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Role of Serum Sodium Level in Predicting Mortality in Patients with Heart Failure: A Prospective Cohort Study

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Abstract

Background: Heart failure is associated with substantial morbidity and mortality. Patients with heart failure often exhibit hyponatremia and may reflect hemodynamic and neurohormonal disturbances.

Aim of study: To evaluate the role of serum sodium level as a predictor of mortality among patients with HF in Iraq.

Methods: A prospective cohort study was conducted among 100 adult patients with heart failure admitted to the Internal Medicine Department of Baghdad Teaching Hospital between July 2025 and July 2026. It included 100 adult patients who presented to the adult patients with HF hospitalized to the hospital with left ventricular ejection fraction < 49% at admission and followed up to evaluate in-hospital mortality. Demographic and clinical characteristics, laboratory parameters, ejection fraction, duration of hospitalization, and patient outcome were recorded.

Results: In this study, hyponatremia was present in 58% of patients. Overall, 32% of patients died. Mortality was significantly higher among patients with hyponatremia than among those with normal serum sodium levels (43.1% vs. 16.7%, $P=0.005$). Patients with hyponatremia also had a significantly longer duration of hospitalization, lower systolic and diastolic blood pressures, and higher mean heart rate than patients with normal sodium levels ($P < 0.001$).

Conclusions: Serum sodium is an inexpensive, readily available clinical marker for risk stratification and prognostic assessment in patients with heart failure as hyponatremia is common among hospitalized patients with heart failure and is significantly associated with increased mortality.

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Keywords: Hyponatremia, heart failure, mortality, predictor, sodium

Introduction

The impaired capacity of the heart to efficiently pump and/or fill is the hallmark of the clinical illness known as heart failure (HF) ^[1]. Patients, healthcare systems, and societies are all heavily burdened by this major cause of death and disability on a global scale ^[2]. More than 40 million people across the globe are living with heart failure, and the outlook for these patients is bleak: 20 percent die within one year after diagnosis, and 53 percent within five years ^[3, 4]. Several etiological factors, such as hereditary predispositions, hypertension, diabetes, coronary artery disease (CAD), valvular heart disease, myocarditis, and cardiomyopathies, combined to cause HF. To develop personalized preventative and therapeutic approaches, knowledge of these aspects is essential ^[5, 6]. Myocardial fibrosis, proarrhythmia, and pump failure are the end results of direct cytotoxicity, which persists even when adequate cardiac output is maintained via sodium and water retention and enhanced myocardial contraction ^[7]. It is crucial to find biomarkers that can be used in clinical settings to help predict who will have a severe aggravation of

chronic HF and how to treat them [8]. Fluid homeostasis, blood pressure regulation, and proper cellular activity are all dependent on serum sodium, an important electrolyte [9]. Patient classification and risk management could benefit greatly from a better understanding of the relationship between serum sodium concentrations and coronary heart disease (CHD) [10]. Hyponatremia and hypotension are associated with an increased risk of death from HF [11]. People with HF are at an increased risk of morbidity and mortality due to pulmonary or peripheral oedema, which can occur from a retention of sodium and water [12]. While some research has linked low serum sodium levels to negative cardiovascular outcomes, other studies have linked high levels to negative results as well, and yet others have shown negative effects from both extremes [13]. Although serum sodium has been investigated as a prognostic marker in several international populations, evidence from Iraq remains limited. Such information could support early risk stratification and potentially assist clinicians in identifying patients who require closer monitoring and more intensive management. The aim of this study is to evaluate the role of serum sodium level as a predictor of mortality among patients with HF in Iraq.

Patients and methods

Study Design and Setting

A prospective cohort study was conducted in the internal medicine department at Baghdad Teaching Hospital in a period of one year from July 2025 to July 2026. The center serves as a major referral facility for cardiology care in central Iraq, providing care to diverse socioeconomic populations.

Study Patients

The study included 100 adult patients who presented to the adult patients with acute HF hospitalized to Baghdad Teaching Hospital with left ventricular ejection fraction (EF) < 49% at admission and followed up to evaluate in-hospital mortality. They were enrolled according to the predefined eligibility criteria during the study period, assessed and enrolled at hospital admission, and the admission serum sodium concentration was used for the primary analysis. Patients with new acute coronary syndrome, sepsis, hypertriglyceridemia, and chronic renal failure were excluded from this study. Diagnosis of HF depends in accordance with European Society of Cardiology (ESC) 2023 guideline [14]:

- **Clinical history:** History of CAD, hypertension, orthopnea, use of diuretics, exposure to cardio toxic drugs, and paroxysmal nocturnal dyspnea.
- **Physical examination:** Displaced apex beat, heart murmur, rales, bilateral ankle edema, S3 heart sound, and jugular venous distention.
- **Electrocardiography (ECG).**
- Echocardiographic examinations were performed by an experienced echocardiographer. Left ventricular EF was assessed using the Simpson biplane method. The initial echocardiographic measurement obtained at admission and used for patient eligibility was the left ventricular EF, before initiation of or early during hospital treatment.

Figure 1 illustrates the study's strict inclusion criteria focused on primary ICH with early neurological assessment and imaging.

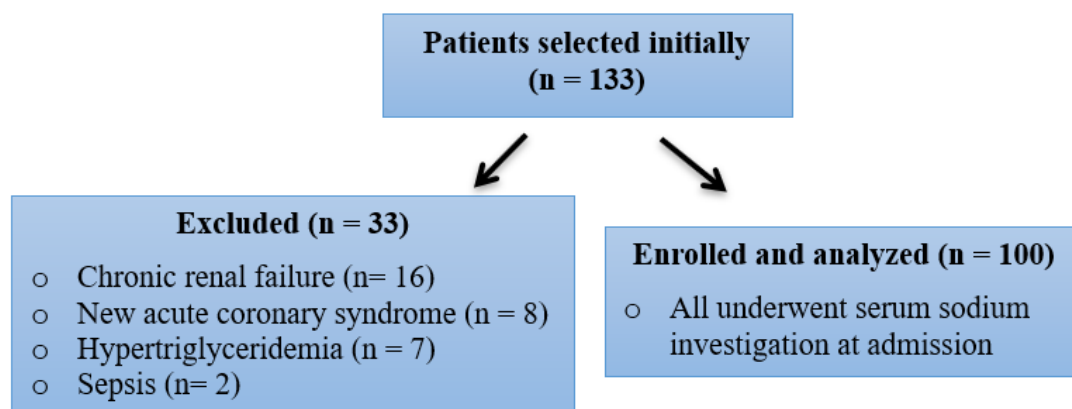


Fig 1: Patient Flow Diagram

Ethical Considerations: The Declaration of Helsinki lays forth the ground rules for ethical conduct. Approval was obtained from Baghdad Teaching Hospital Ethics Committee. Written informed consent was acquired from all patients or surrogates. Data were stored securely using coded identifiers in a password-protected environment.

Data Collection: A questionnaire was applied to collect the needed information as sociodemographic information (Age, gender, occupation, residence, smoking status, and Body Mass Index (BMI), cause of HF, Vital signs as systolic and diastolic blood pressure (SBP and DBP) and heart rate, left ventricular EF by Echo study, duration of hospitalization, history of previous hospitalization, and investigation as CBC,

FBS, RFT, s. cholesterol, s. potassium, and s. sodium), and fate of patients. Serum sodium level < 135 mmol/L is considered hyponatremia [15].

Statistical Analysis: Statistical Package for the Social Sciences (SPSS) version 28 was used to analyze the data. The data is displayed using standard deviation, ranges, and mean. Information is organized into categories with percentages and frequencies displayed. To compare the continuous variables, an independent t-test with two tails was employed. We utilized a chi-square test to determine whether there was a correlation between serum sodium level and death. A p-value lower than 0.05 was considered statistically significant.

Results

In this study, mean age of patients was 68.34 ± 9.8 years. Males constituted nearly two-thirds of the study population (64%), most patients were from urban areas (74%), more than

half had higher education (52%), retired individuals represented the largest occupational group (41%), more than half of the patients had a normal BMI (52%), and 38% of patients were smokers. (Table 1)

Table 1: Socio-demographic characteristics (n= 100)

Variable	Frequency	Percentage (%)
Age group (years)	< 60	33
	60 – 69	41
	≥ 70	26
Gender	Male	64
	Female	36
Residence	Urban	74
	Rural	26
Educational level	Illiterate	12
	Primary / Secondary school	36
	Higher education	52
Occupation	Employee	12
	Housewife	26
	Retired	41
	Private work	21
BMI Level	Normal	52
	Overweight	34
	Obese	14
Smoking	Yes	38
	No	62

As shown in table 2, ischemic heart disease was the most frequently reported underlying cause of HF, accounting for 46% of cases, most patients (78%) had a history of previous hospitalization for HF, 42% of patients remained hospitalized

for more than 7 days. Hyponatremia was observed in 58% of patients. Overall, 32% of the patients died during the study period, whereas 68% survived.

Table 2: Clinical characteristics (n= 100)

Variable	Frequency	Percentage (%)
Cause of HF	Ischemic heart disease	46
	Valvar Heart Disease	16
	COPD	12
	Dilated cardiomyopathy	11
	Diabetes mellitus	8
	Atrial fibrillation	5
	Unknown cause	2
Previous Hospitalization	Yes	78
	No	22
Duration of hospitalization (Days)	< 3	26
	3 – 7	32
	> 7	42
S. Na Level	Hyponatremia	58
	Normal level	42
Mortality	Yes	32
	No	68

A statistically significant association detected between serum sodium status and mortality among patients with HF ($P=0.005$). Mortality was substantially more frequent among patients with hyponatremia, with 43.1% dying compared with 16.7% with normal serum sodium levels. Conversely,

survival was observed in 56.9% of patients with hyponatremia compared with 83.3% of those with normal serum sodium levels. These findings indicate that hyponatremia at admission was associated with a higher proportion of mortality among the studied patients (Table 3).

Table 3: Association between mortality and serum sodium level

Serum Sodium level	Mortality		Total (%) n= 100	P - Value
	Yes (%) n= 32	No (%) n= 68		
Hyponatremia	25 (43.1)	33 (56.9)	58 (58.0)	0.005
Normal level	7 (16.7)	35 (83.3)	42 (42.0)	

Patients with hyponatremia had a significantly longer duration of hospitalization than those with normal serum sodium levels ($P < 0.001$). Mean SBP and DBP were also significantly lower among patients with hyponatremia (both $P < 0.001$), accompanied by a significantly higher mean heart rate ($P < 0.001$). In contrast, there was no statistically

significant difference in mean EF and BMI level between the two groups ($P \geq 0.05$). Overall, these findings demonstrate that hyponatremia was associated with prolonged hospitalization and less favorable hemodynamic parameters, while left ventricular EF and BMI level did not differ significantly according to serum sodium status (Table 4).

Table 4: Comparison of certain clinical parameters according to serum sodium level

Variable	Serum Sodium level		P- Value
	Hyponatremia Mean $\pm$ SD	Normal level Mean $\pm$ SD	
BMI (kg/m ²)	27.33 $\pm$ 6.3	25.98 $\pm$ 4.6	0.126
Duration of hospitalization (day)	4.98 $\pm$ 1.92	6.78 $\pm$ 1.44	< 0.001
EF (%)	36.2 $\pm$ 5.41	37.3 $\pm$ 6.32	0.411
SBP (mmHg)	101.4 $\pm$ 23.59	132.3 $\pm$ 25.14	< 0.001
DBP (mmHg)	61.81 $\pm$ 18.41	79.15 $\pm$ 10.32	< 0.001
Heart Rate (beats/min)	89.71 $\pm$ 12.1	77.6 $\pm$ 12.13	< 0.001

Discussion

Low sodium levels, or hyponatremia, are common electrolyte abnormalities in HF patients and are linked to both short- and long-term complications. In patients with HF, a seemingly simple laboratory measurement such as serum sodium may provide important insight into the severity and prognosis of the disease [16]. In this study, hyponatremia was common among hospitalized patients with HF and was significantly associated with mortality, with patients presenting with low serum sodium experiencing a substantially higher mortality rate than those with normal sodium levels. Similar findings were reported in studies conducted by Peng S *et al* [17] and Durrani O *et al* [18] as they reported that admission hyponatremia is associated with higher in-hospital and 30-day mortality in HF patients. In fact, hyponatremia is common in cardiac patients, and it is associated with increased mortality. The processes are not yet understood. Hyponatremia may reduce tolerance to ischemia reperfusion injury, according to some research, since it alters NO production and increase protein nitrosylation [19]. Low serum sodium is not only an electrolyte abnormality, but it reflects advanced cardiac dysfunction, impaired renal water handling, and neurohormonal activation [16]. In HF, the sympathetic nervous system, renin–angiotensin–aldosterone system, and particularly arginine vasopressin release (AVP) is stimulated by cardiac output reduction and effective arterial blood volume [20]. Dilutional hyponatremia results from the promotion of renal water retention by persistent AVP production, which is caused by enhanced water reabsorption. Concurrently, salt dilution is worsened by reduced renal function and renal hypoperfusion, which decreases the capacity to excrete free water [21].

In the current study, hyponatremia had a significantly longer duration of hospitalization, lower SBP and DBP, and higher mean heart rate than those with normal serum sodium levels in HF patients. Ali K *et al* study found similar results as hyponatremic patients had significantly longer hospitalization than normonatremic patients, and also had lower blood pressure and poorer functional status [22]. The correlation between hyponatremia and longer hospital stays, reduced blood pressure, and increased heart rate could reflect the hemodynamic and neurohormonal abnormalities involved in HF. Reduced effective arterial blood volume in HF typically leads to hyponatremia. This, in turn, triggers compensatory activation of the sympathetic nervous system and the renin-angiotensin-aldosterone system, coupled with

increased production of arginine vasopressin [23].

Conclusion

This study showed that hyponatremia is common among hospitalized patients with HF and is significantly associated with increased mortality. Furthermore, hyponatremia was associated with a longer duration of hospitalization, lower SBP and DBP, and higher heart rate, suggesting a relationship between reduced serum sodium levels and greater clinical and hemodynamic compromise. These findings highlight the potential value of serum sodium as an inexpensive, readily available clinical marker for risk stratification and prognostic assessment in patients with HF. Thus, measuring serum Na at admission and before discharge in patients with HF is highly recommended. Larger studies with larger sample size and longer duration are recommended to establish its independent predictive value for mortality.

Study Limitations

This study had number of limitations such as:

- The study was conducted at a single tertiary hospital in Baghdad, which may limit the generalizability of the results to other hospitals and populations in Iraq.
- Serum sodium was assessed at admission, and the study did not evaluate changes in sodium concentration during hospitalization or the prognostic significance of persistent or corrected hyponatremia.
- The study focused on hospitalized patients with reduced left ventricular EF and therefore the findings may not be directly applicable to patients with preserved or mildly reduced EF or to community-based HF populations.

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