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# Exploring the Link between eGFR and All-Cause Mortality in Atrial Fibrillation Patients with Heart Failure: Insights from the MIMIC-IV Database

*Aim* — Atrial fibrillation (AF) and heart failure (HF) are prevalent cardiovascular conditions. The estimated glomerular filtration rate (eGFR) is a crucial marker for assessing kidney function and has demonstrated prognostic significance in various cardiovascular diseases. However, its specific impact on patients with both AF and HF remains unclear.

*Material and methods* — This retrospective cohort study utilized data from the MIMIC–IV database, focusing on a subset of ICU patients diagnosed with both atrial fibrillation (AF) and heart failure (HF). Patients were categorized based on eGFR levels, and the association between eGFR and all-cause ICU mortality, as well as 28-day post-discharge mortality, was analyzed using the Cox proportional hazards model.

*Results* — Analysis revealed significant differences ($p<0.001$) in age, ICU length of stay, and prevalence of chronic diseases across different eGFR groups. As eGFR increased, the risk of death (HR) significantly decreased. The group with the lowest eGFR (first quartile, Q1) had the highest mortality risk, whereas the highest eGFR group (Q4) showed a protective effect (HR=1.14, P=0.019). There was a significant non-linear relationship between eGFR and all-cause mortality ($p<0.001$). Lower eGFR levels substantially increased mortality risk, highlighting eGFR as a key prognostic indicator for AF patients with HF. Survival probability and mortality risk varied significantly among different eGFR levels (HR=0.54, 95% CI: 0.48–0.60, $p<0.001$). These findings underscore the importance of monitoring and intervening in renal function.

*Conclusion* — Lower eGFR levels are independently linked to higher all-cause mortality in patients with AF and HF.

*Keywords* — eGFR; all-cause mortality; atrial fibrillation; heart failure; MIMIC-IV database

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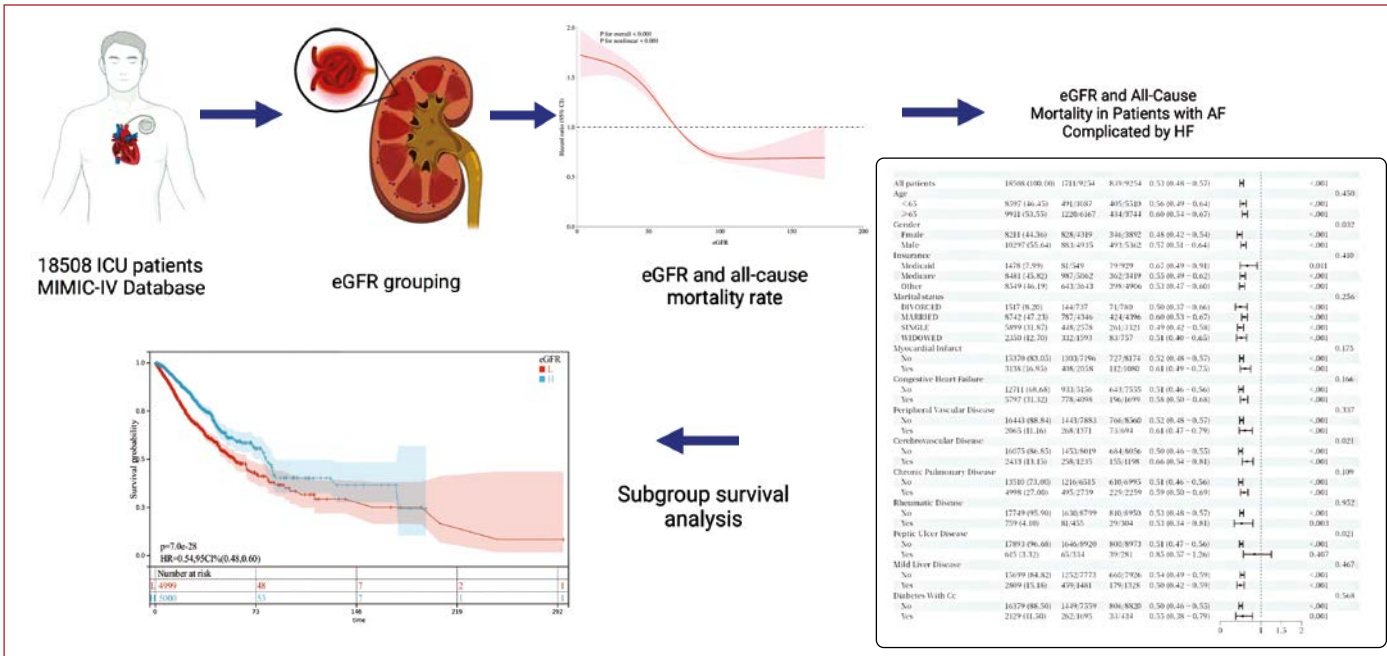
Central illustration. Exploring the Link between eGFR and All-Cause Mortality in Atrial Fibrillation Patients with Heart Failure: Insights from the MIMIC-IV Database



## Introduction

Atrial fibrillation (AF) and heart failure (HF) are two of the most common cardiovascular conditions, and they frequently coexistence. This comorbidity presents a substantial clinical challenge due to the synergistic effect of both conditions, which exacerbates patient morbidity and mortality [1–3]. Patients with AF have an irregular and often rapid heart rate that can lead to poor blood flow and various complications, including stroke and HF. Among those with HF, the heart is unable to pump sufficiently to maintain blood flow to meet the body's needs, leading to symptoms of shortness of breath, fatigue, and fluid retention [4–6].

Renal function, as measured by the estimated glomerular filtration rate (eGFR), is a critical factor in the management of cardiovascular diseases. eGFR provides an estimate of the rate at which the kidneys filter blood and is a widely used measure to assess kidney function [7–10]. Declining eGFR is indicative of worsening renal function and has been linked to adverse outcomes in various diseases, including cardiovascular diseases. In patients with both AF and HF, impaired renal function can complicate disease management and has been associated with increased mortality.

Despite the known interactions between cardiovascular and renal health, the specific relationship between eGFR and all-cause mortality in patients with AF complicated by HF is not fully understood. Previous studies have highlighted the prognostic value of eGFR in individual cardiovascular conditions [11, 12], but there is a paucity of data on its impact in the context of coexisting AF and HF. Understanding this relationship is crucial for optimizing patient management and improving outcomes in this high-risk population.

This study aims to bridge this knowledge gap by investigating the association between eGFR and all-cause mortality in patients with AF complicated by HF. Utilizing the MIMIC–IV (Medical Information Mart for Intensive Care IV) database, which provides extensive clinical data from critically ill patients, we conducted a retrospective cohort study. The MIMIC–IV database includes detailed patient demographics, laboratory results, and clinical outcomes, thus making it an ideal resource for this investigation.

We hypothesized that lower eGFR levels are associated with higher all-cause mortality in patients with AF and HF. By categorizing eGFR into clinically relevant groups and employing Cox proportional hazards models, we aimed to quantify the risk and provide insights into the prognostic significance of renal function in this patient population. Our findings highlight the importance of monitoring and managing renal function to improve survival outcomes in patients with AF and HF.

## Material and methods

### *Study design and data source*

This was a retrospective cohort study of data sourced from the MIMIC–IV database, a publicly accessible database containing a large amount of clinical data from intensive care unit (ICU) patients [13, 14].

### *Study population*

The inclusion criteria: a diagnosis of AF and HF as described in the MIMIC–IV database. These patients were ≥18 yrs old and had been admitted to the ICU for the first time. Patients with incomplete data or obvious data entry errors were excluded. The patient information collected included demographics, comorbidities, vital signs, laboratory results, medication use, fluid balance data, including fluid intake and output, and other clinically relevant data. Patients were categorized into quartiles based on eGFR levels to explore its association with ICU and 28-day mortality. The primary outcome measure was ICU mortality rate, and the secondary outcome measure was mortality rate within 28 days post-ICU discharge. Fluid balance was defined as the difference between daily fluid intake and output during the first 72 hrs in the ICU.

### *Calculation of cGFR*

Renal function can be evaluated by eGFT, which is based on serum creatinine, age, and gender. Calculation formula:

$$eGFR=141 \times \min(Scr/k,1)\ a \times \max(Scr/k,1) -1.209 \times 0.993^{Age} \times \text{sex factor}.$$

### *Grouping method*

To evaluate the relationship between renal function and clinical outcomes, patients were stratified into four groups based on the quartile distribution of estimated glomerular filtration rate (eGFR) values. The quartile cut-off points were derived from the overall eGFR distribution in the study cohort as follows: Q1 (<38.9 mL/min/1.73 m$^2$), Q2 (38.9–69.3), Q3 (69.3–94.8), and Q4 (>94.8). These eGFR-based groups were used for subsequent comparisons of baseline characteristics, survival analysis, and Cox regression modeling.

### *Statistical Analysis*

Descriptive statistics were used to summarize patient baseline characteristics and clinical data. Continuous variables were tested for normality using the Shapiro–Wilk test. Based on distribution, Student's t-test was used for normally distributed variables, while the Wilcoxon rank-sum test was applied for non-normally distributed data. The chi-square test was used for categorical variables when the expected cell counts were ≥5; otherwise, Fisher's exact test was applied.. A multivariable Cox proportional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hazards model was constructed to assess the relationship between fluid balance and mortality risk, adjusting for potential confounders such as age, sex, comorbidities, the Acute Physiology and Chronic Health Evaluation II (APACHE II) score, and the Sequential Organ Failure Assessment (SOFA) score. Kaplan–Meier survival curves were used to evaluate the probability of survival during ICU stay and within 28 days after discharge, stratified by eGFR quartiles. Patients were stratified into eGFR quartiles: Q1 (<38.9), Q2 (38.9–69.3), Q3 (69.3–94.8), and Q4 (>94.8 mL/min/1.73 $m^2$), based on the interquartile distribution of the study cohort.

## Results

### *Baseline characteristics of population data*

This text provides statistical analysis data on 18 508 patients, covering various physiological indicators and disease-related items. Baseline characteristics including global protein, total protein, anion gap, blood pressure, white blood cells, red blood cells, and other clinical variables were summarized using mean and standard deviation. Patients' age, ICU length of stay, comorbidities, and laboratory values were compared across eGFR quartile groups using appropriate statistical tests. The study found significant differences ($p<0.001$) in various indicators between groups, especially in terms of age, length of hospital stay, and proportion of chronic disease patients (Table 1).

### *Single and multiple factor Cox regression of eGFR*

The Cox regression analysis results of different eGRF quantiles (Q1 to Q4) and related risks are divided into four models. The main finding is that as the eGRF quantile increases, the hazard ratio (HR) decreases, indicating that the lower the eGRF value, the higher the risk of death. Model 1 was unadjusted. Model 2 adjusted for age and gender. Model 3 further included vital signs (heart rate, systolic blood pressure, respiratory rate, temperature, and $SpO_2$) and laboratory indicators (e.g., creatinine, lactate). Model 4 additionally adjusted for comorbidities such as diabetes, congestive heart failure, chronic pulmonary disease, and Charlson comorbidity index. Model 4 included adjustments for various underlying diseases and biochemical indicators. The results showed that the HR of Q4 was significant (HR=1.14, p=0.019), while the HRs of Q2 and Q3 showed protective effects. These associations remained significant after adjusting for age, gender, vital signs (heart rate, blood pressure, $SpO_2$), laboratory parameters (creatinine, lactate, glucose), and comorbidities (e.g., diabetes, CHF, COPD), suggesting that eGFR may be an independent prognostic factor in ICU patients. The study suggests considering eGRF levels as part of clinical evaluation. See Table 2 for details.

### *The relationship between eGFR and all-cause mortality rate*

The main focus of the study was on the relationship between eGFR and all-cause mortality. The overall p-value derived from the restricted cubic spline analysis (Figure 1) was <0.001, indicating a statistically significant association between eGFR and all-cause mortality. The non-linear p-value ($p < 0.001$), derived from a Wald test of the non-linear terms in the restricted cubic spline Cox model, indicated a statistically significant non-linear relationship between eGFR and all-cause mortality.. The hazard ratio and its confidence interval (95% CI) shows the importance of patient risk assessment. Overall, the study suggests that changes in eGFR are highly significantly correlated with all-cause mortality outcomes, demonstrating the need to emphasize eGFR as a potential biomarker (Figure1).

### *Analysis of the relationship between eGFR and all-cause mortality in patients with AF complicated by HF*

The Figure 2 provides a comprehensive analysis of the relationship between various demographic and clinical factors and all-cause mortality in patients with atrial fibrillation (AF) complicated by heart failure (HF). The analysis includes hazard ratios (HR) with 95% confidence intervals (CI) and p-values for each factor. Older age (≥65 years) and male gender were associated with higher mortality rates. Insurance status impacts mortality, with Medicaid patients had a higher HR compared to those with Medicare or other insurance types. Among the comorbidities assessed, myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, chronic pulmonary disease, mild liver disease, and complicated diabetes were significantly associated with increased all-cause mortality. In contrast, conditions such as peptic ulcer disease, rheumatic disease, and AIDS did not show statistically significant associations.

### *Subgroup survival analysis*

We performed subgroup survival analyses to evaluate the relationship between glomerular filtration rate (eGFR) and survival probability over time.. The data analysis showed a hazard ratio (HR) of 0.54 with a 95% confidence interval (CI) of 0.48–0.60, indicating significant differences in mortality risk among patients with different eGFR levels ($p<0.0001$). The 'Number at risk' in Figure 3 indicates the number of patients remaining under observation at each time point. A sufficient number at risk ensures adequate statistical power and narrower confidence intervals, supporting the reliability of the survival estimates over time. These findings emphasize the prognostic value of renal function, particularly that lower eGFR levels (e.g., Q1: <38.9 mL/min/1.73$m^2$) are significantly associated with increased mortality. They support the need for closer monitor-

**Table 1 (Beginning).** Baseline characteristics of population data

| Variables | Total (n=18 508) | Q1 (n=4 627) | Q2 (n=4 627) | Q3 (n=4 627) | Q4 (n=4627) | Statistic | p |
|---|---|---|---|---|---|---|---|
| Age, yrs | 65.12±16.22 | 69.37±14.88 | 71.22±13.91 | 67.97±13.95 | 51.91±14.31 | F=1802.18 | <.001 |
| Hospital Stay Duration (days) | 14.59±15.34 | 15.70±15.59 | 14.38±15.54 | 13.36±13.99 | 14.92±16.08 | F=19.06 | <.001 |
| Wbc ($10^9$/L) | 12.12±14.16 | 13.01±15.02 | 12.35±13.31 | 11.92±16.59 | 11.20±11.05 | F=13.35 | <.001 |
| Basophils Abs ($10^9$/L) | 0.03±0.08 | 0.03±0.10 | 0.03±0.10 | 0.03±0.06 | 0.03±0.06 | F=0.79 | 0.502 |
| Eosinophils Abs ($10^9$/L) | 0.15±0.38 | 0.16±0.37 | 0.16±0.53 | 0.14±0.27 | 0.14±0.30 | F=5.19 | 0.001 |
| Lymphocytes Abs ($10^9$/L) | 1.60±7.12 | 1.49±7.86 | 1.68±7.04 | 1.81±9.44 | 1.42±1.46 | F=2.84 | 0.036 |
| Monocytes Abs ($10^9$/L) | 0.69±1.30 | 0.77±1.74 | 0.72±1.59 | 0.66±0.86 | 0.62±0.64 | F=12.05 | <.001 |
| Eosinophils (%) | 1.50±2.38 | 1.57±2.55 | 1.52±2.62 | 1.46±2.15 | 1.46±2.15 | F=2.57 | 0.052 |
| Lymphocytes (%) | 14.38±12.30 | 12.14±10.95 | 14.20±12.28 | 15.18±12.48 | 16.00±13.07 | F=85.82 | <.001 |
| Monocytes (%) | 6.06±4.43 | 6.16±4.55 | 6.05±4.67 | 6.02±4.45 | 6.02±4.02 | F=1.07 | 0.362 |
| Neutrophils (%) | 75.33±15.83 | 77.10±14.87 | 75.46±16.08 | 74.76±15.92 | 73.98±16.26 | F=32.72 | <.001 |
| Hematocrit (%) | 31.85±6.52 | 30.31±6.14 | 32.04±6.63 | 32.77±6.58 | 32.29±6.44 | F=127.06 | <.001 |
| Hemoglobin (g/dL) | 10.45±2.21 | 9.79±2.00 | 10.50±2.22 | 10.82±2.25 | 10.70±2.21 | F=209.99 | <.001 |
| Mch, (pg) | 29.94±2.86 | 29.81±2.95 | 29.89±2.76 | 30.04±2.75 | 30.04±2.95 | F=7.41 | <.001 |
| Mchc, (g/dL) | 32.82±1.70 | 32.31±1.70 | 32.77±1.66 | 33.02±1.61 | 33.17±1.68 | F=239.26 | <.001 |
| Mcv, (fL) | 91.30±7.59 | 92.32±8.13 | 91.28±7.33 | 91.02±7.16 | 90.58±7.59 | F=44.17 | <.001 |
| Platelet ($10^9$/L) | 208.67±121.41 | 196.38±114.62 | 203.64±114.45 | 211.23±120.41 | 223.45±133.53 | F=42.27 | <.001 |
| Rbc ($10^{12}$/L) | 3.51±0.77 | 3.31±0.72 | 3.54±0.79 | 3.62±0.78 | 3.58±0.76 | F=156.05 | <.001 |
| Scr Baseline (mg/dL) | 0.95±0.90 | 1.77±1.46 | 0.87±0.30 | 0.67±0.20 | 0.51±0.22 | F=2525.09 | <.001 |
| Charlson Comorbidity Index (score) | 6.07±3.05 | 7.71±2.78 | 6.66±2.68 | 5.75±2.63 | 4.15±2.94 | F=1382.05 | <.001 |
| Albumin (g/dL) | 3.10±0.68 | 3.00±0.65 | 3.12±0.67 | 3.17±0.68 | 3.12±0.70 | F=57.35 | <.001 |
| Globulin (g/dL) | 2.56±0.81 | 2.58±0.85 | 2.57±0.80 | 2.56±0.82 | 2.52±0.79 | F=5.31 | 0.001 |
| Total Protein (g/dL) | 5.73±0.99 | 5.66±1.00 | 5.75±1.00 | 5.79±0.98 | 5.73±1.00 | F=14.42 | <.001 |
| Aniongap (mmol/L) | 14.52±4.21 | 17.43±4.87 | 14.36±3.66 | 13.34±3.30 | 12.95±3.25 | F=1299.66 | <.001 |
| Bicarbonate (mmol/L) | 23.89±4.96 | 21.97±5.48 | 23.86±4.78 | 24.78±4.45 | 24.93±4.49 | F=368.64 | <.001 |
| Bun (mg/dL) | 27.50±22.24 | 52.50±27.57 | 26.79±13.01 | 17.73±8.30 | 12.97±6.97 | F=5491.61 | <.001 |
| Calcium (mg/dL) | 8.40±0.87 | 8.41±0.99 | 8.47±0.82 | 8.44±0.76 | 8.31±0.87 | F=31.24 | <.001 |
| Chlorid (mmol/L) | 102.88±6.51 | 101.72±7.50 | 103.27±6.40 | 103.35±5.75 | 103.20±6.13 | F=67.17 | <.001 |
| Creatinine (mg/dL) | 1.52±1.66 | 3.42±2.43 | 1.21±0.24 | 0.84±0.17 | 0.62±0.16 | F=5095.74 | <.001 |
| Glucose (mg/dL) | 138.78±73.72 | 149.17±87.09 | 145.10±85.33 | 133.48±56.00 | 127.38±58.59 | F=88.01 | <.001 |
| Sodium (mmol/L) | 138.06±5.22 | 137.69±5.89 | 138.29±5.30 | 138.32±4.80 | 137.92±4.81 | F=15.77 | <.001 |
| Potassium (mmol/L) | 4.15±0.70 | 4.41±0.83 | 4.18±0.70 | 4.06±0.58 | 3.96±0.58 | F=379.29 | <.001 |
| Crp (mg/L) | 90.49±81.27 | 100.37±83.34 | 89.21±80.44 | 84.18±79.47 | 88.20±80.93 | F=33.87 | <.001 |
| Alt (U/L) | 107.93±490.36 | 167.06±684.55 | 87.95±386.55 | 78.19±364.67 | 98.54±453.94 | F=31.38 | <.001 |
| Alp (U/L) | 122.38±130.64 | 140.72±157.14 | 116.49±113.83 | 114.47±125.00 | 117.83±120.62 | F=41.31 | <.001 |
| Ast (U/L) | 161.36±793.54 | 276.39±1200.81 | 136.73±671.20 | 102.34±433.48 | 129.97±648.49 | F=45.16 | <.001 |
| Amylase (U/L) | 91.33±161.64 | 114.24±186.87 | 87.71±159.69 | 81.76±151.38 | 81.62±143.04 | F=43.02 | <.001 |
| Bilirubin Total (mg/dL) | 1.51±3.54 | 1.92±4.75 | 1.46±3.22 | 1.25±2.61 | 1.40±3.20 | F=30.46 | <.001 |
| Bilirubin Direct (mg/dL) | 1.78±3.16 | 2.25±3.89 | 1.66±2.95 | 1.54±2.76 | 1.68±2.86 | F=46.93 | <.001 |
| Bilirubin Indirect (mg/dL) | 1.06±1.60 | 1.17±1.84 | 1.03±1.52 | 1.00±1.49 | 1.04±1.53 | F=10.96 | <.001 |
| Ck Cpk (U/L) | 672.78±4746.31 | 1031.53±8072.10 | 533.81±3127.41 | 506.69±2471.44 | 619.09±2982.99 | F=12.24 | <.001 |
| Ck Mb (U/L) | 12.03±35.90 | 13.78±37.33 | 11.79±35.93 | 10.62±31.93 | 11.93±38.03 | F=6.10 | <.001 |
| Ggt (U/L) | 247.32±372.78 | 258.76±376.74 | 235.16±322.96 | 240.08±388.91 | 255.30±397.58 | F=4.39 | 0.004 |
| Ld Ldh (U/L) | 436.74±970.26 | 583.73±1456.92 | 425.92± 889.69 | 362.66±570.02 | 374.66±704.31 | F=51.31 | <.001 |
| Lactate (mmol/L) | 2.08±1.78 | 2.40±2.26 | 2.11±1.72 | 1.92±1.58 | 1.91±1.39 | F=76.55 | <.001 |
| Apsiii (score) | 52.76±25.37 | 67.35±25.50 | 53.29±24.25 | 45.92±22.10 | 44.50±22.80 | F=900.74 | <.001 |
| Heart Rate (bpm) | 92.48±21.24 | 93.11±21.81 | 91.61±21.07 | 91.51±21.08 | 93.67±20.94 | F=11.99 | <.001 |
| Sbp (mmHg) | 122.82±24.55 | 120.81±24.32 | 122.49±24.61 | 123.73±25.00 | 124.25±24.11 | F=18.10 | <.001 |
| Dbp (mmHg) | 68.53±17.84 | 66.73±17.95 | 67.50±18.39 | 69.05±17.43 | 70.84±17.28 | F=48.43 | <.001 |
| Mbp (mmHg) | 82.93±18.36 | 80.83±18.82 | 82.12±18.65 | 83.53±17.72 | 85.24±17.93 | F=49.66 | <.001 |
| Temperature (°C) | 36.78±0.85 | 36.75±0.92 | 36.75±0.84 | 36.76±0.83 | 36.86±0.81 | F=19.13 | <.001 |
| $SpO_2$ (%) | 96.98±3.92 | 96.73±4.07 | 96.87±4.05 | 97.15±3.77 | 97.19±3.77 | F=14.60 | <.001 |


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**Table 1 (Ending).** Baseline characteristics of population data

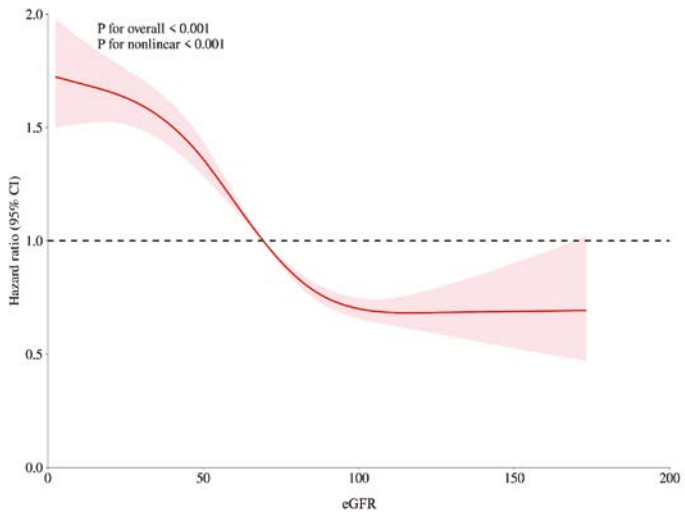
| Variables | Total (n=18 508) | Q1 (n=4 627) | Q2 (n=4 627) | Q3 (n=4 627) | Q4 (n=4 627) | Statistic | p |
|---|---|---|---|---|---|---|---|
| Age, yrs | 65.12±16.22 | 69.37±14.88 | 71.22±13.91 | 67.97±13.95 | 51.91±14.31 | F=1802.18 | <.001 |
| Gcs (score) | 14.42±1.88 | 14.35±1.95 | 14.38±2.01 | 14.44±1.87 | 14.54±1.66 | F=9.28 | <.001 |
| Hourly Patient Fluid Removal (mL/hr) | 148.99±157.53 | 151.00±158.25 | 146.83±157.14 | 148.02±155.47 | 150.12±159.23 | F=0.68 | 0.566 |
| Ventilation Duration (hours) | 31.73±46.29 | 37.43±55.28 | 31.70±43.56 | 27.87±37.72 | 29.92±46.31 | F=36.71 | <.001 |
| Gender (n, %) | | | | | | $\chi^2$=45.25 | <.001 |
| F | 8211 (44.36) | 2178 (47.07) | 2141 (46.27) | 1894 (40.93) | 1998 (43.18) | | |
| M | 10297 (55.64) | 2449 (52.93) | 2486 (53.73) | 2733 (59.07) | 2629 (56.82) | | |
| Insurance (n, %) | | | | | | $\chi^2$=1313.57 | <.001 |
| Medicaid | 1478 (7.99) | 264 (5.71) | 285 (6.16) | 250 (5.40) | 679 (14.67) | | |
| Medicare | 8481 (45.82) | 2568 (55.50) | 2494 (53.90) | 2299 (49.69) | 1120 (24.21) | | |
| Other | 8549 (46.19) | 1795 (38.79) | 1848 (39.94) | 2078 (44.91) | 2828 (61.12) | | |
| Marital Status (n, %) | | | | | | $\chi^2$=868.22 | <.001 |
| Divorced | 1517 (8.20) | 347 (7.50) | 390 (8.43) | 383 (8.28) | 397 (8.58) | | |
| Married | 8742 (47.23) | 2129 (46.01) | 2217 (47.91) | 2435 (52.63) | 1961 (42.38) | | |
| Single | 5899 (31.87) | 1366 (29.52) | 1212 (26.19) | 1221 (26.39) | 2100 (45.39) | | |
| Widowed | 2350 (12.70) | 785 (16.97) | 808 (17.46) | 588 (12.71) | 169 (3.65) | | |
| Acute myocardial infarction (n, %) | | | | | | $\chi^2$=466.65 | <.001 |
| No | 15 370 (83.05) | 3533 (76.36) | 3663 (79.17) | 3919 (84.70) | 4255 (91.96) | | |
| Yes | 3138 (16.95) | 1094 (23.64) | 964 (20.83) | 708 (15.30) | 372 (8.04) | | |
| Congestive Heart Failure (n, %) | | | | | | $\chi^2$=1752.44 | <.001 |
| No | 12 711 (68.68) | 2295 (49.60) | 2861 (61.83) | 3508 (75.82) | 4047 (87.46) | | |
| Yes | 5797 (31.32) | 2332 (50.40) | 1766 (38.17) | 1119 (24.18) | 580 (12.54) | | |
| Peripheral Vascular Disease (n, %) | | | | | | $\chi^2$=322.46 | <.001 |
| No | 16 443 (88.84) | 3894 (84.16) | 3989 (86.21) | 4160 (89.91) | 4400 (95.09) | | |
| Yes | 2065 (11.16) | 733 (15.84) | 638 (13.79) | 467 (10.09) | 227 (4.91) | | |
| Cerebrovascular Disease (n, %) | | | | | | $\chi^2$=75.80 | <.001 |
| No | 16 075 (86.85) | 4088 (88.35) | 3931 (84.96) | 3911 (84.53) | 4145 (89.58) | | |
| Yes | 2433 (13.15) | 539 (11.65) | 696 (15.04) | 716 (15.47) | 482 (10.42) | | |
| Chronic Pulmonary Disease (n, %) | | | | | | $\chi^2$=96.89 | <.001 |
| No | 13510 (73.00) | 3246 (70.15) | 3269 (70.65) | 3374 (72.92) | 3621 (78.26) | | |
| Yes | 4998 (27.00) | 1381 (29.85) | 1358 (29.35) | 1253 (27.08) | 1006 (21.74) | | |
| Rheumatic Disease (n, %) | | | | | | $\chi^2$=36.34 | <.001 |
| No | 17749 (95.90) | 4392 (94.92) | 4407 (95.25) | 4455 (96.28) | 4495 (97.15) | | |
| Yes | 759 (4.10) | 235 (5.08) | 220 (4.75) | 172 (3.72) | 132 (2.85) | | |
| Peptic Ulcer Disease (n, %) | | | | | | $\chi^2$=8.44 | 0.038 |
| No | 17893 (96.68) | 4448 (96.13) | 4472 (96.65) | 4475 (96.71) | 4498 (97.21) | | |
| Yes | 615 (3.32) | 179 (3.87) | 155 (3.35) | 152 (3.29) | 129 (2.79) | | |
| Mild Liver Disease (n, %) | | | | | | $\chi^2$=116.59 | <.001 |
| No | 15699 (84.82) | 3770 (81.48) | 4003 (86.51) | 4098 (88.57) | 3828 (82.73) | | |
| Yes | 2809 (15.18) | 857 (18.52) | 624 (13.49) | 529 (11.43) | 799 (17.27) | | |
| Diabetes (n, %) | | | | | | $\chi^2$=1291.69 | <.001 |
| No | 16379 (88.50) | 3460 (74.78) | 4099 (88.59) | 4352 (94.06) | 4468 (96.56) | | |
| Yes | 2129 (11.50) | 1167 (25.22) | 528 (11.41) | 275 (5.94) | 159 (3.44) | | |

**Table 2.** Single and multiple factor Cox regression results

| eGFR Quantile | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | HR (95%CI) | P | HR (95%CI) | p | HR (95%CI) | P | HR (95%CI) | p |
| Q1 | 1.00 (Reference) | | 1.00 (Reference) | | 1.00 (Reference) | | 1.00 (Reference) | |
| Q2 | 0.70 (0.64 ~ 0.78) | <.001 | 0.64 (0.59 ~ 0.70) | <.001 | 0.98 (0.90 ~ 1.08) | 0.695 | 0.98 (0.90 ~ 1.08) | 0.695 |
| Q3 | 0.52 (0.47 ~ 0.58) | <.001 | 0.51 (0.46 ~ 0.57) | <.001 | 1.03 (0.93 ~ 1.15) | 0.545 | 1.03 (0.93 ~ 1.15) | 0.545 |
| Q4 | 0.39 (0.35 ~ 0.44) | <.001 | 0.55 (0.49 ~ 0.62) | <.001 | 1.14 (1.02 ~ 1.28) | 0.019 | 1.14 (1.02 ~ 1.28) | 0.019 |

HR, hazard ratio; CI, confidence interval.

**Figure 1.** The relationship between eGFR and all-cause mortality rate




of mortality, with a hazard ratio (HR) significantly higher than those with eGFR ≥90 mL/min/1.73 m². This suggests that renal impairment is a critical factor that influences survival in this patient population. The analysis also highlighted the impact of various demographic and clinical factors on mortality. Older age (≥65 years) and male gender were associated with higher mortality rates, which is consistent with the general understanding of these variables as risk factors in cardiovascular diseases. Insurance status emerged as a significant determinant of mortality, with Medicaid patients showing higher HRs compared to those with Medicare or other insurance types. This finding could reflect differences in access to healthcare resources and quality of care.

Several comorbid conditions, including myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, and chronic pulmonary disease, were significantly associated with increased mortality. This is consistent with the results of previous research [18–22].

ing and early intervention in patients with impaired renal function.

## Discussion

The coexistence of atrial fibrillation (AF) and heart failure (HF) represents a significant clinical challenge due to their combined impact on patient morbidity and mortality [15–17]. This study aimed to elucidate the relationship between estimated glomerular filtration rate (eGFR) and all-cause mortality in patients with AF complicated by HF, using data from the MIMIC–IV database.

The results confirm a strong association between lower eGFR and increased all-cause mortality in patients with AF and HF. This finding agrees with previous research that has established the prognostic value of eGFR in various cardiovascular conditions. Specifically, patients with an eGFR <30 ml/min/1.73 m² exhibited the highest risk

**Figure 2.** Analysis of the relationship between eGFR and all-cause mortality in patients with AF complicated by HF. Forest plot showing the hazard ratios (HRs) and 95% confidence intervals for all-cause mortality associated with various baseline characteristics in ICU patients

| | | | | | | |
|---|---|---|---|---|---|---|
| All patients | 18508 (100.00) | 1711/9254 | 839/9254 | 0.53 (0.48 ~ 0.57) | <.001 | |
| Age | | | | | | 0.450 |
| <65 | 8597 (46.45) | 491/3087 | 405/5510 | 0.56 (0.49 ~ 0.64) | <.001 | |
| ≥65 | 9911 (53.55) | 1220/6167 | 434/3744 | 0.60 (0.54 ~ 0.67) | <.001 | |
| Gender | | | | | | 0.032 |
| Fmale | 8211 (44.36) | 828/4319 | 346/3892 | 0.48 (0.42 ~ 0.54) | <.001 | |
| Male | 10297 (55.64) | 883/4935 | 493/5362 | 0.57 (0.51 ~ 0.64) | <.001 | |
| Insurance | | | | | | 0.410 |
| Medicaid | 1478 (7.99) | 81/549 | 79/929 | 0.67 (0.49 ~ 0.91) | 0.011 | |
| Medicare | 8481 (45.82) | 987/5062 | 362/3419 | 0.55 (0.49 ~ 0.62) | <.001 | |
| Other | 8549 (46.19) | 643/3643 | 398/4906 | 0.53 (0.47 ~ 0.60) | <.001 | |
| Marital status | | | | | | 0.256 |
| DIVORCED | 1517 (8.20) | 144/737 | 71/780 | 0.50 (0.37 ~ 0.66) | <.001 | |
| MARRIED | 8742 (47.23) | 787/4346 | 424/4396 | 0.60 (0.53 ~ 0.67) | <.001 | |
| SINGLE | 5899 (31.87) | 448/2578 | 261/3321 | 0.49 (0.42 ~ 0.58) | <.001 | |
| WIDOWED | 2350 (12.70) | 332/1593 | 83/757 | 0.51 (0.40 ~ 0.65) | <.001 | |
| Myocardial Infarct | | | | | | 0.175 |
| No | 15370 (83.05) | 1303/7196 | 727/8174 | 0.52 (0.48 ~ 0.57) | <.001 | |
| Yes | 3138 (16.95) | 408/2058 | 112/1080 | 0.61 (0.49 ~ 0.75) | <.001 | |
| Congestive Heart Failure | | | | | | 0.166 |
| No | 12711 (68.68) | 933/5156 | 643/7555 | 0.51 (0.46 ~ 0.56) | <.001 | |
| Yes | 5797 (31.32) | 778/4098 | 196/1699 | 0.58 (0.50 ~ 0.68) | <.001 | |
| Peripheral Vascular Disease | | | | | | 0.337 |
| No | 16443 (88.84) | 1443/7883 | 766/8560 | 0.52 (0.48 ~ 0.57) | <.001 | |
| Yes | 2065 (11.16) | 268/1371 | 73/694 | 0.61 (0.47 ~ 0.79) | <.001 | |
| Cerebrovascular Disease | | | | | | 0.021 |
| No | 16075 (86.85) | 1453/8019 | 684/8056 | 0.50 (0.46 ~ 0.55) | <.001 | |
| Yes | 2433 (13.15) | 258/1235 | 155/1198 | 0.66 (0.54 ~ 0.81) | <.001 | |
| Chronic Pulmonary Disease | | | | | | 0.109 |
| No | 13510 (73.00) | 1216/6515 | 610/6995 | 0.51 (0.46 ~ 0.56) | <.001 | |
| Yes | 4998 (27.00) | 495/2739 | 229/2259 | 0.59 (0.50 ~ 0.69) | <.001 | |
| Rheumatic Disease | | | | | | 0.952 |
| No | 17749 (95.90) | 1630/8799 | 810/8950 | 0.53 (0.48 ~ 0.57) | <.001 | |
| Yes | 759 (4.10) | 81/455 | 29/304 | 0.53 (0.34 ~ 0.81) | 0.003 | |
| Peptic Ulcer Disease | | | | | | 0.021 |
| No | 17893 (96.68) | 1646/8920 | 800/8973 | 0.51 (0.47 ~ 0.56) | <.001 | |
| Yes | 615 (3.32) | 65/334 | 39/281 | 0.85 (0.57 ~ 1.26) | 0.407 | |
| Mild Liver Disease | | | | | | 0.467 |
| No | 15699 (84.82) | 1252/7773 | 660/7926 | 0.54 (0.49 ~ 0.59) | <.001 | |
| Yes | 2809 (15.18) | 459/1481 | 179/1328 | 0.50 (0.42 ~ 0.59) | <.001 | |
| Diabetes With Cc | | | | | | 0.568 |
| No | 16379 (88.50) | 1449/7559 | 806/8820 | 0.50 (0.46 ~ 0.55) | <.001 | |
| Yes | 2129 (11.50) | 262/1695 | 33/434 | 0.55 (0.38 ~ 0.79) | 0.001 | |



The x-axis represents the hazard ratio on a linear scale (ranging from 0 to 2).
A value of HR > 1 indicates increased mortality risk, while HR < 1 indicates reduced risk.


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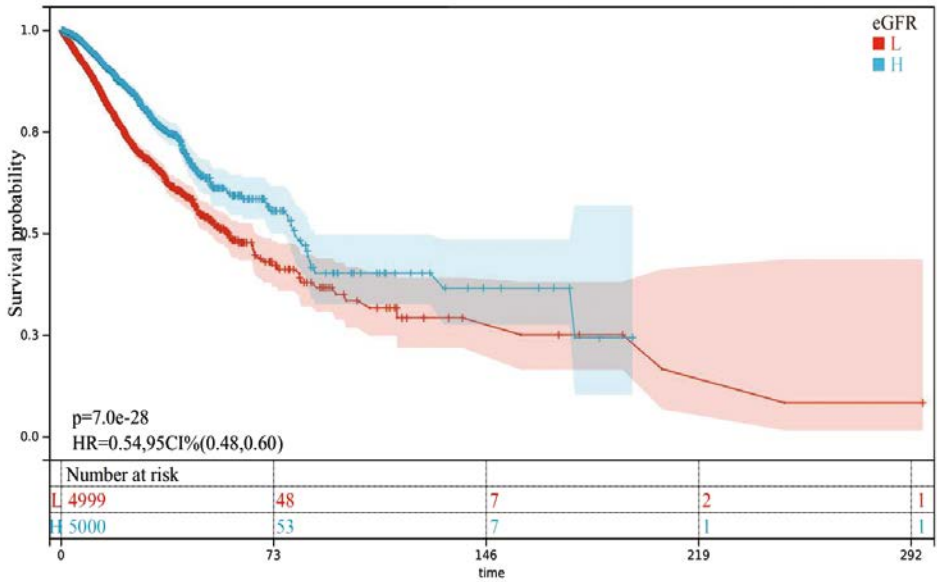
**Figure 3.** Subgroup survival analysis showing Kaplan-Meier survival curves by eGFR quartiles. Time is measured in days




These conditions likely exacerbate the overall health status of patients with AF and HF, contributing to poorer outcomes. Interestingly, mild liver disease and diabetes with complications also showed significant associations with mortality, underscoring the importance of comprehensive management of these comorbidities. Peptic ulcer disease did not significantly impact mortality in this cohort, suggesting that its role in the context of AF and HF may be less critical compared to other comorbid conditions.

The findings of this study have important clinical implications for the management of patients with AF and HF. Monitoring renal function and implementing strategies to preserve or improve eGFR should be integral components of patient care. Given the significant association between lower eGFR and higher mortality, healthcare providers should prioritize interventions aimed at maintaining renal function. This could include optimizing fluid management, avoiding nephrotoxic medications, and addressing underlying conditions that may contribute to renal impairment.

Additionally, the significant impact of demographic and clinical factors on mortality highlights the need for personalized treatment approaches. For instance, older patients and those with multiple comorbidities may require more intensive monitoring and tailored therapeutic strategies to improve outcomes.

### *Limitations*

The retrospective design inherently limits the ability to establish causality. Furthermore, the reliance on data from the MIMIC–IV database, while comprehensive, may introduce biases related to data entry and completeness. Future prospective studies are warranted to confirm these findings and explore potential interventions aimed at improving renal function and reducing mortality in this high-risk population.

## Conclusion

Reduced eGFR was significantly associated with increased all-cause mortality in patients with AF and HF, even after adjusting for demographics, comorbidities, and laboratory variables in multivariate models. These findings underscore the importance of renal function monitoring and management in this patient population. By addressing renal impairment and considering the broader spectrum of demographic and clinical factors, healthcare providers can potentially improve survival outcomes in patients with AF and HF.

*No conflicts of interest are reported.*

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