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Original Research Article

Study of Serum Phosphate Levels and Its Clinical Significance in Diabetic Ketoacidosis

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Abstract

Hypophosphatemia, though rare in the general population, is common in conditions like DKA. This study evaluates serum phosphate levels and their clinical significance in diabetic ketoacidosis (DKA). A total of 105 DKA patients (Type 1 and Type 2 DM) were studied, measuring serum phosphate at admission, day 2, and discharge/death. Hypophosphatemia was common and associated with increased mortality. This study highlights the importance of monitoring and therapeutic management of phosphate in DKA.

Keywords: Diabetic Ketoacidosis, Serum Phosphate, Hypophosphatemia.

Introduction

Diabetic ketoacidosis (DKA) is a common, preventable life-threatening complication of diabetes mellitus characterized by hyperglycemia, ketonemia, and metabolic acidosis. Alterations in serum phosphate are frequently observed during DKA, but their clinical implications need further elucidation. This study aims to evaluate serum phosphate levels in DKA patients and assess their clinical and prognostic relevance.

Materials and Method

Study Design: This was a prospective observational study conducted at the Department of Medicine, Karnataka Institute of Medical Sciences, Hubballi, from November 2019 to September 2021.

The study included 105 patients diagnosed with diabetic ketoacidosis (DKA), both Type 1 and Type 2 diabetes mellitus.

Inclusion Criteria

- Patients diagnosed with diabetic ketoacidosis who provided written informed consent
- Patients aged 18 years or older
- Both Type 1 and Type 2 diabetes mellitus patients presenting with DKA

Exclusion Criteria

- Patients who did not provide informed consent
- Patients with malnutrition or malabsorption syndromes
- Alcoholics
- Patients on diuretics, steroids, or phosphate-binding antacids
- Patients with renal transplantation or hyperparathyroidism
- Patients with pancreatitis, burns, or volume expansion conditions

Methodology

Upon admission, detailed history and clinical examination were conducted. Laboratory investigations included random blood sugar, arterial blood gas analysis (ABG), serum electrolytes (including phosphorous), complete blood count, renal and liver function tests, ECG, and urine ketone bodies. Serum phosphate was measured on Day 0 (admission), Day 2, and at discharge or death. Therapeutic interventions were given as per standard DKA protocols.

Statistical Analysis: Data were entered and analyzed using Microsoft Excel 2007 and SPSS version 20.0. Categorical variables were analyzed qualitatively using the Chi-square test and continuous variables quantitatively using the Student's t-test. Statistical significance was set at $p < 0.05$. Correlation and regression analyses were performed to assess associations between serum phosphate levels and patient outcomes.

Results

Patient Demographics and Clinical Profiles: A total of 105 patients with DKA were studied, comprising 30 (28.6 percent) with Type 1 DM and 75 (71.4 percent) with Type 2 DM. The majority were males (62 percent), with the most patients aged 61-70 years. Infection was the most common precipitating factor (50.47 percent) followed by medication non-compliance (28.57 percent). Cardiovascular events and cerebrovascular accidents were less frequent triggers.

Serum Phosphorous Levels and Trends: Serum phosphate levels were evaluated on Day 0 (admission), Day 2, and at discharge or death.

- Day 0: 70.5 percent had normal phosphate levels (2.5-4.5 mg/dL), 21 percent had mild hypophosphatemia (2-2.5 mg/dL), and 6.7 percent had moderate hypophosphatemia (1-2 mg/dL). Hyperphosphatemia was seen in 1.9 percent.

- Day 2: Significant reduction in phosphate levels (p=0.004) with normal levels in 63.8 percent, mild hypophosphatemia in 22.9 percent, and moderate hypophosphatemia in 12.4 percent.

- Discharge or Death: 79 percent had normal phosphate, with 10.5 percent mild and 8.6 percent moderate hypophosphatemia. The decline from Day 2 to discharge or death was statistically significant (p=0.001).

Patient Outcomes: Of 105 patients, 92 (87.6 percent) recovered while 13 (12.4 percent) died.

Moderate hypophosphatemia was significantly associated with mortality. Among those who died, 62 percent had moderate hypophosphatemia and 23 percent had mild hypophosphatemia at discharge or death.

Statistical Analysis: Mean phosphate level at discharge was significantly lower in mortality patients (2.08 plus or minus 0.82 mg/dL) compared to those who recovered (3.20 plus or minus 0.72 mg/dL).
Pearson correlation indicated a significant negative correlation between phosphate levels and mortality at all measured times: Day 0 (r = -0.408, p=0.001), Day 2 (r = -0.412, p=0.001), and discharge or death (r = -0.548, p=0.001). Binary logistic regression showed that each 1 mg/dL rise in serum phosphate reduced mortality risk by 94 percent (OR 0.06; p=0.003).

Table 1: Serum Phosphate Levels at Day 0 (Admission)

Phosphorous Level	Number of Patients	Percentage (%)
Normal (2.5-4.5 mg/dL)	74	70.5
Mild Hypophosphatemia (2-2.5 mg/dL)	22	21
Moderate Hypophosphatemia (1-2 mg/dL)	7	6.7
Severe Hypophosphatemia (<1 mg/dL)	0	0
Hyperphosphatemia (>4.5 mg/dL)	2	1.9

Table 2: Serum Phosphate Levels at Day 2 of Treatment

Phosphorous Level	Number of Patients	Percentage (%)
Normal (2.5-4.5 mg/dL)	67	63.8
Mild Hypophosphatemia (2-2.5 mg/dL)	24	22.9
Moderate Hypophosphatemia (1-2 mg/dL)	13	12.4
Severe Hypophosphatemia (<1 mg/dL)	0	0
Hyperphosphatemia (>4.5 mg/dL)	1	1.0

Table 3: Serum Phosphate Levels at Discharge or Death

Phosphorous Level	Number of Patients	Percentage (%)
Normal (2.5-4.5 mg/dL)	83	79.0
Mild Hypophosphatemia (2-2.5 mg/dL)	11	10.5
Moderate Hypophosphatemia (1-2 mg/dL)	9	8.6
Severe Hypophosphatemia (<1 mg/dL)	0	0
Hyperphosphatemia (>4.5 mg/dL)	2	1.9

Table 4: Patient Outcome

Outcome	Number of Patients	Percentage (%)
Recovered	92	87.6
Died	13	12.4

Table 5: Mean Serum Phosphate Values at Discharge/Death (mg/dL)

Outcome	Mean Phosphate	Standard Deviation
Recovered	3.20	0.72
Died	2.08	0.82

Table 6: Statistical Comparison of Phosphate Levels

Comparison	Mean Difference	t-value	p-value
Day 0 vs Day 2	0.150	2.915	0.004*
Day 2 vs Discharge/Death	-0.220	-3.829	0.001*

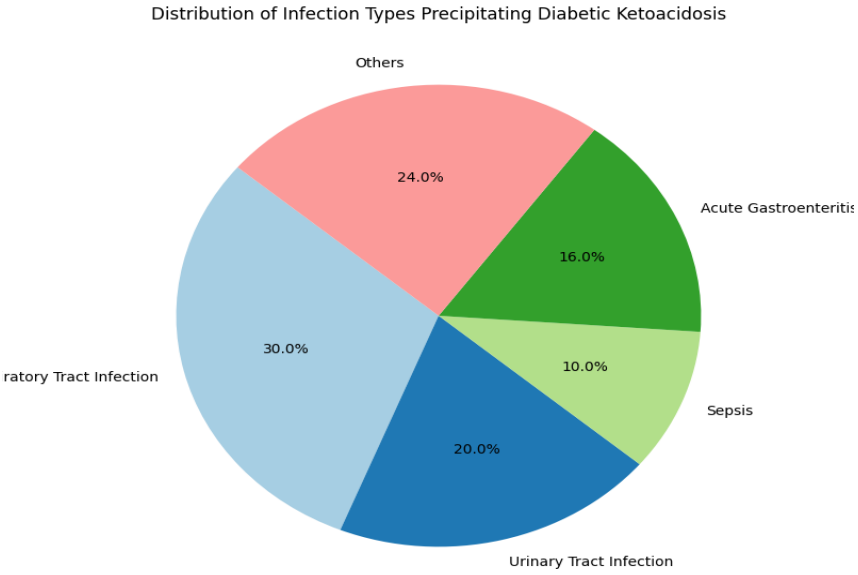

Figure 1: Distribution of infection types precipitating diabetic ketoacidosis

Discussion

This study assessed serum phosphate levels in 105 patients presenting with diabetic ketoacidosis (DKA), including both Type 1 and Type 2 diabetes mellitus, reflecting a representative clinical population. The majority of patients were male and aged 61-70 years, consistent with other contemporary studies showing increased DKA incidence among older adults and males.

Serum Phosphate Level Changes: Serum phosphate levels showed dynamic changes during the course of treatment: near-normal levels at admission, followed by significant declines at Day 2 and at discharge or death.

This pattern aligns with known diabetic ketoacidosis physiology, in which phosphate shifts into cells following insulin administration and acidosis correction, causing transient hypophosphatemia. Worsening hypophosphatemia was statistically significant and clinically notable.

Clinical Significance and Mortality: Hypophosphatemia correlated strongly with adverse outcomes. Of the 13 deaths, 11 had mild or moderate hypophosphatemia, indicating phosphate depletion as a potential prognostic marker. The logistic regression revealed that higher serum phosphate levels decreased mortality risk substantially. These findings are concordant with prior research, reinforcing the necessity for frequent serum phosphate monitoring and timely phosphate supplementation to reduce complications such as impaired myocardial contractility, respiratory failure, and rhabdomyolysis.

Comparison with Literature: Our observations confirm previous reports in the literature (Betdur et al., Rajendran et al., and Raul et al.) about the high incidence of hypophosphatemia in DKA and its association with morbidity and mortality. This warrants reconsideration of practice guidelines for phosphate management in DKA, moving beyond ad hoc supplementation toward protocolized care.

Study Limitations: The study was limited by its single-center design and modest sample size, which may affect extrapolation of results. Confounding factors such as infection severity, fluid therapy volumes, and other electrolyte imbalances were not fully controlled, highlighting opportunities for larger-scale, multicenter prospective studies.

Recommendations

- Routine serum phosphate assessment should be integrated into DKA management protocols.

- Phosphorus replacement therapy, particularly potassium phosphate, should be considered for patients with moderate to severe hypophosphatemia during DKA treatment.
- Clinical vigilance for complications linked to hypophosphatemia must be maintained.
- Further research should aim to establish standardized phosphate replacement guidelines to improve DKA outcomes.

Conclusion

Severe hypophosphatemia being associated with increased morbidity and mortality. The study revealed a statistically significant correlation between low serum phosphate levels and poor prognosis in DKA.

Persistent hypophosphatemia adversely affects clinical outcomes and is linked to complications like respiratory failure, cardiac dysfunction, and increased mortality.

Therefore, frequent monitoring of serum phosphate levels in DKA patients is crucial. Furthermore, phosphate replacement therapy with potassium phosphate should be considered and included in treatment protocols for patients exhibiting severe hypophosphatemia to improve clinical outcomes. However, further studies are warranted to strengthen these recommendations.

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