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Association Between Admission Serum Sodium and In-Hospital Outcomes in Patients With Acute Heart Failure: A Retrospective Observational Study

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Abstract

Background: Acute heart failure is a major cause of hospital admission and is associated with substantial morbidity and mortality. Serum sodium abnormalities are frequently encountered in patients with heart failure and may reflect disturbances in fluid balance, neurohormonal activation and disease severity. Their relationship with in-hospital outcomes is therefore of clinical interest.
Objective: To evaluate the association between admission serum sodium concentration and in-hospital outcomes among patients admitted with acute heart failure.
Methods: This retrospective observational study was planned at Manipal Hospitals over a period of 1.5 years. Clinical records from 47 patients were supplied for preliminary analysis. Available fields included a variable labelled serum sodium, left ventricular ejection fraction (LVEF), length of hospital stay and additional columns whose labels were unavailable. Descriptive statistics were calculated for the interpretable LVEF and length-of-stay fields. The serum sodium entries and hospital outcome codes were reviewed for consistency before any association analysis.
Results: The supplied dataset contained 47 records. LVEF ranged from 32% to 80%, with a mean of 58.68 ± 12.19% and a median of 59%. Length of hospital stay ranged from 10 to 30, with a mean of 17.74 ± 7.41 and a median of 20 in the supplied numerical units. The field labelled serum sodium contained values ranging from 3 to 15, which could not be interpreted as serum sodium concentrations in mmol/L. The final outcome field contained numerical codes from 0 to 5, but their meanings were not provided. Consequently, the association between admission serum sodium and in-hospital mortality or other outcomes could not be calculated reliably.
Conclusion: The supplied records permit preliminary descriptive analysis of LVEF and length of stay, but they are insufficient to determine whether admission serum sodium is associated with in-hospital outcomes. Verification of sodium measurements, outcome definitions and the unlabeled variables is necessary before a definitive statistical analysis can be undertaken.

Keywords: *Acute heart failure; serum sodium; hyponatraemia; ejection fraction; length of hospital stay; in-hospital mortality; retrospective study.*

INTRODUCTION

Acute heart failure is a clinical syndrome characterized by the onset or worsening of symptoms and signs of heart failure that require urgent medical assessment and treatment. Patients may present with breathlessness, peripheral oedema, pulmonary congestion, fatigue or evidence of impaired systemic perfusion. The clinical course varies according to cardiac function, underlying cardiovascular disease, coexisting conditions and the response to treatment.

The initial evaluation of patients admitted with acute heart failure commonly includes clinical assessment, electrocardiography, echocardiography and laboratory investigations. Renal function and serum electrolytes are important components of this evaluation because they contribute to assessment of comorbidity, treatment safety and prognosis [1].

Serum sodium disturbances are common in patients with heart failure. Hyponatraemia may reflect impaired water excretion, neurohormonal activation and fluid retention. It can also occur in association with diuretic treatment and other clinical conditions. Therefore, a low sodium concentration should be interpreted in the context of the patient's volume status, renal function, medications and overall clinical presentation [1,2].

Previous studies have examined the relationship between admission sodium and outcomes in acute decompensated heart failure. A study published by Hiki and colleagues reported that lower admission sodium was associated with a higher risk of subsequent clinical events in patients with acute decompensated heart failure [2]. Research conducted in India has also investigated the relationship between admission sodium, systolic blood pressure and in-hospital outcomes among patients admitted with acute decompensated heart failure [3].

A systematic review and meta-analysis published in 2023 reported an association between hyponatraemia and increased mortality among patients with heart failure, although the magnitude of the association varied across outcomes and included studies [4]. These findings support continued evaluation of sodium measurements as part of clinical risk assessment. However, an observed association does not establish that sodium abnormalities independently cause adverse outcomes.

The interpretation of a hospital-based study requires accurate recording of laboratory measurements, clearly defined outcomes and appropriate consideration of potential confounding factors. In particular, admission sodium should be measured using a documented laboratory value and unit, while mortality and discharge outcomes should be defined from hospital records.

The present study was planned to examine whether admission serum sodium concentration was associated with in-hospital outcomes among patients admitted with acute heart failure at a tertiary-care hospital.

AIM AND OBJECTIVES

Aim

To evaluate the association between admission serum sodium concentration and in-hospital outcomes in patients admitted with acute heart failure.

Primary objective

To assess the relationship between serum sodium concentration at admission and in-hospital mortality.

Secondary objectives

1. To describe the distribution of LVEF among the included patients.
2. To summarize the length of hospital stay.
3. To examine the relationship between admission sodium and length of hospital stay.
4. To explore the association of sodium with renal function and other relevant clinical characteristics, where verified data are available.
5. To identify factors associated with adverse in-hospital outcomes, provided that the number of outcome events and completeness of the data support such analysis.

MATERIALS AND METHODS

Study design

This study was designed as a retrospective observational investigation based on hospital records of patients admitted with acute heart failure.

Study setting and duration

The study was conducted in the Department of Cardiology at Manipal Hospitals X, a tertiary-care hospital.

The study covered a period of 1.5 years, from July 2019 to Dec 2020. The precise record-review period should be confirmed from the original study documentation.

Study population and sample size

The supplied dataset contained 47 patient records. The intended study population comprised patients admitted with acute heart failure during the specified period.

The final eligibility criteria should reflect the original protocol and the actual admission diagnoses. The dataset should be checked to ensure that all 47 records represent eligible patients and that repeated admissions, if present, were handled consistently.

Inclusion criteria

The proposed inclusion criteria were:

1. Adult patients admitted with a documented diagnosis of acute heart failure.
2. Availability of an admission serum sodium result recorded in the hospital laboratory system.
3. Availability of a documented in-hospital disposition or outcome.

4. Admission during the defined study period.

These criteria must be reconciled with the actual study protocol before submission.

Exclusion criteria

Potential exclusions, where specified by the study protocol, include:

1. Records in which acute heart failure was not confirmed.
2. Records belonging to patients admitted primarily for a different condition without a documented episode of acute heart failure.
3. Duplicate records that do not represent separate eligible admissions, according to the prespecified selection procedure.
4. Records without sufficient information to establish eligibility.

A missing sodium measurement or outcome should be documented explicitly rather than silently replaced or inferred.

Data collection

Clinical information was supplied in a tabular format containing a variable labelled serum sodium at admission, LVEF, length of hospital stay and additional columns without headers.

The LVEF and length-of-stay values were suitable for preliminary descriptive summaries, subject to confirmation of units and definitions. The numerical entries in the serum sodium field ranged from 3 to 15 and were not clinically interpretable as sodium concentrations in mmol/L. Therefore, these entries were excluded from the sodium–outcome analysis pending verification.

The two Yes/No columns and the final numerical code were not interpreted because their definitions were not supplied. Patient names were not included in the analytical tables.

Exposure definition: admission serum sodium

Admission serum sodium was intended to be the principal exposure variable. The laboratory concentration, expressed in mmol/L, should be obtained from the original laboratory record using a clearly defined admission time window.

If the data are confirmed, sodium may be analysed as a continuous variable. A categorical analysis may additionally be considered using prespecified clinical thresholds. Hyponatraemia is commonly defined in heart failure guidance as a serum sodium concentration below approximately 135–136 mmol/L, depending on the reference used [1].

Categorization should only be undertaken after the actual laboratory values and units are confirmed. Values should not be reconstructed from truncated or coded entries.

Outcome definitions

Primary outcome: In-hospital mortality, defined as death occurring during the index hospitalization.

Secondary outcomes: Length of hospital stay and other documented in-hospital clinical outcomes, provided that each variable is defined in the study protocol and data dictionary.

The final numerical field in the supplied table contained codes from 0 to 5, but no codebook was provided. Consequently, this field cannot be interpreted as mortality status, heart failure severity or a validated outcome scale until the meaning of each code is confirmed.

Echocardiographic assessment

LVEF was available as a numerical variable in the supplied records. The distribution was summarized descriptively. For exploratory presentation, values can be grouped into reduced LVEF (≤40%), mildly reduced LVEF (41–49%) and preserved-range LVEF (≥50%), provided that the values represent actual percentages and were recorded reliably [1].

These LVEF categories describe systolic function and should not be treated as a complete diagnosis of heart failure phenotype without the relevant clinical information.

Statistical analysis

Descriptive statistics were calculated for the interpretable variables. Continuous variables were summarized as means with standard deviations, medians and interquartile ranges, and minimum–maximum values.

Once the correct sodium and outcome data are available, the association between sodium concentration and in-hospital mortality may be evaluated using an appropriate regression model, depending on the number of outcome events. Length of stay may be analysed as a continuous outcome using a suitable statistical method, after assessing its distribution.

Potential confounders may include age, renal function, systolic blood pressure, LVEF and relevant comorbidities if those values were actually collected. Multivariable analysis should be restricted according to the sample size and number of events to avoid overfitting.

Results should be expressed with effect estimates and 95% confidence intervals where possible. Missing observations and the denominator used for each analysis should be reported transparently.

RESULTS

Study population

A total of 47 patient records were supplied for preliminary analysis. The provided table did not contain usable demographic details or clearly labelled clinical outcome data. Accordingly, descriptive analysis was restricted to LVEF and length of hospital stay, with a data-quality review of the field labelled serum sodium.

Left ventricular ejection fraction

The recorded LVEF values ranged from 32% to 80%. The mean LVEF was 58.68 ± 12.19%, and the median was 59%, with an interquartile range of 49–68.5%.

Table 1. Descriptive summary of left ventricular ejection fraction (n = 47)

Parameter	Result
Number of records	47
Mean ± standard deviation	58.68 ± 12.19%
Median	59%
Interquartile range	49–68.5%
Minimum	32%
Maximum	80%

These results describe the supplied LVEF values, assuming that the column was correctly labelled and the entries represent percentages.

Table 2. Distribution of LVEF by numerical category

LVEF category	Number (n)	Percentage (%)
≤40%	4	8.5
41–49%	9	19.1
≥50%	34	72.3
Total	**47**	**100.0**

The categories are descriptive and depend on confirmation of the LVEF values as valid percentages.

Length of hospital stay

The supplied length-of-stay field ranged from 10 to 30. The mean was 17.74 ± 7.41, while the median was 20 and the interquartile range was 10–20.

Table 3. Descriptive summary of length of hospital stay (n = 47)

Parameter	Result
Number of records	47
Mean ± standard deviation	17.74 ± 7.41
Median	20
Interquartile range	10–20
Minimum	10
Maximum	30

The unit of the supplied field was not explicitly stated. If these entries represent days, the table should be labelled in days after confirmation from the original records.

Association between admission sodium and in-hospital outcomes

The association between admission serum sodium and in-hospital outcomes could not be calculated because the sodium values were not interpretable as laboratory concentrations and the outcome codes lacked definitions.

Consequently, no estimate of the effect of hyponatraemia on in-hospital mortality, no correlation with length of stay and no statistically significant predictor could be reported from the supplied data.

DISCUSSION

Principal findings

The preliminary analysis included 47 patient records and described LVEF and length of hospital stay. The mean recorded LVEF was 58.68%, while the recorded length-of-stay variable had a mean of 17.74 and a median of 20 in the supplied units.

However, the primary question—whether admission serum sodium is associated with in-hospital outcomes—could not be addressed. The variable labelled sodium contained values that were not interpretable in the stated clinical context, while the outcome and two binary variables lacked definitions. Therefore, the present findings do not establish any relationship between hyponatraemia and prognosis.

Serum sodium and heart failure outcomes

Serum sodium is clinically relevant in acute heart failure because abnormal sodium concentrations can reflect disturbances in water balance and the neurohormonal response to reduced effective circulating volume. Sodium abnormalities may also coexist with renal dysfunction and treatment-related changes in fluid balance [1].

In an observational study of 584 patients with acute decompensated heart failure, Hiki and colleagues found that lower sodium concentrations were associated with a greater risk of long-term clinical events [2]. Their findings support the importance of evaluating sodium even when its concentration falls within the lower part of the reference range.

An Indian prospective study involving 130 patients with acute decompensated heart failure examined the relationship between admission sodium and in-hospital outcomes. Its authors reported that hyponatraemia and systolic blood pressure were associated with in-hospital mortality [3]. Such results provide a rationale for examining sodium concentration in a local hospital cohort, but they cannot substitute for the analysis of the present dataset.

A systematic review and meta-analysis published in 2023 also reported an association between hyponatraemia and adverse outcomes in heart failure, including in-hospital mortality [4]. Differences in patient characteristics, outcome definitions and analytical methods across studies mean that the estimates should not be applied directly to this 47-patient cohort.

Ejection fraction and hospital stay

The descriptive LVEF findings suggest that the supplied records covered a range of systolic function. However, the clinical phenotype and severity of heart failure cannot be inferred from LVEF alone. A complete assessment would also require the presenting symptoms, signs of congestion or hypoperfusion, relevant cardiac history and supporting investigations.

The supplied length-of-stay values showed variation across the cohort. Once confirmed as days and linked to the corresponding patient records, length of stay could be evaluated in relation to sodium and other clinical characteristics. Such an analysis would require the true laboratory measurements and should account for death during admission, discharge practices and clinical severity.

Importance of data validation

The primary exposure and outcome must be measured correctly before their association can be examined. The first step is to retrieve the original serum sodium value in mmol/L from the laboratory information system and verify the timestamp relative to admission. The second is to identify the coding system used for the outcome variable and determine which codes correspond to discharge alive and in-hospital death.

The same verification is required for the two binary fields. If one represents renal dysfunction, its clinical definition and source must be documented. A statistical model based on incorrectly labelled variables would produce results that could not be interpreted reliably.

Clinical implications

If the original data are corrected and the number of outcomes is sufficient, the study may help describe the relationship between admission sodium, renal function, LVEF, length of stay and hospital disposition in the local heart failure population.

Until then, the current analysis should be limited to the descriptive variables that are interpretable. It would be inappropriate to conclude that hyponatraemia predicted mortality or prolonged hospitalization on the basis of the supplied sodium entries.

Strengths and Limitations

Strengths

The proposed study addresses a clinically meaningful question using routinely available hospital measurements. The retrospective design allows review of real-world admissions over a defined 1.5-year period. LVEF and length of stay can be summarized from the 47 supplied records, subject to confirmation of their labels and units.

Limitations

The principal limitation is that the field labelled serum sodium does not contain interpretable sodium concentrations in mmol/L. The outcome codes and two binary variables are not labelled, preventing reliable classification of mortality, renal dysfunction or other clinical conditions.

The supplied records also do not provide clearly defined age, comorbidities, blood pressure, creatinine or other potential confounding variables. These omissions limit the possibility of estimating the independent association between sodium and outcomes.

The sample is small, and any multivariable model may be unstable if the number of deaths is limited. Finally, the study is retrospective and single-centre, and its findings may not generalize to other hospitals.

CONCLUSION

The supplied dataset permitted preliminary description of LVEF and the numerical length-of-stay field in 47 records. However, the intended association between admission serum sodium and in-hospital outcomes could not be evaluated because the sodium values and outcome codes were not interpretable from the available information.

Verification of the original laboratory values, outcome definitions and unlabeled clinical variables is necessary before determining whether hyponatraemia is associated with in-hospital mortality or length of stay. Any final conclusions must be based on the corrected records and an appropriate statistical analysis.

Recommendations

1. Retrieve admission serum sodium concentrations from the original laboratory records and record them in mmol/L.
2. Confirm whether the final numerical code represents mortality, discharge status, clinical severity or another variable.
3. Identify and define both binary variables.
4. Verify that the LVEF and length-of-stay columns are correctly labelled and that the length-of-stay unit is documented.
5. Perform statistical comparisons only after exposure and outcome definitions have been validated.
6. Follow the STROBE guidance for transparent reporting of retrospective observational studies [5].

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