

Spectrum of Electrolyte Abnormalities and their Association with Mortality and Intensive Care Unit Outcomes in Critically Ill Patients: A Prospective Observational Study

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ABSTRACT

Introduction: Electrolyte disturbances are common in critically ill patients and may adversely affect cardiac conduction, neuromuscular function, and acid–base balance. These abnormalities may reflect disease severity and are associated with poor intensive care unit (ICU) outcome and increased mortality. This study aimed to determine the spectrum of electrolyte imbalances among critically ill patients and assess their association with mortality. **Methodology:** After obtaining approval from the Institutional Ethics Committee, a hospital-based, prospective study was carried out in the Department of Respiratory Medicine, Gouri Devi Institute of Medical Sciences and Hospital over a period of 3 months, including 123 adult ICU patients. Serum sodium and potassium levels obtained within the first 24 h were measured by the ion-selective electrode method, and clinical outcomes were recorded using a structured case record form. **Results:** A total of 123 critically ill patients were included. Hyponatremia was the most common electrolyte abnormality (29.3%), followed by hypokalemia (12.2%), hypernatremia (10.6%), and hyperkalemia (9.8%). Overall ICU mortality was 33.3% (41/123) and was higher among patients with electrolyte abnormalities than those with normal electrolyte levels, with the highest mortality observed in hypernatremia (46.2%) and hypokalemia (53.3%). **Conclusion:** Electrolyte imbalances are common in critically ill ICU patients, and routine monitoring and appropriate management of electrolyte abnormalities are important.

Keywords: Electrolytes, Intensive care unit

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INTRODUCTION

Electrolyte disturbances are among the commonest metabolic problems encountered in the intensive care unit (ICU). Sodium, potassium, calcium, magnesium and phosphate together maintain the internal milieu on which normal cellular excitability, myocardial conduction, neuromuscular function and acid-base balance depend, and even a modest deviation from the physiological range can precipitate an arrhythmia, a seizure, muscle weakness or a delay in recovery that is otherwise avoidable.^[1] Critically ill patients are exposed simultaneously to the disease process itself, to aggressive fluid resuscitation, diuretics, vasopressors and mechanical ventilation, and to an altered renal handling of solutes, so it is not surprising that they are particularly prone to electrolyte derangement.^[1] Hyponatremia and hypernatremia are common electrolyte abnormalities among critically ill patients and have been associated with adverse outcomes.^[2,3] Both abnormalities have been associated with increased ICU mortality, extended mechanical ventilation, and neurological complications.^[2,3] Although the derangements of potassium are usually temporary, severe potassium disturbances can cause life-threatening complications, particularly cardiac arrhythmias.^[1] The abnormalities are not only common in critically ill patients, but they often become both the indicators of disease severity and the possible causes of poor clinical outcomes.^[1-3]

A number of workers, over more than a decade and across different parts of the world, have looked into how frequently these abnormalities occur in ICU patients and whether they carry any prognostic weight of their own. This study is aimed to determine the spectrum of electrolyte imbalances present among critically ill

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patients and assess their association with major clinical outcome and ICU mortality.

METHODOLOGY

This hospital-based, prospective study was conducted in the ICU of Gouri Devi Institute of Medical Sciences and Hospital, Durgapur, West Bengal, a tertiary care teaching hospital, over a period of 3 months from April, 2026 to July, 2026. The study included adult critically ill patients aged 18 years or older who were admitted to ICU for at least 24 h and had at least one documented serum sodium and potassium measurement obtained within the first 24 h of admission. Patients with incomplete clinical or biochemical records, those patients who died or were discharged within 24 h of ICU admission before completion of baseline electrolyte assessment, patients receiving long-term correction therapy for a

known chronic electrolyte disorder, and those admitted primarily under surgical or trauma services were excluded.

A consecutive sampling technique was employed, and all eligible patients admitted during the study period were enrolled, resulting in a final sample of 123 patients. Data were collected using a structured case record form that recorded baseline serum sodium and potassium concentrations. Serum electrolytes were measured using the ion-selective electrode method in the hospital's central laboratory. Serum sodium was classified as hyponatremia (<135 mmol/L), normonatremia (135–145 mmol/L), and hypernatremia (>145 mmol/L), while serum potassium was classified as hypokalemia (<3.5 mmol/L), x (3.5–5.0 mmol/L), and hyperkalemia (>5.0 mmol/L). Outcomes were recorded as survival or death, using a structured case record form. Data were entered into Microsoft Excel and analyzed using IBM Statistical Package for the Social Sciences Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as frequencies and percentages.

Institutional Ethics Committee clearance was obtained from Gouri Devi Institute of Medical Sciences and Hospital (IEC Ref No: CREC/GIMSH/270326/08) before the study began. Written informed consent was taken from each patient. Patient information was kept confidential throughout, in keeping with the Declaration of Helsinki.

RESULTS

A total of 123 critically ill patients were included in the study. The age of the participants ranged from 29 to 87 years, with a mean age of 57.4 ± 16.2 years. There was a male predominance, with 83 (67.5%) males and 40 (32.5%) females.

The distribution of serum sodium and potassium abnormalities is shown in Table 1. Among the study participants, 74 (60.2%) had normonatremia, while 36 (29.3%) had hyponatremia and 13 (10.6%) had hypernatremia. Thus, 49 (39.8%) patients had abnormal serum sodium levels, with hyponatremia being the most common sodium abnormality. The distribution of serum sodium categories is shown in Figure 1.

Regarding serum potassium, 96 (78.0%) patients were normokalemic, whereas 15 (12.2%) had hypokalemia and 12 (9.8%) had hyperkalemia. Overall, 27 (22.0%) patients had abnormal serum potassium levels, with hypokalemia being marginally more frequent than hyperkalemia. The distribution of serum potassium categories is shown in Figure 2.

Comparison of the electrolyte abnormalities demonstrated that sodium abnormalities were more prevalent than potassium abnormalities (39.8% vs. 22.0%). Among all electrolyte disturbances, hyponatremia was the most frequent abnormality, occurring in 29.3% of patients, followed by hypokalemia (12.2%), hypernatremia (10.6%), and hyperkalemia (9.8%). The majority of critically ill patients maintained normal serum potassium concentrations (78.0%), whereas only 60.2% had normal serum sodium levels,

indicating that disturbances in sodium homeostasis were more common than potassium abnormalities in this study population.

Among the 123 critically ill patients, 41 (33.3%) died, and 82 (66.7%) survived during ICU stay. For serum sodium, mortality was 41.7% (15/36) among patients with hyponatremia, 27.0% (20/74) among those with normonatremia, and 46.2% (6/13) among those with hypernatremia. Although mortality was numerically higher in both hyponatremic and hypernatremic groups compared with the normonatremic group, the association between sodium category and ICU mortality was not found statistically significant ($\chi^2 = 4.016$, $df = 2$, $P = 0.134$).

For serum potassium, mortality was highest among patients with hypokalemia (53.3%; 8/15), followed by hyperkalemia (50.0%; 6/12), while patients with normokalemia had the lowest mortality (28.1%; 27/96). Thus, mortality was substantially higher among patients with both hypo- and hyperkalemia compared with normokalemic patients. Overall, the findings suggest a higher mortality burden among patients with electrolyte abnormalities, particularly potassium disturbances. The association between serum potassium status and ICU mortality did not reach statistical significance ($\chi^2 = 5.37$, $df = 2$, $P = 0.068$).

DISCUSSION

Lee (2010), in a review article published in electrolyte and blood pressure, explained that fluid and electrolyte disturbances are among the most common problems seen in the ICU and are linked with higher morbidity and mortality. He stressed that clinicians treating critically ill patients need a sound understanding of fluid and electrolyte physiology, since abnormalities such as hyponatremia, hypernatremia, hypokalemia and hyperkalemia can each lead to serious complications if not corrected appropriately.^[1]

Stelfox *et al.* studied how often ICU-acquired hyponatremia and hypernatremia develop in medical-surgical ICU patients who had normal sodium levels at the time of admission. They found that a substantial proportion of patients developed a sodium abnormality during their ICU stay itself, and that these ICU-acquired abnormalities were also associated with worse outcomes and a longer hospital stay, independent of the admission electrolyte status.^[2]

Funk *et al.* looked at the incidence and prognosis of sodium abnormalities present at ICU admission. They found that both hyponatremia and hypernatremia at admission were associated with higher mortality, and that the risk of death increased further if the sodium abnormality failed to correct during the course of the ICU stay.^[3]

Kunal *et al.*, in a prospective observational study from a tertiary care teaching hospital in North India, followed 42 adult ICU patients over 6 months. Sodium abnormalities were the commonest disturbance in their series, followed by potassium, calcium and magnesium derangements in that order. Most

Table 1: Distribution of serum sodium and potassium abnormalities among critically ill patients (n=123)

Electrolyte	Category	Frequency (n)	Percentage	Death	Survived
Serum sodium	Hyponatremia	36	29.3	15	21
	Normonatremia	74	60.2	20	54
	Hypernatremia	13	10.6	6	7
Serum potassium	Hypokalemia	15	12.2	8	7
	Normokalemia	96	78.0	27	69
	Hyperkalemia	12	9.8	6	6

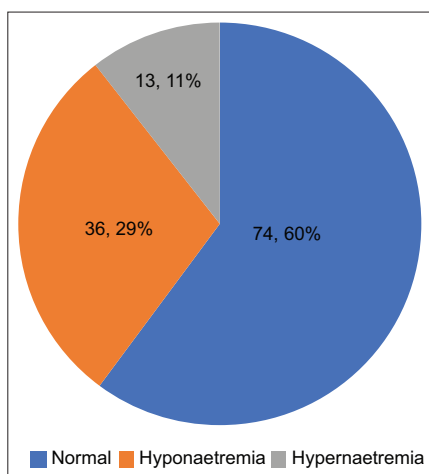


Figure 1: Distribution of serum sodium levels among critically ill patients ($n = 123$)

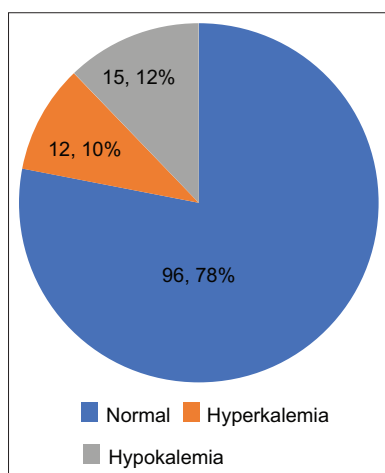


Figure 2: Distribution of serum potassium levels among critically ill patients ($n = 123$)

patients in their cohort had a single electrolyte abnormality, although about a third had more than one at the same time. They found a statistically significant association between the presence of an electrolyte imbalance and an ICU stay of more than 5 days.^[4]

Iqbal *et al.*, in an analytical cross-sectional study from Lahore, Pakistan, examined 355 medical ICU patients over a year and they found that, electrolyte imbalances were common in critically ill medical ICU patients and were significantly associated with mortality, prolonged ICU stay, and major complications. Hyponatremia, hypokalemia and hypocalcemia were the leading individual disturbances, but hypernatremia and hyperkalemia showed the strongest link with poor outcome. On multivariate analysis, hypernatremia, hyperkalemia and having two or more electrolyte abnormalities together each remained independently associated with ICU mortality even after adjusting for age and the primary illness.^[5]

Deep *et al.* compared patients presenting with acute exacerbation of chronic obstructive pulmonary disease (AECOPD) to patients with stable chronic obstructive pulmonary disease in a case-control study at Kalinga Institute of Medical Sciences, Bhubaneswar. Hyponatremia was the commonest abnormality;

mean sodium and calcium were lower in the exacerbation group, while potassium tended to run higher. Patients with two or more electrolyte imbalances together were more likely to need long-term oxygen or non-invasive ventilation at discharge and had a higher mortality than those with a single or no abnormality.^[6]

Nagar *et al.* studied AECOPD patients requiring ICU admission and found an unusually high burden of derangement – 92% had sodium below 135 mEq/L and 86% had potassium below 3.5 mEq/L. They concluded that hyponatremia and hypokalemia were closely linked with the severity of the exacerbation.^[7]

Bachmann *et al.* carried out a retrospective analysis of 2056 consecutive ICU patients in Switzerland, looking specifically at how electrolyte disorders develop and interact over the first 96 h of ICU stay. Only about 15% of patients had entirely normal electrolytes, while nearly four out of ten had more than one electrolyte disorder simultaneously; a substantial share of these disorders was noted to develop only after ICU admission rather than being present at the time of entry, underlining that ongoing monitoring through the stay is as important as the baseline work-up.^[8]

Sodium disturbances, hyponatremia in particular, are the electrolyte abnormality most often in the ICU; potassium derangements, though less common, carry a mortality and arrhythmia risk out of proportion to their frequency; and having more than one electrolyte deranged at the same time seems to matter more, prognostically, than any single abnormality on its own.

In this study, it is found that dyselectrolytemia is common in the ICU. Both sodium and potassium values can go high or low. A statistically significant correlation was not established between the electrolyte abnormality and ICU mortality. This may be because a single-center study, small sample size, the machine used for electrolyte measurement, ICU protocols, and other confounding factors. Most of the patients had hyponatremia and hypokalemia, so patients admitted in ICU should be looked for any electrolyte disturbances. Early interventions in correcting dyselectrolytemia may prevent morbidity and mortality in critically ill patients.

CONCLUSION

Electrolyte abnormalities were common among critically ill patients, with sodium abnormalities occurring more frequently than potassium abnormalities. Hyponatremia was the most common electrolyte abnormality found, while Hypokalemia showed the highest observed mortality (53.3%), although the association between potassium category and ICU mortality was not statistically significant. Although mortality was numerically higher among patients with electrolyte abnormalities, the observed differences in mortality across sodium and potassium categories were not statistically significant. Therefore, the electrolyte abnormalities may serve as clinically relevant markers of illness severity and warrant close monitoring. Early recognition and appropriate management of electrolyte abnormalities may be clinically important in critically ill patients.

ETHICAL APPROVAL

Approved (IEC Ref No: CREC/GIMSH/270326/08).

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