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Original Research Article

Assessment of Prognostic Role of Spot Urinary Sodium and Chloride in Hospitalized Acute Decompensated Heart Failure Patients

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Conflict of interest: Nil

Abstract:

Introduction: Recent investigations have established the predictive relevance of spot urine sodium (UNa+) in acutely decompensated chronic HF (ADCHF) patients. However, there is little information available on the predictive significance of spot urine chloride (UCl−) and UNa+ in patients with advanced heart failure. Spot assessment of urine sodium (UNa+) has emerged as a viable method for monitoring diuretic responsiveness in patients with acute heart failure (AHF). In the present prospective pilot study, we evaluated the prognostic value of spot UNa+ and UCl− concentration at baseline, at 2 h and at 24 h after admission for all-cause mortality and HF re-hospitalization up to 6-month post discharge.

Methods: Consecutive advanced HF patients (n = 90) admitted with ADCHF and aged > 18 years were included in the study. Loop diuretics were administered based on the natriuresis-guided algorithm recommended by the recent HF guidelines. Exclusion criteria were Stage 5 chronic kidney disease, Severe hepatic dysfunction, Inability to collect adequate urine samples.

Result: A total of 90 patients were included. A poor diuretic response was observed in 26 (28.8%). Survival analysis tests demonstrated significant differences showing a higher proportion of all-cause mortality (ACM) and HF re-hospitalization in the poor-diuretic-response group.

Conclusions: In outpatients with chronic HF, decreased UNa+ was related with a higher risk of recurrent WHF episodes. Patients with an adequate diuretic response demonstrated significantly higher decongestion at 48 h and a better prognosis regarding ACM and/or HF re-hospitalizations.

Keywords: Heart Failure; Congestion; Natriuresis; Diuretic Response; Spot Urinary Electrolytes.

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Introduction

Acute decompensated heart failure (ADHF) is a leading cause of hospitalization globally, contributing significantly to medical expenses due to its high rates of morbidity and mortality. The most prevalent form of AHF, accounting for 50–70% of presentations, is acute decompensated heart failure [1]. An estimated 2–5 million patients in India suffer from heart failure (HF), with an incidence of 2-3 per 1000 people, according to estimations based on data from limited research and recognized risk factors for HF [2]. The treatment of acute heart failure (AHF) has not evolved over the last few decades; it still focuses on lowering hospital stays, traffic, and volume overload [3].

Signs and symptoms of extracellular fluid accumulation that contribute to high ventricular filling pressures are referred to as congestion, a typical finding in acute decompensated chronic heart failure (ADCHF). The mainstay of modern HF medication is the treatment of congestion in acute HF, which is generally performed with loop diuretics [4]. Intravenous loop diuretics are used to treat fluid overload symptoms in patients with ADCHF because the increase in venous return and ventricular filling pressures is caused by sodium (Na+) and water retention in the extracellular space. More than 90% of patients with ADCHF employ loop diuretics, which are the cornerstone of diuretic therapy [5].

Although these are not ideal, the clinical examination results (symptoms and/or signs), urine output, weight loss, blood levels of natriuretic peptides, and renal function (creatinine/urea) are commonly used to estimate decongestion. Many patients with acute decompensated CHF display an insufficient diuretic response, which is linked to prolonged congestion and a higher risk of death and rehospitalisation for heart failure [6]. While spot urinary chloride (UCl−) is less well understood, several recent studies have established the prognostic importance of urine Na+ UNa+ concentration in patients presenting in the emergency department (ED) with ADCHF [7].

Therefore, it's vital to recognize those who don't respond well to diuretics as soon as they're admitted to the hospital. Natriuretic may be a sensitive, objective, quantitative, and trustworthy marker to evaluate responsiveness given the way loop diuretics act. In a recent consensus agreement on diuretic medication, the Heart Failure Association of the European Society of Cardiology (ESC) proposed checking into spot urine sodium and/or diuresis very soon after diuretic initiation in AHF [8].

Material & Methods

Study Design: In order to assess the predictive significance of spot urine salt and chloride values in hospitalized heart failure patients, a single-centre prospective observational cohort study was carried out. The purpose of the study was to evaluate the relationship between early urine electrolyte concentrations and clinical outcomes, such as diuretic response patterns, mortality, and readmission rates.

Study Setting and Duration: The study, which ran from January 2024 to June 2025, was carried out at the SCBMCH CUTTACK, Department of Cardiology. Eligibility screening was performed on all consecutive patients admitted to the cardiology ward with acute or acute-on-chronic heart failure as their major diagnosis.

Study Population

Inclusion Criteria

- Age ≥18 years
- Primary diagnosis of heart failure requiring hospitalization
- Clinical indication for intravenous loop diuretic therapy
- Ability to provide informed consent

Exclusion Criteria

- Stage 5 chronic kidney disease (eGFR<15mL/min/1.73m²)
- Active use of diuretics within 24 hours prior to admission
- Active malignancy with life expectancy <30 days
- Severe hepatic dysfunction
- Inability to collect adequate urine samples

Sample Size Calculation: A minimum sample size of 76 patients was needed, based on prior research looking at urine electrolyte indicators in heart failure and assuming a moderate effect size (Cohen's d = 0.6) for the primary endpoint of all-cause mortality, with $\alpha = 0.05$ and power = 80%. We sought to enlist 90 patients, taking into consideration possible dropouts and insufficient data collection.

Results

Study Population: A total of 90 patients were enrolled in the study. Out of the 90 patients 60 were male patients (66.7%,), females constituting 30 patients (33.3%). The mean age of the study population was 61.2 years (SD=11.2) with values ranging from 36 to 95 yrs. The mean weight was 71.9 kg (SD=11.8).

Statistical Analysis: All collected data were analysed using SPSS version 21.

Descriptive Statistics

- Continuous variables: Presented as mean ± standard deviation for normally distributed data, or median (interquartile range) for non-normally distributed data
- Categorical variables: Presented as frequencies and percentages

Comparative Analysis

- **Group Comparisons:** Mann-Whitney U test for continuous variables (non-parametric approach due to small sample sizes).
- **Correlation Analysis:** Pearson correlation for normally distributed data, Spearman correlation for non-parametric data.

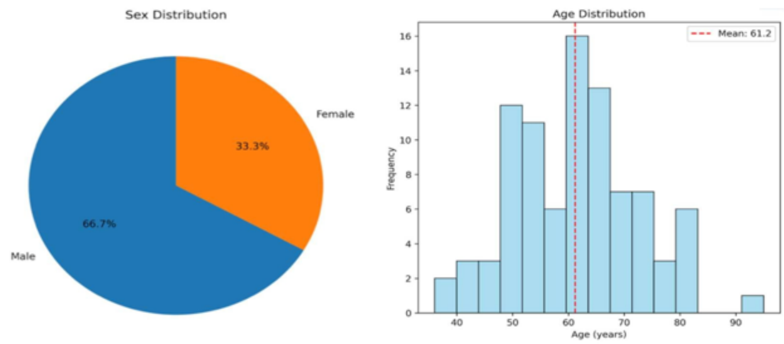

Figure 1: Sex Distribution and Age distribution Of Patients

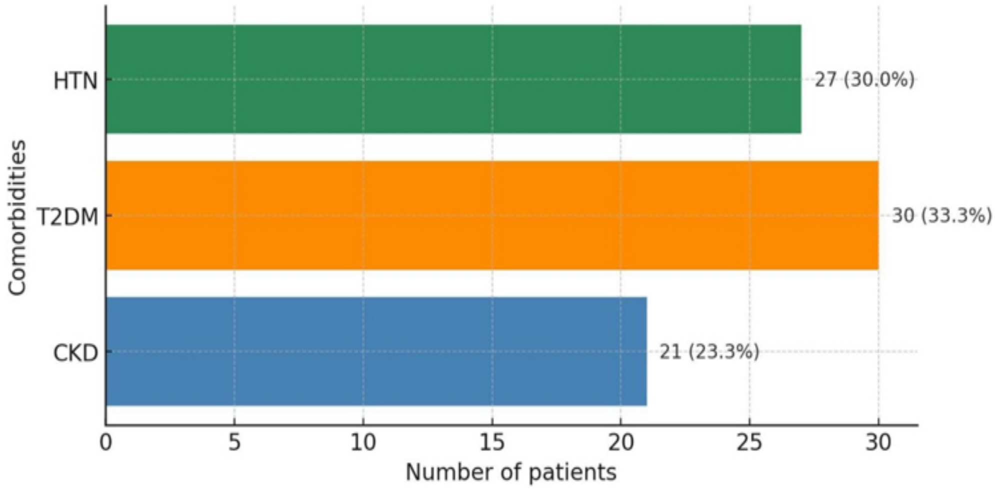

Figure 2: Distribution of Comorbid Illnesses Among Study Population(N=90)

Clinical Status at The Time of Admission

Table 1: Vital Parameters of the Study Population(n=90)

Clinical Parameter	Mean (SD)
Systolic Blood Pressure (mm hg)	128.1 (19.4)
Diastolic Blood Pressure (mm hg)	78.8 (12.6)
Heart Rate(beats/min)	92.0 (16.8)
NYHA Class III	50(55.6%)
NYHA Class IV	40(44.4%)

Table 2: Laboratory blood investigation of study participants (N=90)

Investigations	Mean (SD)
Haemoglobin (g/dL)	12.5 (1.8)
Urea (mg/dL)	55.9 (23.4)
Creatinine(mg/dL)	1.30 (0.42)

Table 3: Primary Aetiological Diagnoses in The Study Population (N=90)

Primary Diagnoses:	N (=90)
Dilated Cardiomyopathy (DCM):	50 patients (55.6%)
Ischemic Cardiomyopathy (ICMP):	19 patients (21.1%)
Hypokinetic Non dilated Cardiomyopathy (HNDC):	4 patients (4.4%)
Other diagnoses:	17 patients (18.9%)

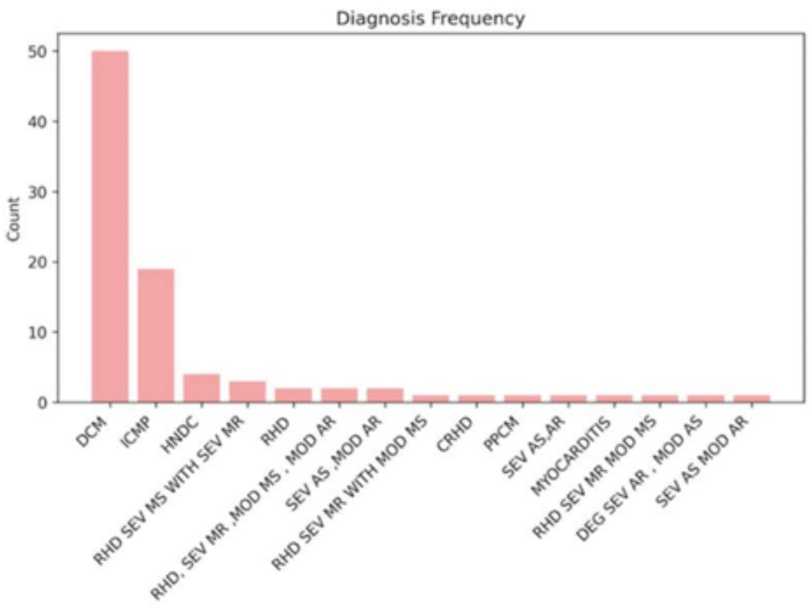

Figure 3: Distribution of Various Diagnosis

Table 4: ECG findings among study participants (N=90)

ECG Findings:	N (%)
Left Bundle Branch Block (LBBB):	53 patients (58.9%)
LBBB with Atrial Fibrillation:	5 patients (5.6%)
LBBB with Right Axis deviation:	3 patients (3.3%)
Other findings:	29 patients (32.2%)

Table 5: Echocardiographic evaluation of study participants (N=90)

Echocardiographic parameter	Mean (SD)
LVDD (mm)	56.7 (5.4)
LVSD (mm)	47.8 (6.9)
Ejection Fraction (EF)	28.9(7.3)

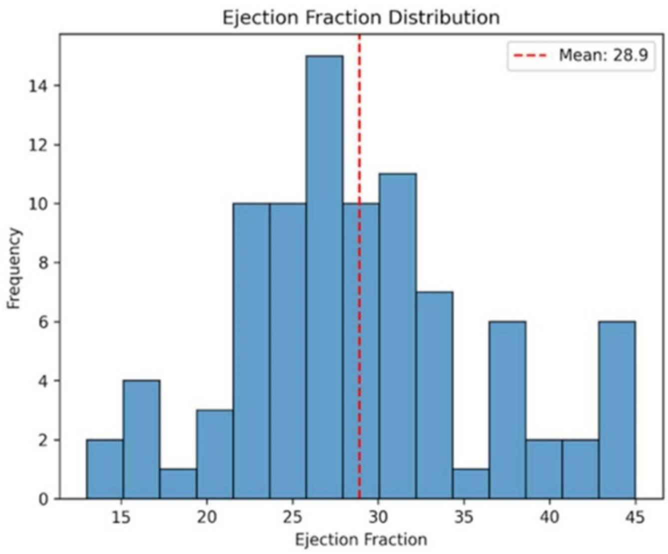

Figure 4: Distribution of EF of study population

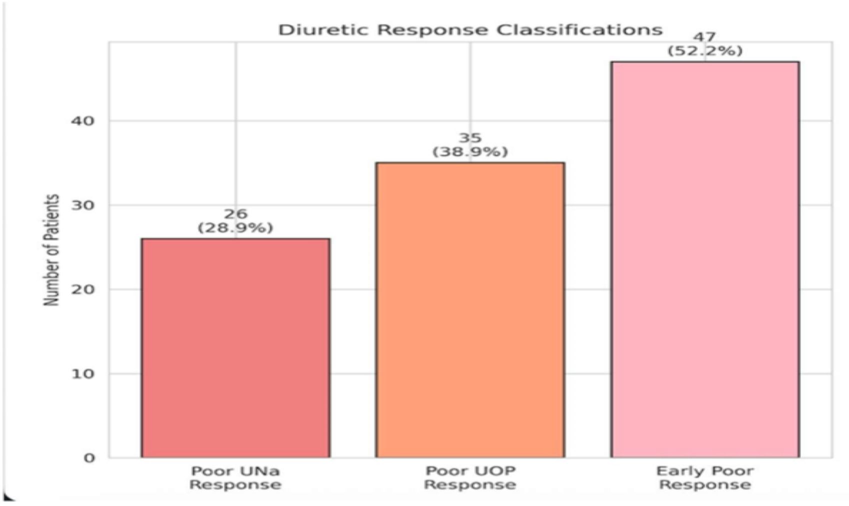

Figure 5: Study Population Classified According to Diuretic Response

Urine Output Response

Table 6: Urine Output Parameters(N=90)

Time Point	Urine Output (mL)	Rate (mL/h)
0-2 hours	211.0 ± 57.8	105.5 ± 28.9
0-6 hours	621.2 ± 186.6	103.5 ± 31.1
0-24 hours	2,126.1 ± 767.8	88.6 ± 32.0

Primary Study Variables: Spot Urine Electrolytes

Table 7: Spot Urine Electrolyte Concentrations (2-hour post-diuretic)

Parameter	Mean (SD)	Range
Spot urine sodium (mmol/L)	76.1 (14.5)	45.0 - 110.0
Spot urine chloride (mmol/L)	74.5 (19.0)	35.0 - 125.0

Table 8: Electrolyte Excretion Patterns

Parameter	Mean ± SD
6-hour sodium excretion (mmol)	46.6 ±19.7
24-hour sodium excretion (mmol)	173.4 ± 76.2
24-hour chloride excretion (mmol)	131.0 ± 68.4
24-hour natriuresis (mg)	3,988.9 ± 1,753.3

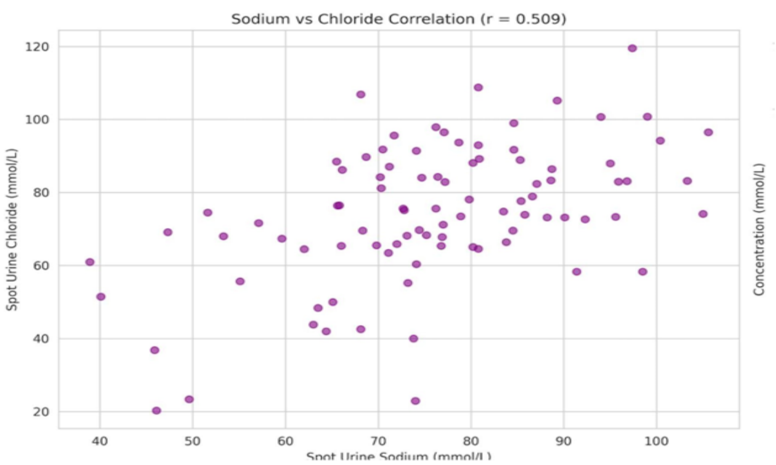

Figure 6: Correlation Between Spot Urinary Sodium and Chloride

Results of Clinical Outcomes

Table 9: Primary Clinical Outcomes

Outcome	Result
Length of Stay	
Mean ± SD (days)	5.9 ± 1.2
Range (days)	4.0 - 10.5
In-Hospital Mortality	
Deaths, n (%)	11 (12.2)
Survivors, n (%)	79 (87.8)

Table 10: Secondary Clinical Outcomes: Results(N=90)

30-Day Readmission	N (%)
Readmitted, n (%)	14 (15.6)
No readmission, n (%)	76 (84.4)
MACE in Hospital	
MACE events, n (%)	11 (12.2)
No MACE, n (%)	79 (87.8)
6-Month Readmissions	
Mean readmissions ± SD	0.8 ± 1.1
Range (0 – 3)	

Table 11: Diuretic Response and its Correlation with Response Markers (Pearson's r)

Variable	Poor UNa Response	Poor UOP Response
Spot urine sodium	-0.752***	-0.359***
Spot urine chloride	-0.417***	-0.351***
24h urine output	-0.329**	-0.581***
24h sodium excretion	-0.419***	-0.642***

Table 12: AUC for Diuretic Response Prediction

Predictor	Poor UNa Response	Poor UOP Response
Spot urine sodium	0.876	0.679
Spot urine chloride	0.708	0.675
24h sodium excretion	0.709	0.821

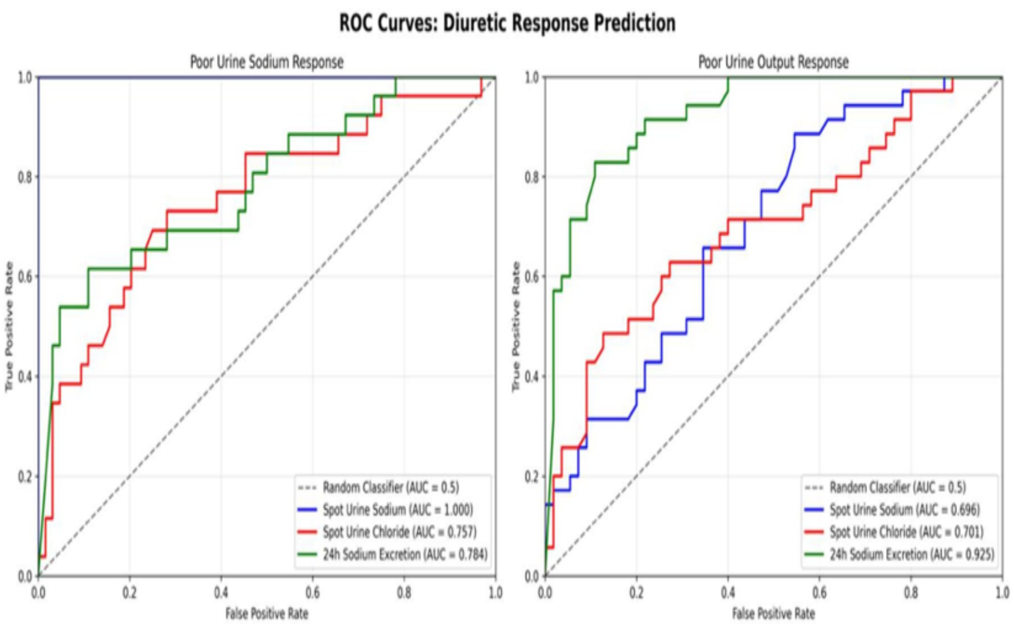

Figure 7: ROC curve for diuretic response

Table 13: Baseline Predictors of Poor Diuretic Response

Parameter	Good Response (n=64)	Poor Response (n=26)	p- value
Age (years)	62.4 ± 11.0	58.2 ± 11.2	0.129
Ejection fraction (%)	29.1 ± 7.2	28.4 ± 7.7	0.834
Creatinine (mg/dL)	1.27 ± 0.45	1.27 ± 0.41	0.904
Loop diuretic dose (mg/kg)	1.05 ± 0.38	0.92 ± 0.35	0.101

Correlations of Spot Urinary Electrolytes with Clinical Outcomes

Table 14: Correlation of Spot Urine Electrolytes with Length of Stay

Predictor	n	Pearson r (95% CI)	p- value	Spearman rho	p- value
Spot urinary sodium	90	-0.197	0.062	-0.203	0.056
(2h)		(-0.389 to			
		0.01)			
Spot urinary chloride	90	-0.102	0.341	-0.118	0.267
(2h)		(-0.302 to			
		0.108)			

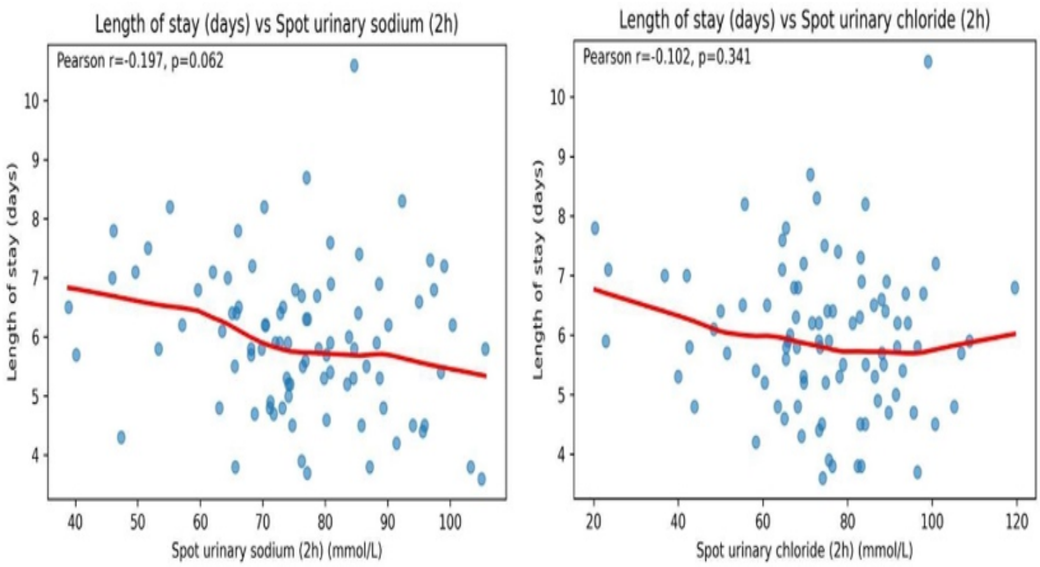

Figure 8: Scatter or distribution plots with overlaid trend lines for Length of stay (days) vs Spot urinary sodium (2h) and Spot urinary chloride (2h) respectively

Table 15: Correlation of Spot Urine Electrolytes with In-Hospital Death

Predictor	n	Pearson r (95% CI)	p- value	Spearman rho	p-value
Spot urinary sodium	90	-0.144	0.175	-0.149	0.162
(2h)		(-0.341 to			
		0.065)			
Spot urinary chloride	90	-0.056	0.6	-0.035	0.743
(2h)		(-0.26 to			
		0.153)			

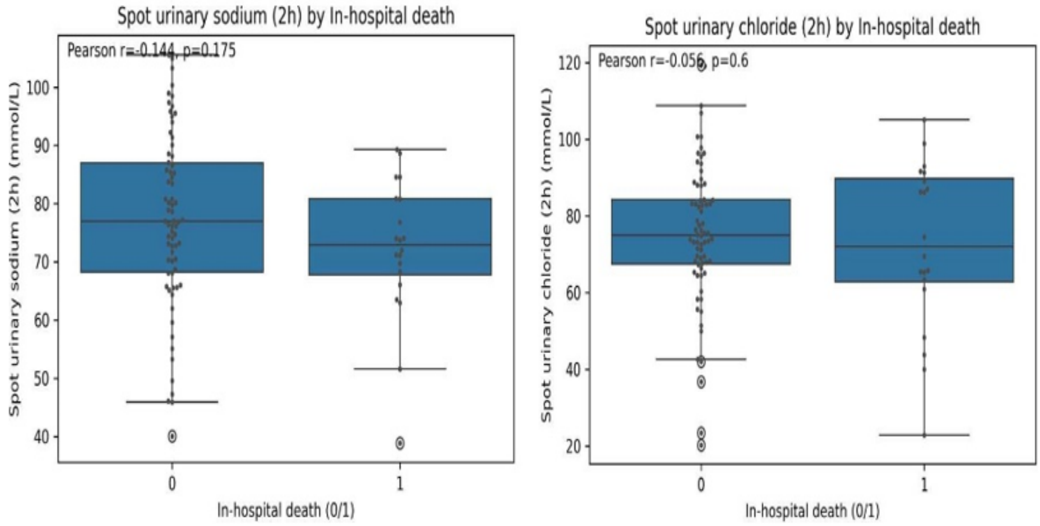

Figure 9: Box and Whisker plot overlaid with scatter plot for In-hospital death vs Spot urinary sodium (2h) and Spot urinary chloride (2h) respectively.

Table 16: Correlation of Spot Urine Electrolytes with 30 Day Readmissions.

Predictor	n	Pearson r (95% CI)	p-value	Spearman rho	p-value
Spot urinary sodium	90	-0.238	**0.024**	-0.252	**0.017**
(2h)		(-0.424 to -			
		0.032)			
Spot urinary chloride	90	-0.218	**0.039**	-0.245	**0.02**
(2h)		(-0.407 to -			
		0.012)			

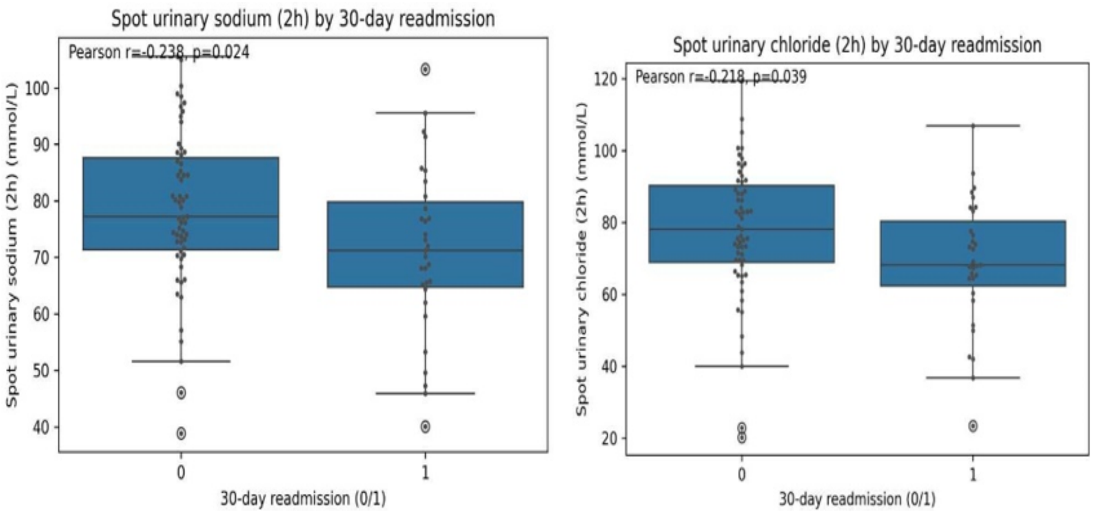

Figure 10: Box and Whisker plot overlaid with scatter plot for 30-day readmission vs Spot urinary sodium (2h) and 4pot urinary chloride (2h) respectively

Table 17: Correlation of Spot Urine Electrolytes with In Hospital MACE

Predictor	n	Pearson r (95% CI)	p-value	Spearman rho	p-value
Spot urinary sodium	90	-0.307	**0.003**	-0.303	**0.004**
(2h)		(-0.484 to -			
		0.107)			
Spot urinary chloride	90	-0.315	**0.002**	-0.29	**0.006**
(2h)		(-0.49 to -			
		0.116)			

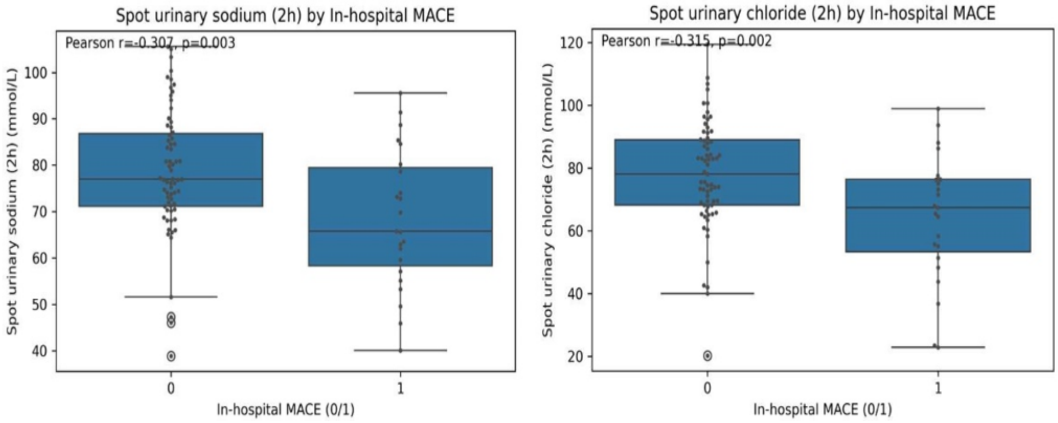

Figure 11. Box and Whisker plot overlaid with scatter plot for In-hospital MACE vs Spot urinary sodium (2h) and Spot urinary chloride (2h) respectively

Table 18: Correlation of Spot Urine Electrolytes with Readmissions At 6 Month

Predictor	**n**	**Pearson r (95% CI)**			**p-value**	**Spearman rho**	**p- value**
Spot urinary sodium	90	-0.433			**<0.001**	-0.438	**<0.001**
(2h)		(-0.587	to	-			
		0.248)					
Spot urinary chloride	90	-0.27			**0.01**	-0.267	**0.011**
(2h)		(-0.452	to	-			
		0.066)					

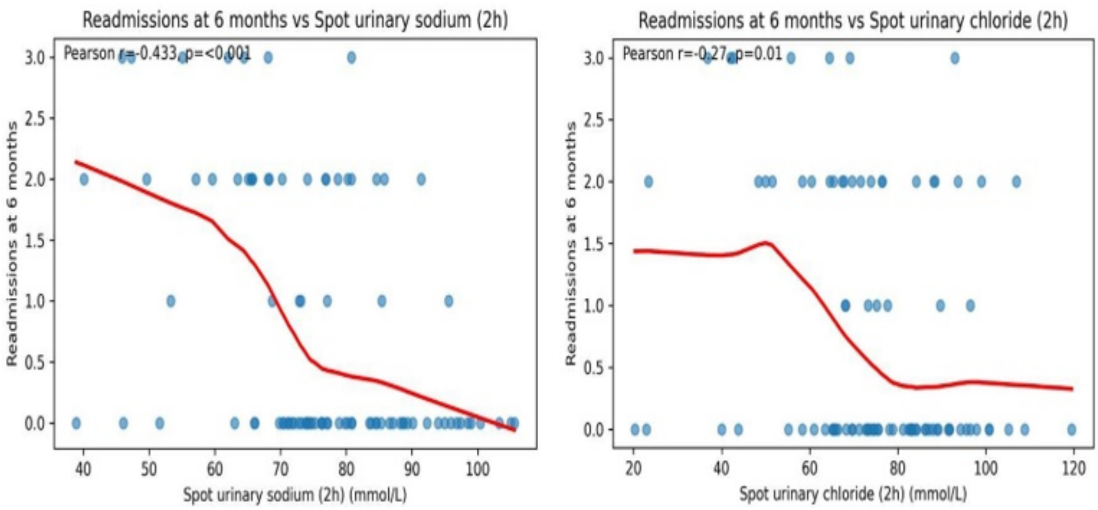

Figure 12: Scatter or distribution plots with overlaid trend lines for Readmissions at 6 months vs Spot urinary sodium (2h) and Spot urinary chloride (2h) respectively

Discussion

Two hours after the initial intravenous loop diuretic dose, the mean spot urinary sodium (UNa) and chloride (UCl) concentrations in this single-centre cohort of hospitalized patients with acute decompensated heart failure and reduced ejection fraction (n = 90) were 76.1 ± 14.5 mmol/L and 74.5 ± 19.0 mmol/L, respectively. While UNa showed a moderate-to-strong negative connection with 6-month readmissions, early post-diuretic UNa and UCl showed moderate inverse correlations with 30-day readmissions and in-hospital major adverse cardiovascular events (MACE). Neither electrolyte linked significantly with in-hospital mortality, and both displayed only a non-significant tendency toward shorter length of hospital stay among patients with stronger early natriuretic or chloruretic responses.

The substantial negative correlations seen between 2-hour UNa/UCl and 30-day and 6-month readmissions are consistent with previous research suggesting that early natriuretic response is a proxy for residual congestion risk and effective decongestion. In order to direct diuretic escalation or the switch to oral medication, the DECONGEST research operationalized serial post-diuretic UNa thresholds, such as UNa ≥80 mmol/L in conjunction with clinical euvolemia [11]. In our dataset, the mean 2-hour UNa of around 76 mmol/L, coupled with the observation that 29% of patients had a poor UNa response, suggests that a clinically meaningful subset would have satisfied criteria for treatment escalation under such protocolized techniques. This correlates with the bad outcome signal reported among poor responders in our population.

According to current European Society of Cardiology (ESC) guidelines, spot UNa measurements should be used to assess the diuretic response as soon as possible, about two hours after initiation. Values below 50–70 mmol/L (or urine output below 100–150 mL/h during the first six hours) indicate insufficient response and the need for immediate intensification [9]. The number of poor UNa responders and the observed correlations between higher UNa/UCl levels and better short- and medium-term outcomes are both consistent with the average 2-hour UNa in our group (~76 mmol/L), which straddles this threshold. These findings underline the feasibility and clinical importance of adding spot UNa and UCl measurements into bedside diuretic titration algorithms.

From a clinical standpoint, our data support the value of a single 2-hour spot UNa/UCl assessment for early risk categorization in ADHF. Patients who would benefit from earlier diuretic intensification or combination therapy may be found using this method. The incorporation of these biomarkers into protocolized treatment pathways, such those used in DECONGEST and ENACT-HF, may shorten hospital stays, decrease early rehospitalizations, and enhance the quality of decongestion [10]. Notably, UNa proved to be the greater individual predictor of medium-term (6-month) readmission risk, but UCl followed closely with in-hospital MACE and 30-day outcomes, suggesting complementary roles for both electrolytes in guiding early treatment decision-making [12].

Conclusion

Spot urine salt and chloride detected early during admission are valuable prognostic indicators in acute decompensated heart failure. Poor in-hospital outcomes are independently linked to low levels of these electrolytes. The optimization of decongestive therapy and the early identification of high-risk patients may benefit from the normal clinical practice of spot urine electrolyte measurement. More extensive multicentre research is necessary to validate these results and establish ideal cutoff points.

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