

Dysnatremia and Prognosis in Critically ill Patients: A Study from a Tertiary Care Hospital of Eastern India

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Abstract

Introduction: Sodium is the most prevalent cation of extracellular fluid. It is responsible for 90% of total serum osmolality. The body finely maintains serum sodium between 135 and 145 mmol/L in spite of variations in salt and water intake. This value reflects total sodium in the body compared to the total body water content. Dysnatremia is the most common electrolyte disorder in hospitalized patients. It encompasses hyponatremic and hypernatremic conditions. It is a common finding at Intensive Care Unit (ICU) admission. Nearly one third of critically ill patients have dysnatremia at ICU admission.

Objectives: Identification of prevalence of dysnatremia in critically ill patients and Identification of the etiology of dysnatremia to find out the relation with treatment outcome.

Materials & Methods: The present study was an institute based descriptive observational cross-sectional study conducted with 120 patients, for a duration of 12 months at Calcutta National Medical College and Hospital, Kolkata.

Result: In our study, 15 (12.5%) patients had chronic kidney disease (CKD), 17 (14.2%) patients had Hyperosmolar Hyperglycaemic State (HHS), 14 (11.7%) patients had Ischemic dilated cardiomyopathy (DCM), 11 (9.2%) patients had multi-infarct state and 10 (8.3%) patients had urosepsis.

Conclusion: We concluded that dysnatremia represents a significant clinical challenge in the management of critically ill patients in our setting, necessitating heightened awareness, proactive monitoring, and timely intervention strategies to mitigate its impact on patient outcomes. We observed that, association between admission and final serum sodium values of the patients with their outcome was statistically significant.

Keywords: Dysnatremia, Hyponatremia, Hypernatremia, Critical Illness.

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Introduction

Sodium is the most prevalent cation of extracellular fluid. It is responsible for 90% of total serum osmolality. Its major function is to maintain ECF volume therefore blood pressure and serum osmolality. The body finely maintains serum sodium between 135 and 145 mmol/L in spite of variations in salt and water intake. This value reflects total sodium in the body compared to the total body water content. Dysnatremia is the most common electrolyte disorder in hospitalized patients. Nearly one-third of critically ill patients have dysnatremia at ICU admission. It encompasses hyponatremic and hypernatremic conditions. Hyponatremia is a pathologic condition defined as a serum sodium < 135 mmol/L. It is the

most common electrolyte disorder in hospitalized patients. Up to 40% of the overall hospitalized patients have a hyponatremia at admission [1]. Presence of severe hyponatremia on hospital admission has been demonstrated to be independently associated with an increased risk of ICU admission and poor prognosis [2]. Hyponatremia may be due to chronic organ dysfunctions (that is heart failure or liver dysfunction), diuretic use and syndrome of inappropriate antidiuretic hormone secretion (SIADH), adrenal insufficiency, and cerebral or renal salt wasting syndromes. In addition to critical illness per se, factors contributing to hyponatremia in ICU include excess use of hypotonic fluids and

drugs stimulating antidiuretic hormone secretion. Hyponatremia is defined as a serum sodium > 145 mmol/L. It is generally related to excess water losses and increased plasma osmolality.

Hyponatremia is less frequent than hyponatremia, with a reported in hospital prevalence of up to 7.7% [3]. Since thirst and free access to water are the most important mechanisms that prevent hyponatremia, critically ill patients and older patients are at high risk of this disorder [3]. As hyponatremia is often iatrogenic, ICU-acquired hyponatremia has been considered as an important index of quality of care [4]. Hyponatremia has multiple adverse effects on physiologic functions, which may explain its association with increased mortality. Hyponatremia aggravates peripheral insulin resistance, impairs hepatic gluconeogenesis and lactate clearance, and decreases left ventricular contractility. Additionally, hyponatremia is associated with various neuromuscular manifestations, such as muscle weakness and cramps [5]. Neurologic impairment remains the most severe consequence of hyponatremia and may prolong the need for mechanical ventilation and delay weaning [6]. Finally, too rapid correction of chronic hyponatremia can cause cerebral edema.

Hyponatremia can be classified on the basis of serum osmolality and volume status into three types:

- Hypovolemic hyponatremia: decreased total body sodium and decreased total body water. e.g. - vomiting, diarrhoea, diuretics etc.
- Euvolemic Hyponatremia: normal body sodium with increase in total body water e.g SIADH
- Hypervolemic hyponatremia: increase in total body water more than increase in total body sodium e.g. congestive cardiac failure, cirrhosis of liver

Hyponatremia usually results from combined water and electrolyte loss. It can be due to:

- Central defect of hypothalamic osmoreceptor function
- Loss of water via non renal route
- Renal loss

Doubts exist regarding prognostic impact of borderline changes in serum sodium concentration. Most of the studies performed to date chose to focus on severe hyponatremia.

Funk and colleagues in their study demonstrated influence of hyponatremia at ICU admission to be independently associated with outcome. In this study, mild hyponatremia was independently associated with a poor outcome. In addition, the association between serum sodium concentration and prognosis followed a U shaped curve [7].

Material and Methods

This study was institute-based, observational, cross-sectional study conducted in the Department of General Medicine, Calcutta National Medical College and Hospital (CNMCH) in collaboration with the Department of Pathology and Biochemistry, CNMCH, Kolkata for 12 months from July 2024 to June 2025, with 120 patients fulfilling the inclusion and exclusion criteria.

Inclusion Criteria: All patients age > 12 years admitted in General Medicine ward of CNMCH in critically ill condition.

Exclusion Criteria: 1) Patients with normal serum sodium level.

2) Patients under any medications affecting serum sodium level e.g. corticosteroids, diuretics, levothyroxine (except the patients who were diagnosed as hypothyroid during their admission) etc.

Study Tools

- 1) Routine blood investigation- Hb%, TC, DC, ESR, Platelets, Na, K, Urea, Creatinine, Liver Function Test, FT4, TSH, urinary sodium.
- 2) Investigations needed according to patients' condition.
- 3) Venous EDTA blood specimens of the patients were sent to assess blood haemoglobin, Total Count, Differential Count, ESR, and platelet count of the patients. Clotted blood specimens of all patients were sent to assess serum urea, creatinine, sodium (Na^+), potassium (K^+), LFT, FT4, TSH of the patients. Transportation time to laboratory from the ward is around 20 minutes. Spot urinary sodium of the patients were also sent who serum sodium was < 135 mEq/L on admission. Venous clotted blood specimens were sent to laboratory twice a day to monitor the serum sodium levels.
- 4) Admission serum sodium values and final serum sodium values of the patient have been taken for this study to analyse its relation with the outcome of the patient.

Outcome Definitions and Parameters: We have studied the clinical outcome of the patients in two ways 1) Number of patients discharged 2) Number of deaths.

We have taken normal serum Sodium level: 135 - 145 mEq/L; hyponatremia: serum Sodium < 135 mEq/L; hyponatremia: serum Sodium > 145 mEq/L.

Data Analysis: All Statistical Analysis Plan was done using IBM SPSS (Statistical Package for the Social Sciences) Version 21. Data was presented as mean \pm SD or number (%) unless specified. All parametric data was analysed using Student's t-test. All non-parametric data was analysed by Chi-

square test. A p-value of <0.05 was considered statistically significant.

Data Collection: Data was collected with the help of a questionnaire containing detailed history,

examination, biochemical and radiological findings, objective measurements was evaluated. All the data was kept for interpretation.

Results

Table 1: Association between Diagnosis: Admission serum sodium level

Diagnosis	Hypernatremia n (%)	Hyponatremia n (%)	Total n (%)
Acid ingestion	3 (6%)	0 (0%)	3 (2.5%)
Acute pancreatitis	3 (6%)	0 (0%)	3 (2.5%)
AECOPD	6 (12%)	0 (0%)	6 (5%)
CKD	0 (0%)	15 (21.4%)	15 (12.5%)
DCLD	0 (0%)	7 (10%)	7 (5.8%)
Dengue	2 (4%)	0 (0%)	2 (1.7%)
Distal RTA, Sjogren syndrome	1 (2%)	0 (0%)	1 (0.8%)
DKA	2 (4%)	0 (0%)	2 (1.7%)
Empyema	0 (0%)	1 (1.4%)	1 (0.8%)
Haemorrhagic CVA	7 (14%)	0 (0%)	7 (5.8%)
Heart failure	0 (0%)	1 (1.4%)	1 (0.8%)
HHS	10 (20%)	0 (0%)	10 (8.3%)
Hypothyroidism	0 (0%)	1 (1.4%)	1 (0.8%)
Ischaemic DCM	0 (0%)	14 (20%)	14 (11.7%)
Lung abscess	0 (0%)	2 (2.9%)	2 (1.7%)
Multi-infarct state	0 (0%)	11 (15.7%)	11 (9.2%)
P. falciparum malaria	2 (4%)	0 (0%)	2 (1.7%)
Paraquat ingestion	3 (6%)	0 (0%)	3 (2.5%)
Pneumonia	0 (0%)	5 (7.1%)	5 (4.2%)
Pyogenic meningitis	2 (4%)	1 (1.4%)	3 (2.5%)
Scrub typhus	0 (0%)	1 (1.4%)	1 (0.8%)
Scrub typhus, HLH	1 (2%)	0 (0%)	1 (0.8%)
Sepsis	1 (2%)	3 (4.3%)	4 (3.3%)
Sheehan syndrome	0 (0%)	1 (1.4%)	1 (0.8%)
Subarachnoid haemorrhage	1 (2%)	0 (0%)	1 (0.8%)
Tubercular meningitis	2 (4%)	0 (0%)	2 (1.7%)
Urosepsis	3 (6%)	7 (10%)	10 (8.3%)
VAP	1 (2%)	0 (0%)	1 (0.8%)
Total	50 (41.7%)	70 (58.3%)	120 (100%)

Table 2: Association Between Admission Serum Sodium Levels vs patient outcome

Admission Serum Sodium Level (mmol/L)	Death n (%)	Discharge n (%)	Total n (%)
<115	7 (100%)	0 (0%)	7 (5.8%)
115–125	0 (0%)	41 (100%)	41 (34.2%)
126–135	0 (0%)	22 (100%)	22 (18.3%)
146–150	0 (0%)	25 (100%)	25 (20.8%)
151–156	10 (40%)	15 (60%)	25 (20.8%)
Total	17 (14.2%)	103 (85.8%)	120 (100%)

Table 3: Association between final serum sodium levels of the patients with outcome

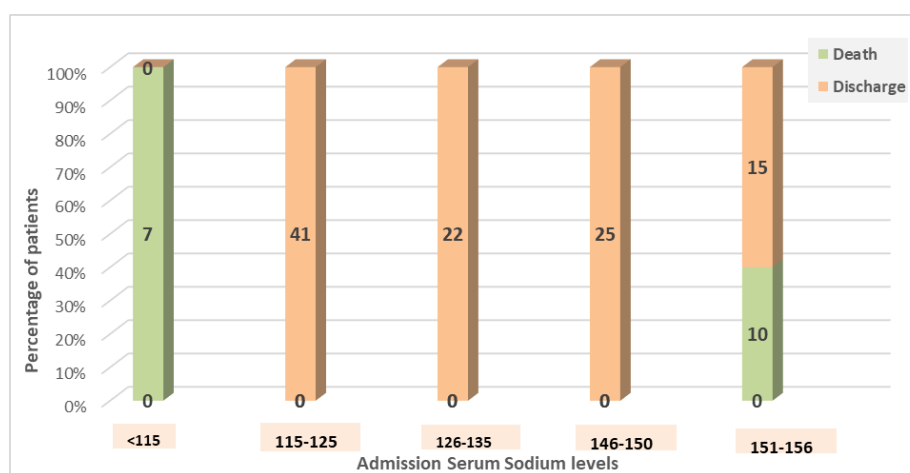
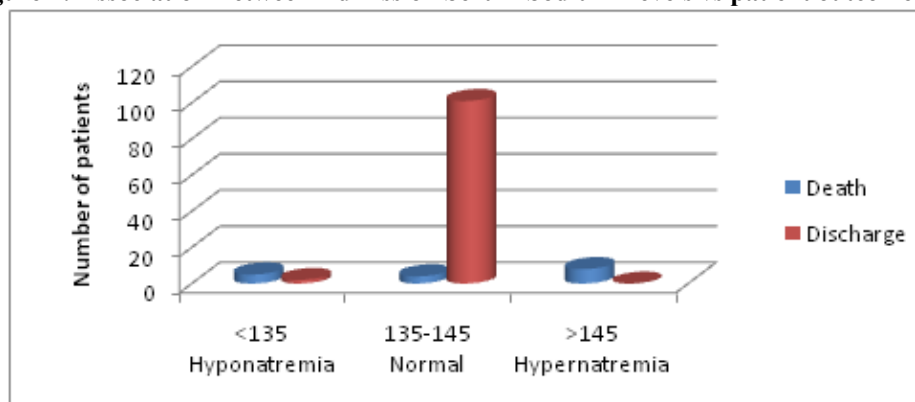
Final Serum Sodium Level	Outcome	Death n (%)	Discharge n (%)	Total n (%)
<135 mEq/L (Hyponatremia)	Death	5 (29.4%)	0 (0%)	5 (4.2%)
135–145 mEq/L (Normal)	Discharge	4 (23.5%)	103 (100%)	107 (89.2%)
>145 mEq/L (Hypernatremia)	Death	8 (47.1%)	0 (0%)	8 (6.7%)
Total		19 (15.8%)	103 (85.8%)	120 (100%)

Table 4: Association between duration of stay (in Days) of the patients with their admission serum sodium level

Duration of Stay (Days)	Admission Serum Sodium <135 mEq/L n (%)	Admission Serum Sodium >145 mEq/L n (%)	Total n (%)
0-6	28 (40%)	4 (8%)	32 (26.7%)
7-13	34 (48.6%)	38 (76%)	72 (60%)
≥14	8 (11.4%)	8 (16%)	16 (13.3%)
Total	70 (100%)	50 (100%)	120 (100%)

Table 5: Association between requirements of ventilator support of the patients with their admission serum sodium level

Ventilator Support	Admission Serum Sodium <135 mEq/L n(%)	Admission Serum Sodium >145 mEq/L n(%)	Total n(%)
Invasive ventilation	4 (5.7%)	9 (18%)	13 (10.8%)
Non-invasive ventilation	0 (0%)	5 (10%)	5 (4.2%)
Not required	66 (94.3%)	36 (72%)	102 (85%)
Total	70 (100%)	50 (100%)	120 (100%)

**Figure 1: Association Between Admission Serum Sodium Levels vs patient outcome in %****Figure 2: Association between final serum sodium levels of the patients with outcome**

In this study, majority of the patients were of 61 to 70 years of age (33.3%) and mean age of the study population was 65.4083 ± 14.2690 years with male (59.2%) predominance.

70 (58.3%) patients had hyponatremia among them 7 had sodium level below 115 mEq/l, 41 had sodium level between 116 to 125 mEq/l and 22 had serum sodium between 126 to 135 mEq/l. On the other hand, 50 (41.7%) patients had hypernatremia at the time of admission. Among them 25 patients had serum sodium between 146-150 mEq/l and the

remaining 25 had sodium between 151-156 mEq/L.

In our study 35(29.2%) patients had Type 2 diabetes mellitus, 20 (16.7%) patients had hypertension whereas 25% had both as their comorbidities. COPD (5.8%) and IHD (2.5%) were among the other comorbidities present. The association between comorbidities with admission serum sodium level of the patients was not statistically significant ($p=0.1011$).

Further, 15 (12.5%) patients had CKD, 10 (8.3%) had HHS (hyperglycemic hyperosmolar state), 14 (11.7%) patients had Ischemic DCM (dilated cardiomyopathy), 11(9.2%) had multi-infarct state and 10 (8.3%) patients had urosepsis as their final diagnosis. (Table 1).

In this study, mean hemoglobin of the study population was 11.2208 ± 1.9229 gm/dL and there was statistically significant association between hemoglobin of the patients with their admission serum sodium level ($p < 0.0001$).

The study also showed, mean serum urea of the patients was 48.6750 ± 21.3880 mg/dL. Mean serum urea of the patients with initial hyponatremia was 49.900 ± 26.9842 mg/dL and the mean serum urea of the patients who were initially hypernatremic was 46.9600 ± 8.9692 mg/dL. Association between serum urea and admission serum sodium level was not statistically significant ($p = 0.4602$). Similarly, there was no statistically significant association between mean serum creatinine (1.53 ± 1.22) and serum sodium at admission. Same result was seen in case of total bilirubin also. Mean serum total bilirubin was 1.6329 ± 1.5832 mg/dL in patients with admission hyponatremia and it was 1.1796 ± 0.3867 in patients with initial hypernatremia. Association between serum total bilirubin with admission serum sodium level was not statistically significant ($p = 0.0522$).

In our study mean serum albumin level was 3.7260 ± 0.3219 gm/dL in patients with admission hypernatremia and it was 3.5014 ± 0.4405 gm/dL in patients with admission hyponatremia. Association between serum albumin with admission serum sodium level was statistically significant ($p = 0.0027$).

In our study mean serum TSH was 4.4040 ± 1.1075 in patients with admission hyponatremia. Association between serum TSH with admission serum sodium was not statistically significant ($p = 0.5558$).

On further analysis it was seen that all 25 patients with admission serum sodium between 146-150 mEq/L were discharged. In contrast, 15 out of 25 patients with admission serum sodium between 151-156 mEq/L were discharged while 10 patients expired. Association between admission serum sodium in hypernatremic subjects with their outcome was statistically significant ($p = 0.0004$). (Table 2, Fig 1)

We found that all the 7 patients with admission serum sodium < 115 mEq/L died, whereas the remaining hyponatremic patients among whom all 41 patients with admission serum sodium between 115-125 mEq/L and all 22 patients with admission serum sodium between 126-135 mEq/L were

discharged. The association between admission serum sodium in hyponatremic subjects with their outcome was statistically significant ($p < 0.0001$). (Table 2, Fig 1)

We also analysed the final serum sodium values of the patient before their outcome. In this regard we found that, 5 (4.16%) patients were having hyponatremia, 8 (66.6%) patients were having hypernatremia and the remaining 107 (89.16%) patients were having normal serum sodium.

We also found that all the 5 patients whose final serum sodium was < 135 mEq/L and all 8 patients with final serum sodium > 145 mEq/L were dead. On the contrary, 4 out of 107 patients (3.73%) whose final serum sodium was between 135-145 mEq/L, were dead, rest discharged. Association between final serum sodium of the patients with their outcome was statistically significant ($p < 0.0001$) (Table 3, Fig 2).

Among the patients with hyponatremia at the time of admission, 28 patients had less than 1 week of hospital stay, 34 had 1-2 weeks of hospital stay and rest 8 patients stayed for more than 2 weeks in the hospital. In case of admission hypernatremic patients these figures were, 4 patients less than 1 week, 38 patients between 1-2 weeks and 8 patients more than 2 weeks. The association between duration of stay (in days) in hospital with the admission serum sodium values of the patients was statistically significant ($p = 0.0005$) (Table 4).

We also analysed the requirement of ventilator support in patients and we found that invasive ventilation was required in 13 (10.8%) patients, out of which 4 were hyponatremic and 9 were hypernatremic at the time of admission. Non-invasive ventilation was required in case of 5 (4.2%) patients and all were hypernatremic at admission. The association between requirement of ventilation with the admission serum sodium values of the patient was statistically significant ($p = 0.0017$) (Table 5).

Discussion

The present study was an Institute based descriptive observational cross-sectional study, conducted for 12 months at Calcutta National Medical College and Hospital with a sample size of 120 patients.

In our study majority of the population was elderly, similar to the study by Basile -Filho A et al in which mean age of the study population was 51.8 ± 17.3 years⁸.

In our study, it was observed that 15 (12.5%) patients had CKD (chronic kidney disease), 10 (8.3%) patients had HHS, 14 (11.7%) patients had ischemic dilated cardiomyopathy, 11 (9.2%) patients had multi-infarct state and 10 (8.3%) patients had

urosepsis. In their study, Padhi R et al showed that pneumonia being the leading cause of hyponatremia⁹. Severe sepsis, renal failure, heart failure, cirrhosis of liver and subarachnoid haemorrhage were other likely etiologic causes.

Hu J et al (2017)¹⁰ found that 16.8% patients were hyponatremic and 1.9% patients were hypernatremic according to their serum sodium level during hospitalization and also found that mixed dysnatremia and hypernatremia are strong risk factors associated with increased hospital mortality. These findings were corroborating with our study findings of increased death rate among patients with dysnatremia.

Like the study conducted by Amit Akirov et al¹¹, we also found that patients with dysnatremia had prolonged hospital stays.

Conclusions

Although this was a single centre study with its own limitations, after the analysis of the present study we can come to the conclusion that dysnatremia is a serious clinical challenge for the care of critically ill patients, requiring increased awareness, pro-active surveillance, and prompt intervention techniques to lessen its effects on patient outcomes. In our context, dysnatremia, especially hyponatremia, affects around 58.3% of the admitted patients and is very common among critically ill patients. This emphasizes how crucial it is to regularly check these individuals' electrolyte levels.

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Author Contributions

Dr Debdeep Das: Collection of data.

Dr Victor Roy: Statistical analysis (corresponding author).

Dr Sujoy Sarkar: Preparation of manuscript.

Dr Salil kr Pal: Preparation of manuscript.

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AI statement: No artificial intelligence (AI) was used in the writing, data analysis, or creation of figures for this manuscript.

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