lastly, the cause of death was not evaluated in patients, so the association between hyperkalemia and mortality could not be determined.

Conclusion

The emergent insulin-dextrose treatment in hyperkalemic patients was associated with a high risk of hypoglycemia, ICU admission, and more extended hospital stay, which indicates a need for improvement in emergency treatment in such patients.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate.
Approved by the department concerned. (IRB-SIHISB-02444/22)

Consent for publication
Approved

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Conflict of interest

The authors declared an absence of conflict of interest.

Authors Contribution

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Final Approval of version
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Revisiting Critically & Data Analysis
FATIMA ASHRAF (HO)
Drafting & Concept & Design of Study

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