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Research Article

Renal Function and Left Ventricular Ejection Fraction in Diabetic Patients with Acute Heart Failure

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ABSTRACT

Background: Acute heart failure (AHF) in patients with type 2 diabetes mellitus (T2DM) is frequently complicated by renal dysfunction, which may aggravate cardiac impairment. Serum creatinine may reflect this cardio–renal interaction, but its association with left ventricular ejection fraction (LVEF) in AHF patients with T2DM remains unclear. **Objective:** To investigate the correlation between serum creatinine and left ventricular ejection fraction (LVEF) in patients with acute heart failure (AHF) and type 2 diabetes mellitus (T2DM). **Methods:** A cross-sectional study of 52 hospitalized AHF patients with T2DM. Clinical data, serum creatinine, A1C, and echocardiographic LVEF (assessed by two independent consultants) were collected. Correlation and multivariable linear regression analyses were performed. **Results:** The patients were middle-aged and predominantly male. Mean LVEF was 33.2 ± 9.1%, and mean serum creatinine was 1.58 ± 0.31 mg/dL. Higher serum creatinine levels were strongly associated with lower LVEF. Glycemic status (A1C) and urea levels also showed negative associations with LVEF. After adjustment, serum creatinine and A1C remained independent predictors of reduced LVEF. **Conclusion:** In AHF patients with T2DM, higher serum creatinine and A1C levels are independently associated with reduced LVEF, underscoring the cardio-renal-metabolic interplay in this population and highlighting the need for integrated management strategies.

Keywords: acute heart failure, cardio-kidney-metabolic syndrome, left ventricular ejection fraction, serum creatinine, type 2 diabetes mellitus

1. Introduction

Acute heart failure (AHF) is a cardiovascular emergency with high morbidity and mortality [1, 2]. Type 2 diabetes mellitus (T2DM) markedly increases the risk of heart failure through metabolic and vascular complications [3], and patients with both conditions often exhibit worse left ventricular (LV) function and poorer prognosis than non-diabetic patients [4].

Serum creatinine, widely used as a marker of renal function, can also reflect cardiac dysfunction in heart failure due to reduced renal perfusion from low cardiac output [5, 6]. In T2DM, elevated creatinine may additionally indicate diabetic cardiomyopathy [3], a condition characterized by myocardial fibrosis, microvascular dysfunction, and impaired contractility driven by chronic hyperglycemia, insulin resistance, and neurohormonal activation [7,8].

These interactions fall within the cardio–kidney–metabolic (CKM) syndrome [4, 9], where dysfunction of the heart, kidneys, and metabolism aggravate each other through inflammatory and fibrotic mechanisms. Left ventricular ejection fraction (LVEF) is one of the parameters for assessing systolic function [10, 11], and its

decline is often more severe in T2DM due to chronic metabolic injury, structural myocardial changes, and increased ventricular stiffness [8, 12].

While previous studies have linked elevated serum creatinine to reduced LVEF, specific data in patients with AHF and T2DM remain limited [13, 14, 15]. This study aimed to investigate the correlation between serum creatinine and LVEF in this high-risk population, using AHF as a clinical model to capture the acute interplay between cardiac and renal dysfunction and to inform more integrated patient management strategies.

2. Methods

2.1. Study design and population

This was an analytical observational study with a cross-sectional design conducted at the cardiology inpatient unit of Haji Adam Malik General Hospital, Medan, Indonesia, from January to June 2025 or until the minimum sample size was achieved. The target population comprised all patients hospitalized with acute heart failure (AHF), and the accessible population consisted of patients diagnosed with AHF and type 2 diabetes mellitus (T2DM). Consecutive sampling was applied, in which all eligible patients meeting the inclusion and exclusion criteria during the study period were enrolled until the minimum sample size was reached.

2.2. Inclusion criteria

Patients were eligible if they met the following criteria:

1. Diagnosis of acute decompensated heart failure (ADHF) or acute lung oedema based on clinical and radiological findings.
2. Confirmed diagnosis of T2DM based on medical history, use of antidiabetic medication, or laboratory results according to the American Diabetes Association (ADA) 2024 guidelines.
3. LVEF measurement obtained by echocardiography within 24–48 hours after admission.
4. Serum creatinine measurement performed at initial admission.
5. Age ≥18 years.

2.3. Exclusion criteria

Patients were excluded if they had:

1. Advanced chronic kidney disease (estimated glomerular filtration rate <15 mL/min/1.73 m²) or were undergoing haemodialysis.
2. Active malignancy or other terminal illnesses.
3. Conditions that could significantly affect serum creatinine levels (e.g., severe sepsis, hepatic failure, or use of nephrotoxic drugs within the past 7 days).
4. Incomplete medical records.

2.4. Data collection

Data collected included demographic characteristics (age, sex), clinical parameters (history of hypertension, smoking status, blood pressure, body mass index), laboratory results (serum creatinine at admission), and echocardiographic findings (LVEF measured by the biplane Simpson method and assessed independently by two echocardiography consultants). All information was obtained from medical records and recorded in standardized research forms. Statistical analysis data were processed using SPSS software. The normality of serum creatinine and LVEF data was tested using the Kolmogorov–Smirnov test ($n > 50$) or the Shapiro–Wilk test ($n < 50$). The correlation between serum creatinine and LVEF was analyzed using Pearson's correlation test for normally distributed data or Spearman's rank correlation test for non-normally distributed data. A p-value < 0.05 was considered statistically significant. Multivariate analysis was performed if necessary to adjust for potential confounding variables.

2.5. Ethical considerations

The study was approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara/Haji Adam Malik General Hospital, Medan, Indonesia. All data were collected and analyzed in accordance with the ethical standards of the institutional and/or national research committee and with the principles of the Declaration of Helsinki (as revised in 2013).

3. Results

A total of 72 patients diagnosed with acute heart failure (AHF) and type 2 diabetes mellitus (T2DM) were screened between January and June 2025 at H. Adam Malik General Hospital, Medan. After applying inclusion and exclusion criteria, 20 patients were excluded: 6 had undergone haemodialysis, 2 had terminal illness, five presented with severe sepsis or acute liver failure, and 7 had incomplete medical records. The final analysis included 52 patients (Figure 1).

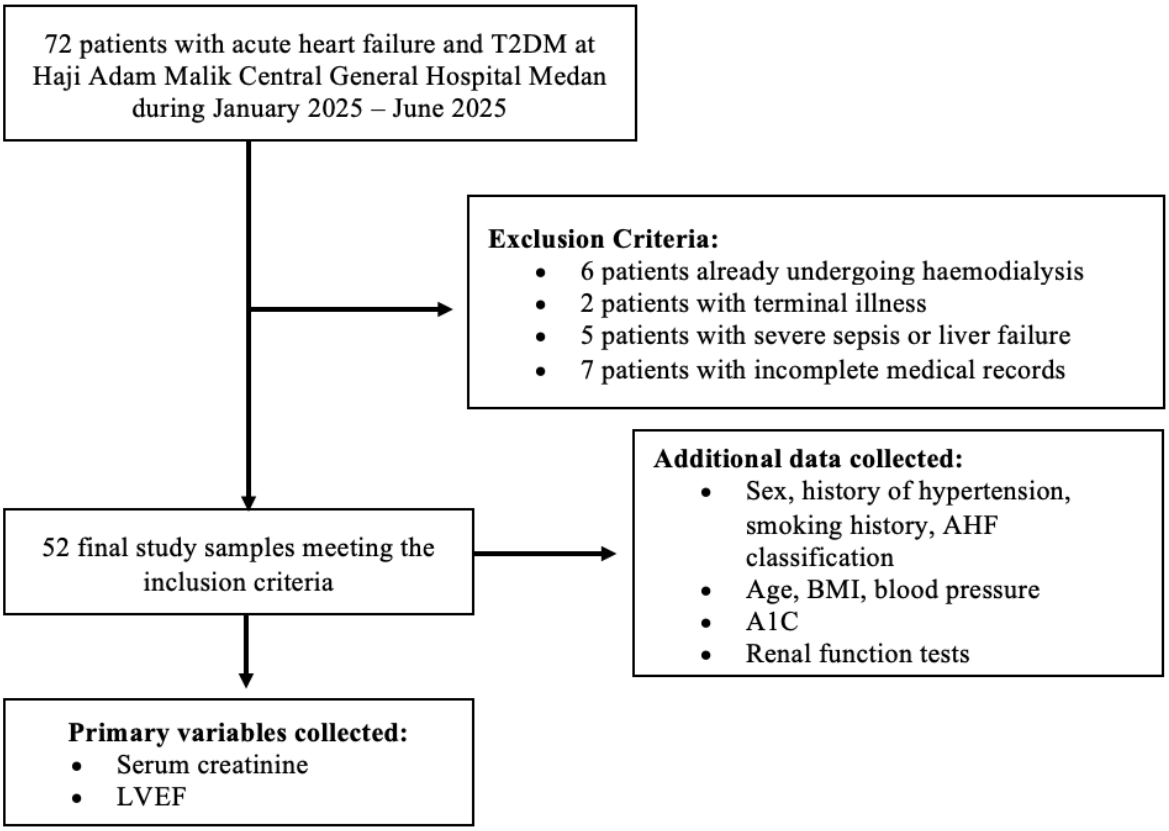

Figure 1. Flowchart of Sample Selection

The baseline characteristics of the study population are summarized in Table 1. The mean age was 55.0 ± 12.3 years, and the majority of patients were male (78.8%). Half of the cohort had a history of hypertension (50.0%), and 61.5% were active smokers. Most patients presented with acute decompensated heart failure (69.2%) compared to acute pulmonary oedema (30.8%). The mean LVEF was 33.2 ± 9.1%, consistent with significant systolic dysfunction. The mean serum creatinine was 1.58 ± 0.31 mg/dL, and the mean A1C was 7.00 ± 0.78%. Pharmacologically, beta-blockers (92.3%) and loop diuretics (86.5%) were the most commonly prescribed medications, while SGLT2 inhibitor use was less frequent (15.4%) due to high cost and lack of coverage by the national health insurance, which limited their accessibility for most hospitalized patients.

Table 1. Baseline Characteristics of the Study Population

Characteristic	Value
Demographics	
Age, years	55.0 ± 12.3
Male sex, n (%)	41 (78.8)
Clinical History	
Hypertension, n (%)	26 (50.0)
Smoking, n (%)	32 (61.5)
Physical Examination	
Systolic BP, mmHg	140.8 ± 27.0
Diastolic BP, mmHg	83.2 ± 19.6
BMI, kg/m²	25.9 ± 4.1
Laboratory Parameters	
Serum Creatinine, mg/dL	1.58 ± 0.31
eGFR, mL/min/1.73m²	50.1 ± 14.1
A1C, %	7.00 ± 0.78
Blood Urea, mg/dL	60.9 ± 52.8
Echocardiography	
LVEF, %	33.2 ± 9.1
Medications, n (%)	
Beta-Blockers	48 (92.3)
Loop Diuretics	45 (86.5)
MRA	35 (67.3)
ACE Inhibitor	25 (48.1)
ARB	20 (38.5)
SGLT2 Inhibitor	8 (15.4)
ARNI	7 (13.5)

Data presented as Mean ± Standard Deviation for numerical variables or n (%) for categorical variables. Abbreviations: BP, blood pressure; BMI, body mass index; eGFR, estimated glomerular filtration rate; MRA, mineralocorticoid receptor antagonist; ARB, angiotensin II receptor blocker; ARNI, angiotensin receptor-neprilysin inhibitor.

Table 2. Normality Test of Key Numerical Variables

Variable	Kolmogorov–Smirnov	Distribution (Normal / Not Normal)
Creatinine	0.295	Normal
LVEF	0.090	Normal

Based on Table 2, Kolmogorov–Smirnov testing showed p-values of 0.295 for serum creatinine and 0.09 for LVEF, both above 0.05, indicating normal distribution. Therefore, Pearson's correlation test was appropriate for further analysis. The reliability of the core echocardiographic measurement, LVEF, was rigorously assessed. The inter-observer intraclass correlation coefficient (ICC) between the two independent consultants was 0.916 (95% CI: 0.854–0.952, $p < 0.001$), indicating excellent agreement and high measurement consistency. Bivariate correlation analysis was performed to identify variables associated with LVEF (Table 3). Although eGFR was recorded, it was not included in the correlation or regression analyses because its calculation incorporates age and sex variables already used in the model, thereby increasing the risk of over-adjustment and collinearity. Serum creatinine was therefore selected as the primary renal marker for the analysis.

Table 3. Bivariate Correlations of Clinical Variables with Left Ventricular Ejection Fraction (LVEF)

Variable	Correlation Coefficient (r)	95% Confidence Interval	p-value
Primary Analysis			
Serum Creatinine	-0.693	-0.81 to -0.52	<0.001
Secondary Analyses			
Age	-0.410	-0.62 to -0.15	0.003
A1C	-0.380	-0.59 to -0.12	0.006
Blood Urea	-0.345	-0.56 to -0.08	0.012
Systolic Blood Pressure	0.327	0.06 to 0.55	0.018
BMI	0.231	-0.04 to 0.48	0.100

Pearson correlation analysis was used for all continuous variables.

The primary analysis confirmed a strong and statistically significant inverse correlation between serum creatinine and LVEF ($r = -0.693$, $p < 0.001$). Furthermore, increasing age, higher A1C, and elevated blood urea nitrogen were also significantly correlated with lower LVEF. In contrast, higher systolic blood pressure showed a significant positive correlation with LVEF. Body mass index (BMI) demonstrated a weak, non-significant positive association. To determine the independent predictors of LVEF after adjusting for potential confounders, a multivariable linear regression model was constructed (Table 4).

Table 4. Multivariable Linear Regression Analysis for Independent Predictors of LVEF

Predictor	Unstandardized Coefficient (B)	Standard Error (SE)	Standardized Coefficient (β)	p-value
Serum Creatinine	-7.24	2.41	-0.320	0.004
A1C	-3.35	1.38	-0.290	0.020
Systolic Blood Pressure	0.07	0.04	0.210	0.070
Age	-0.08	0.13	-0.045	0.540
Blood Urea	-0.03	0.03	-0.080	0.260

The model Adjusted R^2 was 0.421 ($p < 0.001$). The model was adjusted for all variables listed.

The model included serum creatinine, age, A1C, systolic blood pressure, and blood urea. It explained a significant proportion of the variance in LVEF (Adjusted $R^2 = 0.421$, $p < 0.001$ for the model). Within this model, both serum creatinine ($\beta = -0.320$, $p = 0.015$) and A1C ($\beta = -0.290$, $p = 0.020$) persisted as statistically significant, independent negative predictors of LVEF. Age, systolic blood pressure, and blood urea did not retain independent significance in the multivariate model.

Given the independent roles of creatinine and A1C, we explored their interaction. A significant positive correlation was found between serum creatinine and A1C levels ($r = 0.612$, $p < 0.001$). However, multicollinearity was assessed using the variance inflation factor (VIF), and all variables demonstrated acceptable VIF values (<5), indicating no significant multicollinearity in the regression model. Substantiating this finding, when patients were stratified by glycemic control status, those with uncontrolled diabetes (A1C ≥6.5%) had significantly higher serum creatinine levels compared to patients with controlled diabetes (1.71 ± 0.33 mg/dL vs. 1.42 ± 0.29 mg/dL; mean difference 0.29 mg/dL, 95% CI: 0.04 to 0.54; $p = 0.023$)

4. Discussion

This study explored the relationship between serum creatinine levels and left ventricular ejection fraction (LVEF) in patients with acute heart failure (AHF) and type 2 diabetes mellitus (T2DM) admitted to Haji Adam Malik General Hospital. The main finding was a statistically significant negative correlation between serum creatinine and LVEF [13,14], suggesting that higher creatinine levels were associated with lower systolic function. This association remained significant after adjustment for key confounders, indicating a consistent relationship between renal function markers and cardiac performance in this high-risk population [4,5].

Our findings align with previous studies demonstrating that impaired renal function is common among patients with AHF and is strongly associated with worse left ventricular systolic performance [5, 6]. Damman et al. reported that elevated serum creatinine in heart failure reflects both reduced renal perfusion and concomitant chronic kidney disease (CKD), which in turn exacerbates neurohormonal activation, inflammation, and myocardial fibrosis [5, 9]. In diabetic patients, this interaction is further aggravated by microvascular damage and metabolic derangements [3, 7], accelerating the progression of both cardiac and renal dysfunction a phenomenon now recognized within the CKM syndrome framework [4, 9].

Several pathophysiological mechanisms may explain the observed association. First, reduced cardiac output in AHF leads to diminished renal perfusion, causing prerenal azotemia and elevating serum creatinine levels [5, 16]. Second, increased central venous pressure in decompensated heart failure can cause renal venous congestion, impairing glomerular filtration independent of forward flow [4, 6]. Third, T2DM contributes to both myocardial and renal structural damage through pathways such as advanced glycation end-product (AGE) accumulation, oxidative stress, and chronic low-grade inflammation [3, 7, 8]. Together, these mechanisms create a vicious cycle of declining LVEF and worsening renal function [4, 9, 12].

Interestingly, the secondary analysis revealed that other variables, including age, A1C, and serum urea, were also negatively correlated with LVEF. Elevated A1C likely reflects long-standing poor glycemic control [15], which promotes diabetic cardiomyopathy through impaired calcium handling, mitochondrial dysfunction, and interstitial fibrosis [3, 8]. This supports evidence from Jia et al. and Ernande et al. that hyperglycemia directly impairs myocardial contractility even in the absence of overt coronary artery disease [3, 12]. Elevated urea levels, similar to creatinine, are markers of impaired renal clearance and may additionally reflect an increased catabolic state and neurohormonal activation in severe heart failure [5, 13].

Multivariable regression confirmed that serum creatinine remained an independent predictor of reduced LVEF even after adjusting for A1C, age, and urea levels [13, 14]. This underscores the robustness of the creatinine–LVEF relationship and suggests that renal function monitoring should be integrated into routine evaluation and prognostication in AHF with T2DM [4, 11, 15]. Clinically, these results support the importance of an integrated management approach targeting the CKM triad, optimizing hemodynamics, improving glycemic control, and preserving renal function [4, 9, 11].

The implications extend to both acute and chronic care. In the acute setting, early recognition of renal dysfunction may prompt timely adjustments in diuretics, vasodilators, and renin–angiotensin–aldosterone system (RAAS) inhibitors [10, 11, 17, 18] to avoid further renal compromise while supporting cardiac function. In the longer term, strategies such as sodium–glucose cotransporter 2 (SGLT2) inhibitors [22, 23] have emerged as promising agents capable of improving both cardiac and renal outcomes in T2DM, as demonstrated in trials such as DAPA-HF [23, 24] and EMPEROR-Reduced [25-30].

From a clinical standpoint, the relationship between creatinine and LVEF has prognostic implications. Elevated creatinine in AHF should not be interpreted solely as a marker of renal disease but also as a potential indicator of more advanced cardiac dysfunction [5, 6]. This reinforces the importance of integrating renal biomarkers into routine cardiac evaluation and risk stratification [4, 9, 11, 13]. Moreover, therapies aimed at optimizing both cardiac output and renal function, such as careful diuretic titration, renin–angiotensin aldosterone system (RAAS) inhibition [10, 11, 17, 18], strategies to relieve renal congestion [29, 30], and sodium glucose co-transporter-2 (SGLT2) inhibitors [22, 23, 25, 30] may be particularly beneficial in this high-risk subgroup.

4.1. Strengths and Limitations

This study has several strengths, including its focus on a well-defined population of AHF with T2DM and the use of echocardiographic LVEF assessment by two independent consultants, enhancing measurement reliability. However, certain limitations should be acknowledged. First, the cross-sectional design precludes causal inference, and the creatinine–LVEF relationship may be bidirectional. Second, the sample size, though adequate for detecting correlations, limits generalizability beyond the studied population. Third, we did not assess markers of chronic kidney disease such as estimated glomerular filtration rate (eGFR) or albuminuria, which could provide further insight into the cardio–renal interaction. Finally, the exclusion of follow-up data means we could not evaluate the prognostic implications of this association.

5. Conclusion

In conclusion, this study demonstrates a significant negative correlation between serum creatinine and LVEF in patients with AHF and T2DM, with creatinine emerging as an independent predictor of systolic dysfunction. The findings highlight the intertwined nature of cardiac and renal impairment within the CKM

framework and underscore the importance of integrated multidisciplinary strategies to optimize outcomes in this vulnerable population.

6. Data Availability Statement

The original contributions presented in the study are included in the article/supplementary material; further inquiries can be directed to the corresponding author.

7. Ethical Statement

The study protocol was approved by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara/Haji Adam Malik General Hospital, Medan, Indonesia (Approval No: DP.04.03/D.XXVIII.2.2.3/659/2025). Written informed consent was obtained from all participants prior to inclusion in the study.

8. Author Contributions

All authors contributed to the design and implementation of the research, data analysis, and finalizing the manuscript.

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11. Conflict of Interest

The authors declare no conflict of interest.

11.1. Abbreviations

ADHF: Acute decompensated heart failure
AHF: Acute heart failure
ALO: Acute lung oedema
ARNI: Angiotensin receptor–neprilysin Inhibitor
CKM: Cardio–Kidney–Metabolic syndrome
DM: Diabetes mellitus
eGFR: Estimated glomerular filtration rate
A1C: Glycated hemoglobin
HF: Heart failure
HFrEF: Heart failure with reduced ejection fraction
BMI: Body mass index
LVEF: Left ventricular ejection fraction
MRA: Mineralocorticoid receptor antagonist
RAAS: Renin–angiotensin–aldosterone system

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