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EARLY POST-DISCHARGE GLYCEMIC CONTROL AND CARDIOVASCULAR EVENT READMISSION IN PATIENTS WITH HEART FAILURE AND TYPE 2 DIABETES: A SINGLE-CENTER RETROSPECTIVE COHORT STUDY

<i>Background</i>	Heart failure (HF) patients with type 2 diabetes mellitus (T2DM) are at high risk of hospital readmission due to cardiovascular events. Glycemic control may play a key role in reducing this risk, but the optimal glycemic control threshold for preventing readmissions remains unclear.
<i>Material and methods</i>	This single-center, retrospective cohort study included 160 adult patients with HF and type 2 diabetes mellitus (T2DM). Patients were classified into two groups based on HbA1c measured 3 months after discharge: poor glycemic control (HbA1c $\geq 7.0\%$) and good glycemic control (HbA1c $< 7.0\%$). Data were collected from electronic medical records, and cardiovascular event readmissions were tracked over a one-year follow-up period. Kaplan–Meier event-free survival (EFS) analysis and Cox regression models were used to examine the relationship between the three-month HbA1c and cardiovascular event readmission. A Fine–Gray competing-risk model was additionally applied to provide a more robust estimate of the cumulative incidence of cardiovascular readmission.
<i>Results</i>	Among the 160 patients, 56 (35%) were readmitted due to cardiovascular events, including HF exacerbation (39.3%), myocardial infarction (25.0%), arrhythmias (14.3%), and coronary artery disease (8.9%). Their median EFS time was 121 days. The readmission rate was significantly higher in patients with poor glycemic control (HbA1c $\geq 7.0\%$), with 58.8% of the patients being readmitted compared to 17.4% in the group with good glycemic control (HbA1c $< 7.0\%$, $p < 0.001$). Kaplan–Meier EFS analysis confirmed a significantly shorter EFS in patients with poor glycemic control. Cox regression analysis identified the three-month HbA1c value as an independent predictor of cardiovascular event readmission (HR=3.41, 95% CI 2.15–5.29, $p < 0.001$), which was consistent with the Fine–Gray competing-risk analysis (sub-distribution HR = 3.12, 95% CI 1.95–4.98, $p < 0.001$).
<i>Conclusion</i>	Early glycemic control, particularly the three-month HbA1c value, is a strong predictor of cardiovascular event readmission in HF patients with DM. Optimizing glycemic control within the first three months post-discharge may significantly reduce readmission risk and improve clinical outcomes.
<i>Keywords</i>	Heart failure; diabetes management; cardiovascular event readmission; glycemic control
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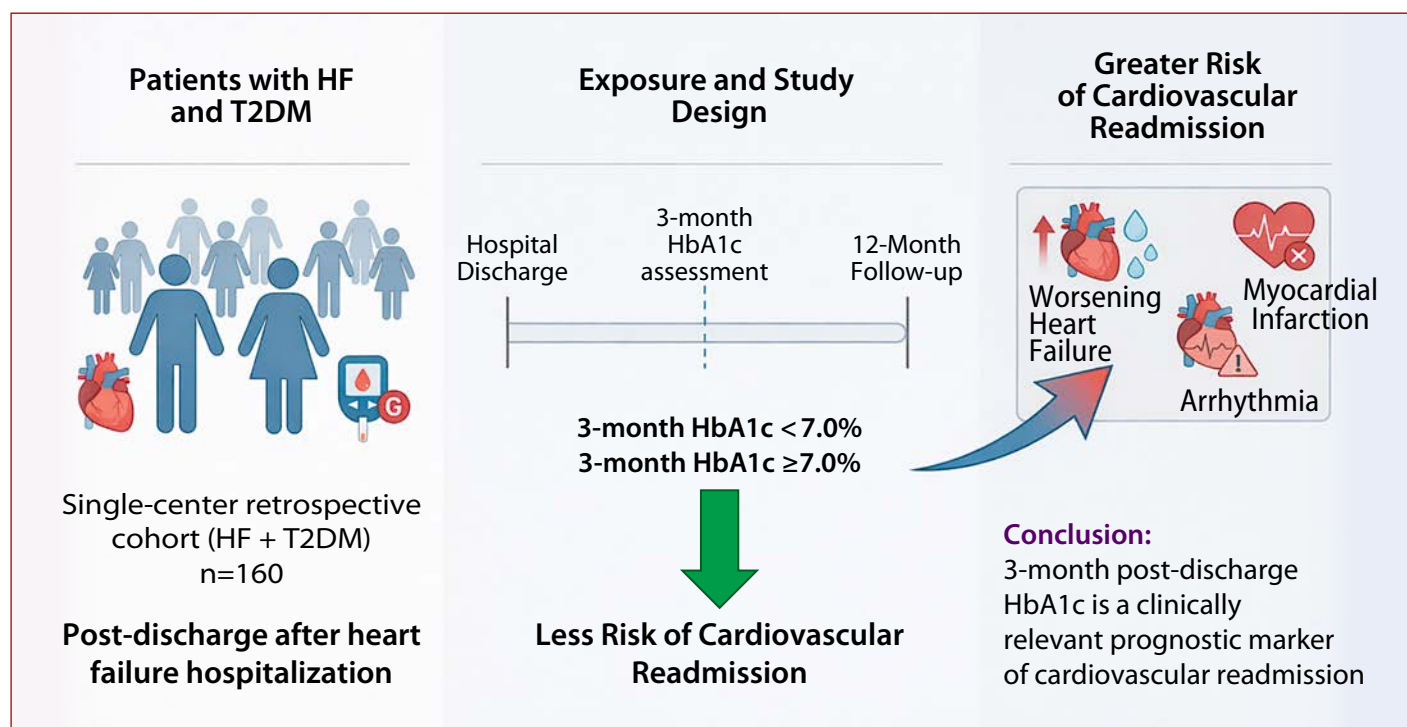
Introduction

The cardiometabolic intersection of heart failure (HF) and diabetes mellitus (DM) constitutes a growing global health crisis, with contemporary registries documenting DM prevalence exceeding 40% in hospitalized HF populations [1]. This clinical synergy translates to dire prognoses since diabetic HF patients face a 72-day shorter median event-free survival (EFS) and 1.9-fold higher 90-day readmission risks than their non-diabetic counterparts [2]. Molecular studies have revealed that sustained hyperglycemia activates myocardial NLRP3 inflammasomes, driving fibrotic remodeling through IL-1 β overproduction [3, 4]. These pathophysiological insights underscore the urgent need for targeted glyce-

mic management strategies in this vulnerable HF and DM population.

Despite therapeutic advancements, optimal glycemic targets remain controversial. Whereas the 2007 Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial demonstrated increased mortality with intensive glycemic control (HbA1c $< 6.0\%$) [5], the 2023 Finerenone in Reducing Cardiovascular Mortality and Morbidity in Diabetic Kidney Disease (FIGARO-DKD) trial identified a protective HbA1c range of 7.0–7.8% that was significantly associated with 29% fewer HF readmissions [6]. This U-shaped risk relationship, and the absence of HF-specific recommendations in the guidelines of the American Diabetes Association or

Central Illustration. HbA1c levels in glycemic control after discharge in a single-center retrospective cohort study



the European Association for the Study of Diabetes, creates clinical equipoise. A previous meta-analysis of 24,589 patients quantifies this paradox: In advanced HF, each 1% reduction in HbA1c below 8.0% decreased microvascular events by 18% (relative risk (RR) = 0.82) while HF hospitalizations increased by 14% (RR = 1.14) [7]. These findings highlight the precarious balance clinicians must navigate in the treatment of patients with HF and DM [8].

Emerging evidence positions the 90-day post-discharge window as a critical intervention phase. Continuous glucose monitoring in the PROGRESS-HF cohort (n=1,842) revealed that 63% of patients experience dangerous glycemic excursions (>180 mg/dl) within 14 days of discharge, correlating with doubled readmission rates and accelerated ventricular remodeling [9]. These early metabolic derangements coincided with persistent mitochondrial dysfunction, as evidenced by a 31% reduction in myocardial ATP production (p=0.02), and suggesting a biological basis for time-sensitive intervention.

Three important knowledge gaps remain in this field. First, conventional measures such as HbA1c, which reflect average glycemia over approximately three months, may not fully capture acute post-discharge fluctuations that are thought to trigger early decompensation and readmission. Second, therapeutic inertia after a heart failure hospitalization is common, with many patients not receiving timely adjustment of glucose-lowering therapy during the vulnerable early post-discharge period. Third, the prognostic value of short-term post-discharge glycemic control – as reflected by early follow-up HbA1c – specifically for cardiovascular readmission in pa-

tients with HF and T2DM has not been well defined [10]. To address these gaps, we conducted a single-center retrospective cohort study of patients with heart failure and type 2 diabetes mellitus (T2DM) who were discharged after a hospitalization for HF. We examined the association between 3-month post-discharge HbA1c and subsequent cardiovascular event readmission within 12 months, using landmark and competing-risk analyses to reduce survival time bias and to account for death as a competing event [11].

Material and methods

Study design

This study was a single-center, retrospective cohort study to assess the association between glycemic control and the risk of cardiovascular event readmission in HF patients with DM. This observational design allows for an analysis of routinely collected clinical data to explore the relationship between blood glycemic management and outcomes, without any intervention from the researchers (Figure 1).

The follow-up period was defined as the time from hospital discharge to either cardiovascular event readmission, death, or the last available clinical record within the twelve-month observation window. Patients who did not experience any cardiovascular event during this period were considered censored at the date of their last follow-up.

Study population

The study included adult patients diagnosed with HF and type 2 DM who were admitted to Hangzhou Normal University Affiliated Xiaoshan Hospital between January 2020

and September 2024. The inclusion criteria encompassed patients aged 18 yrs or older with a documented diagnosis of both HF and DM during the study period. Patients with significant comorbidities such as active cancer, end-stage renal disease, or other conditions that could confound the results were excluded from the study. Additionally, patients with missing data on key variables, such as HbA1c values, were also excluded.

Inclusion and exclusion criteria

Inclusion Criteria:

- 1) Adult patients ≥ 18 yrs with a diagnosis of HF and type 2 diabetes mellitus (T2DM) at the time of hospital admission;
- 2) Patients who were discharged after an episode of HF and had available baseline HbA1c data;
- 3) Patients with at least six months of follow-up data available, i.e., three-month and six-month HbA1c data;
- 4) Patients with clinically confirmed cardiovascular events during hospitalization, e.g., HF exacerbation, myocardial infarction, arrhythmia.

Exclusion criteria:

- 1) Patients with advanced or terminal illnesses, such as cancer, that could substantially confound cardiovascular outcomes;
- 2) Patients with incomplete medical records or missing data on key variables required for the primary analyses, particularly baseline or 3-month HbA1c measurements and cardiovascular outcome data;
- 3) Patients whose index hospitalization was primarily for non-cardiovascular reasons during the study period.
- 4) Pregnant or lactating women were excluded due to the potential confounding effects of pregnancy on glycemic control and cardiovascular events.

To summarize, all patients diagnosed with both DM and CHF during the study period were screened. Patients were included if they fulfilled the study's inclusion criteria and excluded if they had missing clinical data, no three-month HbA1c results, or significant comorbidities.

Data collection

Data were retrospectively retrieved from the hospital's electronic medical records system. The variables collected included demographic information (age, gender), clinical characteristics (hypertension, coronary artery disease, and comorbidities), baseline HbA1c values, and data on cardiovascular event readmissions. All patients were followed from the date of hospital discharge until the first readmission due to a cardiovascular event; patients who did not experience cardiovascular readmission were censored at the date of their last available clinical contact or at the end of the 12-month observation period, whichever occurred first. In the Cox

models, patients who died before experiencing cardiovascular readmission were censored at the date of death, whereas in the Fine–Gray competing-risk models death was treated as a competing event.

Glycemic control was evaluated by HbA1c values recorded during hospitalization (baseline) and at subsequent follow-up visits at three months and at six months. Patients were categorized into two groups based on their three-month HbA1c values: poor glycemic control ($\text{HbA1c} \geq 7.0\%$) and good glycemic control ($\text{HbA1c} < 7.0\%$). The primary endpoint of the study was cardiovascular event readmission within one year of hospital discharge, which was defined as any rehospitalization due to HF worsening, myocardial infarction, arrhythmias, or other cardiovascular-related causes.

Statistical analysis

Descriptive statistics were used to summarize baseline patient characteristics. Continuous variables are reported as mean $\pm$ standard deviation (SD), and categorical variables are described as counts and percentages. Longitudinal changes in glycemic control were evaluated by comparing HbA1c measured at baseline, 3 months, and 6 months after discharge. For normally distributed variables, repeated-measures analysis of variance (ANOVA) was applied, and when normality assumptions were not met, the Friedman test was used. When overall differences were significant, pairwise comparisons were conducted with Bonferroni adjustment to control for multiple testing.

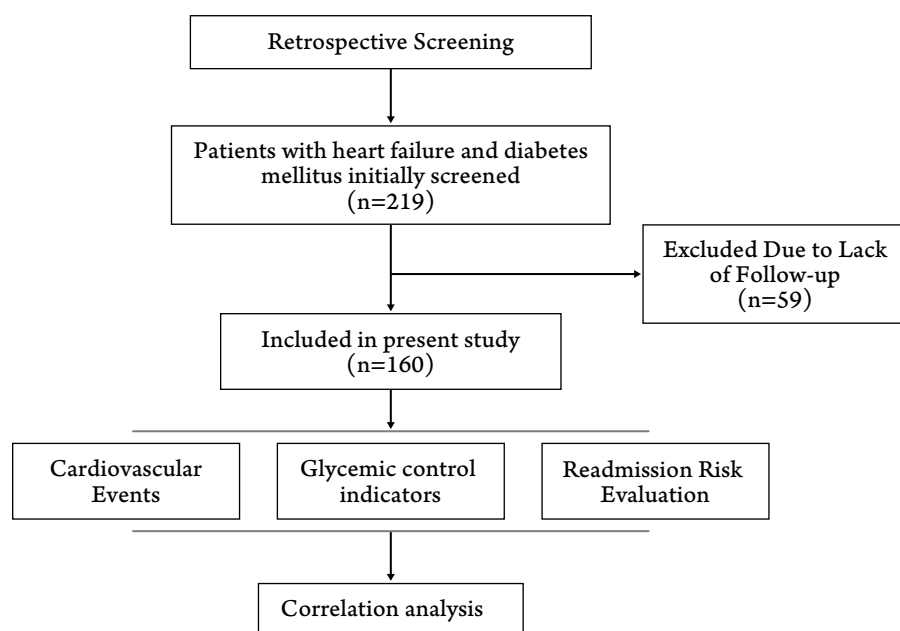
To examine the association between glycemic control and cardiovascular event readmission, survival analysis methods were applied. Kaplan–Meier event-free survival (EFS) curves were generated to evaluate the time from discharge to cardiovascular readmission, with censoring at the last available follow-up for patients without an event or who died during follow-up.

To minimize immortal time bias and evaluate the prognostic significance of short-term glycemic control, a three-month landmark analysis was conducted. Only patients who were alive and free of cardiovascular readmission at three months were included, and survival time was recalculated from the three-month landmark to the outcome event or to censoring.

A Fine–Gray competing-risk regression model was performed to account for death as a competing event, and cumulative incidence function (CIF) curves were generated to complement the Kaplan–Meier analysis (Supplementary Figure 1). This approach provided a more accurate estimate of the incidence of cardiovascular readmission in the presence of competing mortality risk.

To assess the independent association between the three-month HbA1c value and cardiovascular event readmission, multivariable Cox proportional hazards models were con-

Figure 1. Design of the study



structured using the landmark cohort. Covariates included age, sex, left ventricular ejection fraction (LVEF), NT-proBNP, and baseline HbA1c value, selected based on their clinical relevance and established prognostic merit in HF. The proportional hazards assumption was verified using Schoenfeld residuals, with no violations detected. A Fine-Gray competing-risk regression model was also applied as a supplementary analysis, confirming the robustness of the findings.

All statistical tests were two-sided, and a p -value <0.05 was considered statistically significant. Statistical analyses were performed using R software, version 4.1.

Table 1. Baseline characteristics of the patients with HF and DM

Characteristic	Total (n = 160)
Age (yrs)	68.4±10.2
Male (%)	110 (68.8)
Female (%)	50 (31.2)
NYHA HF Class I (%)	12 (7.5)
NYHA HF Class II (%)	72 (45.0)
NYHA HF Class III (%)	56 (35.0)
NYHA HF Class IV (%)	20 (12.5)
LVEF (%)	37.2±11.3
NT-proBNP (pg/ml)	2365±1052
Hypertension (%)	126 (78.8)
Coronary artery disease (%)	88 (55.0)
Atrial fibrillation (%)	45 (28.1)
Chronic kidney disease (%)	34 (21.3)
ACEI/ARB (%)	134 (83.8)
Beta-blockers (%)	112 (70.0)
Diuretics (%)	149 (93.1)

Data are mean±SD or as number (percentage). Baseline characteristics are summarized descriptively for the overall cohort, and no between-group hypothesis tests were performed.

Reporting standards

This study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies [12]. A completed STROBE checklist demonstrating adherence to these criteria is provided in Supplementary Table 1.

Outcome measures

The main outcome of the study was the occurrence of HF exacerbation or other cardiovascular events leading to hospital readmission. Secondary outcomes included changes in HbA1c values over time, as well as the association between early post-discharge glycemic control (three-month HbA1c values) and the risk of readmission.

Results

Patient baseline characteristics

A total of 219 patients were screened, and 160 patients with HF and DM were included in the final analysis (Figure 1). A comprehensive summary of baseline demographic and clinical characteristics is presented in Table 1. The mean age was 68.4 yrs, and approximately two-thirds of the population were male. Most patients were classified as NYHA class II or III, and the cohort overall exhibited reduced systolic function, as reflected by the mean LVEF. Comorbidities such as hypertension, coronary artery disease, atrial fibrillation, and chronic kidney disease were frequently observed, and baseline NT-proBNP values were elevated, indicating substantial cardiac stress. Guideline-directed HF therapies, including that ACEI/ARB, beta-blockers, and diuretics, were widely used.

Table 2. DM related characteristics and management in patients with HF and DM

Characteristics	Total (n=160)
HbA1c (%)	7.2±1.8
Blood glucose (mmol/l)	9.2±3.4
Insulin Use (%)	40 (25.0)
Oral Hypoglycemic Agents (%)	120 (75.0)
Diabetic retinopathy (%)	36 (22.5)
Diabetic nephropathy (%)	29 (18.1)
Diabetic neuropathy (%)	19 (11.9)
Diabetic foot ulcer (%)	11 (6.9)

Data are mean ± SD or as number (percentage).

Table 3. Distribution of baseline indicators according to baseline HbA1c values

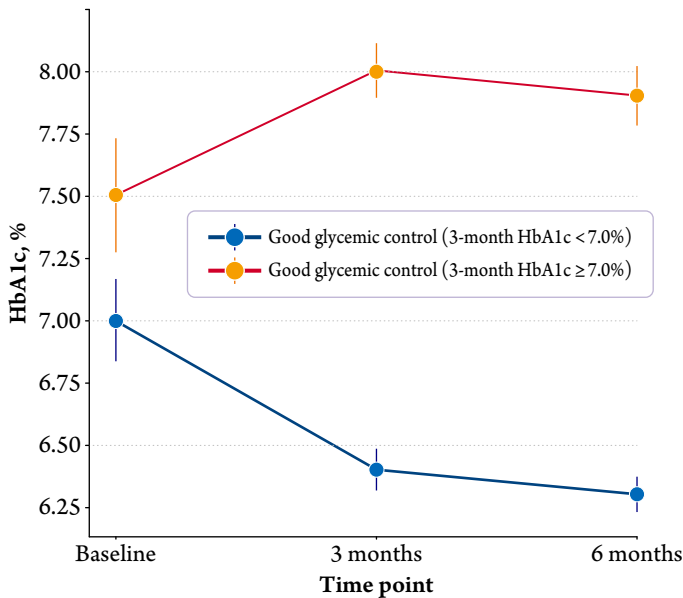
Characteristic	HbA1c < 7.0% (n=92)	HbA1c ≥ 7.0% (n=68)
Age (yrs)	67.8±10.5	69.2±9.7
Male (%)	69 (66.3)	41 (73.2)
Female (%)	35 (33.7)	15 (26.8)
NYHA HF Class I (%)	10 (9.6)	2 (3.6)
NYHA HF Class II (%)	48 (46.2)	24 (42.9)
NYHA HF Class III (%)	30 (28.8)	26 (46.4)
NYHA HF Class IV (%)	16 (15.4)	4 (7.1)
LVEF (%)	38.4±10.5	34.8±12.5
Hypertension (%)	78 (84.7)	48 (70.6)
Coronary artery disease (%)	52 (56.5)	36 (52.9)
Insulin use (%)	30 (32.6)	18 (26.5)

Data are mean ± SD or as number (percentage).

DM-related characteristics and management

A complete descriptive summary of all DM-related variables is presented in Table 2. At baseline, patients demonstrated suboptimal glycemic control, with HbA1c and blood glucose values reflecting a moderately elevated glycemic burden across the cohort. Most patients were managed with oral hypoglycemic agents, while a smaller proportion received insulin therapy. DM-related complications, including retinop-

Figure 2. Longitudinal changes in HbA1c at baseline, 3 months, and 6 months after hospital discharge among patients with heart failure and type 2 diabetes mellitus (T2DM)



Separate curves are shown for patients with good glycemic control (3-month HbA1c < 7.0%; n=92) and poor glycemic control (3-month HbA1c ≥ 7.0%; n=68). HbA1c measurements were available for all 160 patients at each time point. Data are presented as mean ± standard error (SE). In the good-control group, mean HbA1c decreased from baseline to 3 months and remained at a similarly low level at 6 months, whereas patients with poor glycemic control had persistently higher HbA1c across all time points. Overall, the longitudinal change in HbA1c over time was statistically significant in the repeated-measures ANOVA (p<0.001).

athy, nephropathy, neuropathy, and foot ulcers, were also prevalent in this population.

To further characterize clinical patterns across glycemic strata, patients were classified by baseline HbA1c value (<7.0% vs. ≥7.0%); the corresponding descriptive distributions are shown in Table 3.

Longitudinal changes in HbA1c values

As part of the secondary outcomes, HbA1c was evaluated longitudinally for the overall cohort at baseline, 3 months, and 6 months after discharge. Mean HbA1c decreased significantly from baseline to 3 months and remained at a similarly lower level at 6 months (p<0.001 for the overall repeated-measures ANOVA; Figure 2).

These findings indicate that, at the cohort level, glycemic control improved substantially during the early months after discharge and that this improvement was sustained through 6 months. The pronounced early decline in HbA1c supports the potential prognostic importance of short-term post-discharge glycemic optimization in patients with HF and T2DM.

Associations between HbA1c and cardiovascular event readmission

Cardiovascular event readmission profile. During the 12-month observation period, 56 of the 160 patients (35%) experienced cardiovascular-related readmission. The distribution of readmission causes is summarized in Table 4. HF worsening and myocardial infarction represented the most common readmission categories, followed by arrhythmias and other cardiovascular conditions.

Substantial variation was observed in the timing of recurrent events across subtypes, with some causes occurring shortly after discharge while others appeared much later during follow-up. This heterogeneity highlights the differing clinical trajectories that contribute to rehospitalization in patients with HF and DM.

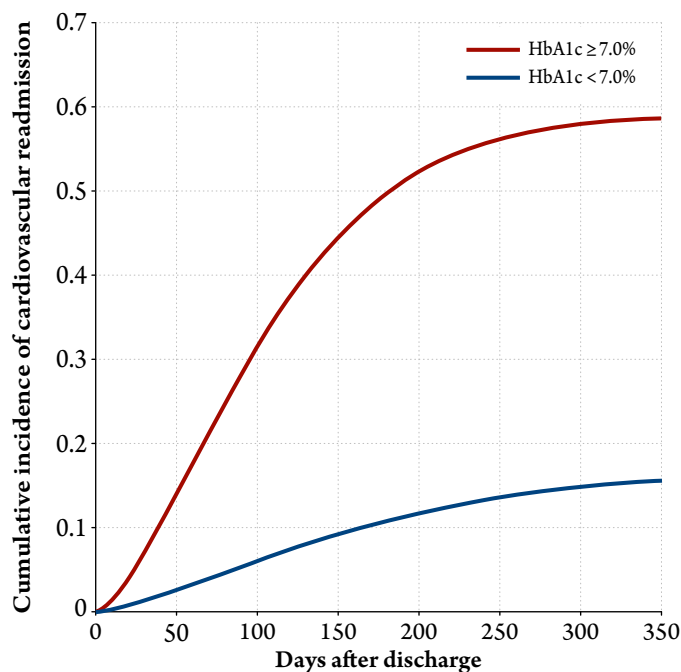
Competing-risk analysis of cardiovascular event readmission

The primary time-to-event analysis was performed in the full cohort of 160 patients using the Fine–Gray subdistri-

Table 4. Distribution of cardiovascular events leading to readmission.

Cardiovascular Event	Number (n=56)	Percentage	Median Days to Event
[HF] Worsening	22	39.3	142
Myocardial Infarction	14	25.0	37
Arrhythmia	8	14.3	51
Coronary Artery Disease	5	8.9	89
Other	5	8.9	331

Figure 3. CIF curves for cardiovascular event readmission according to the three-month HbA1c values



bution hazard model, which accounts for death as a competing event and provides an appropriate estimate of cardiovascular readmission probability. The cumulative incidence function (CIF) for these 160 patients demonstrated a progressive increase in cardiovascular readmissions over the 12-month observation period, with a particularly vulnerable period occurring shortly after hospital discharge. (Figure 3).

When categorized according to 3-month glycemic status, patients with HbA1c $\geq 7.0\%$ had a higher cumulative incidence of cardiovascular readmission than those with HbA1c $< 7.0\%$, reinforcing the prognostic importance of short-term post-discharge glycemic control. Kaplan–Meier curves com-

paring event-free survival between the two glycemic groups are presented in Supplementary Figure 1.

Predictive value of the HbA1c value at three-months for cardiovascular rehospitalization.

The prognostic importance of glycemic control was assessed using HbA1c values measured at baseline and again at the three-month follow-up visit. While baseline HbA1c values showed only limited descriptive differences, the three-month HbA1c value demonstrated a substantially stronger association with subsequent cardiovascular readmission risk.

In the primary Cox proportional hazards model, patients with three-month HbA1c $\geq 7.0\%$ had a significantly higher hazard of cardiovascular readmission compared with those achieving HbA1c $< 7.0\%$ (Table 5). To address potential survival bias, a three-month landmark analysis, including only patients alive and event-free at the landmark time, was performed and yielded similar effect estimates. The association remained robust in the Fine–Gray competing-risk model, confirming that the relationship persisted even when death was treated as a competing event.

Event proportions observed at the three-month landmark further supported this pattern, indicating a substantially greater burden of cardiovascular readmissions among patients with inadequate glycemic control. Collectively, these findings demonstrate that short-term post-discharge glycemic status, rather than baseline HbA1c, is the key predictor of cardiovascular readmission in patients with HF and DM.

Discussion

This study provides significant insights into the relationship between early glycemic control and cardiovascular event readmission in patients with HF and DM. The findings suggest that the HbA1c value at three-months is a strong indicator of readmission risk. On the other hand, poor glyce-

Table 5. Prognostic impact of three-month HbA1c value on cardiovascular event readmission: Landmark and competing-risk analyses

Model	Analysis Population (n)	Analysis Type	HbA1c Groups ($\geq 7.0\%$ vs $< 7.0\%$)	Adjusted HR (95% CI)	p Value	Interpretation
Model 1	160	Cox proportional hazards regression (from discharge)	Poor vs Good Control	3.41 (2.15–5.29)	<0.001	Full cohort. Survival time calculated from discharge to first cardiovascular readmission or censoring. Adjusted for age, sex, LVEF, NT-proBNP, and baseline HbA1c.
Model 2	138	Landmark Cox regression (from three months post-discharge)	Poor vs Good Control	3.27 (2.01–5.06)	<0.001	Landmark cohort, including only patients alive and event-free at three months. Survival time recalculated from the three-month landmark date to readmission or censoring. Adjusted for age, sex, NT-proBNP, and baseline HbA1c.
Model 3	138	Fine–Gray competing-risk regression	Poor vs Good Control	3.12 (1.95–4.98)	<0.001	Competing-risk analysis treating death as a competing event. Results consistent with Cox and landmark models, confirming robustness.

HR, hazard ratio; CI, confidence interval. All models used the three-month HbA1c value as the primary exposure (HbA1c $\geq 7.0\%$ vs $< 7.0\%$). HR, hazard ratio; CI, confidence interval. HbA1c was included as an adjustment variable in multivariable Cox and landmark models, but it was not used as the exposure of interest. Thus, the hazard ratios presented in this table reflect the impact of three-month post-discharge glycemic status on subsequent cardiovascular event readmission.

mic control ($\text{HbA1c} \geq 7.0\%$) significantly increases the likelihood of rehospitalization due to cardiovascular events. This association aligns with prior research indicating that DM, particularly if poorly controlled, is a major risk factor for adverse outcomes in HF patients, including increased hospitalizations and higher mortality rates [13, 14]. The Kaplan – Meier EFS analysis, which identified a median EFS of 121 days, further underscores the early vulnerability of these patients following discharge, with half of the hospital readmissions occurring within the first four months.

This study extends previous findings by re-emphasizing the critical importance of early post-discharge glycemic control [15, 16]. While baseline HbA1c values have been shown to correlate with long-term cardiovascular risks in DM [17, 18], the predictive power of the HbA1c value at three-months is particularly noteworthy. In addition to its prognostic value, longitudinal analysis revealed that HbA1c values decreased significantly from the initial value at hospitalization to that at three months follow-up and then remained stable for the next three months. This indicated that early improvement in glycemic control was both achievable and sustainable during follow-up (Supplementary Figure 2). The 58.8% readmission rate among patients with poor glycemic control ($\text{HbA1c} \geq 7.0\%$) within the first three months highlights the urgency of early glycemic interventions. In contrast, those with good glycemic control ($\text{HbA1c} < 7.0\%$) experienced a markedly lower readmission rate of 17.4%. This pattern of sustained early HbA1c reduction supports the hypothesis that effective glucose optimization immediately after discharge may stabilize cardiovascular status and mitigate recurrent decompensation [19]. Taken together, our findings suggest that optimizing glycemic control during the early post-discharge phase may help reduce the risk of cardiovascular readmission and potentially improve longer-term outcomes in this high-risk population.

The mechanisms underlying the relationship between poor glycemic control and increased cardiovascular event readmissions are likely multifactorial. Hyperglycemia promotes the development of microvascular and macrovascular complications, which are central to the progression of both DM and HF [20]. Chronic hyperglycemia accelerates vascular remodeling, endothelial dysfunction, and increased myocardial fibrosis, all of which exacerbate the pathophysiology of HF [21]. Furthermore, elevated glucose values are associated with increased oxidative stress and inflammation, which contribute to both cardiac remodeling and increased arrhythmia risk, further heightening the likelihood of readmission [22, 23]. These findings are consistent with prior studies that have shown that glycemic excursions during the first few weeks following hospital discharge are associated with worse outcomes and higher readmission rates [24].

Interestingly, the three-month post-discharge period appears to represent a clinically critical window for intervention. The current study highlights this early phase as a key window for intervention, as it aligns with observations from the PROGRESS-HF cohort [25], which showed that patients experiencing glycemic excursions within the first 14 days post-discharge were at doubled risk of readmission. A relationship between early hyperglycemia and accelerated ventricular remodeling is supported by the finding of reduced myocardial ATP production in this population [26]. Early and targeted interventions aimed at stabilizing glycemic control during this period may therefore improve patient prognosis and reduce healthcare burden.

This study adds to the body of evidence suggesting that early optimization of glycemic control is not only beneficial in terms of managing DM, but it also plays a critical role in the cardiovascular health of HF patients. These findings support the need for personalized glycemic management strategies, especially in high-risk groups such as HF patients with DM. While current clinical guidelines focus on long-term glycemic control, the results of this study highlight the time-sensitive nature of post-discharge care, suggesting that HbA1c targets during the early months following discharge should be revisited.

To ensure methodological rigor and minimize potential survival time bias, a landmark analysis was conducted at three months post-discharge. Only patients who survived and remained event-free during this period were included, and survival time was recalculated from the landmark date. This approach eliminated immortal time bias and confirmed that the three-month HbA1c value remained a significant independent predictor of readmission risk (Table 5).

Furthermore, a Fine–Gray competing-risk regression was performed to account for death as a competing event. The results were highly consistent with both the landmark Cox model and the main analysis, reinforcing the robustness of the association between short-term glycemic control and cardiovascular readmission (Table 5, Supplementary Figure 1).

This study has some limitations. The retrospective design means that causality cannot be firmly established, and the results are based on data from a single-center cohort, which may limit generalizability. In addition, the relatively small sample size reduces statistical power and did not allow us to develop or validate a robust multivariable risk prediction model. Thus, although 3-month HbA1c emerged as an independent prognostic marker of cardiovascular readmission, the findings should be interpreted with caution and require confirmation in larger, external cohorts. The reliance on HbA1c as a measure of glycemic control is also a limitation, as it does not capture short-term glucose fluctuations, including postprandial glucose excursions, particularly in patients with more unstable diabetes. Future studies utilizing continuous glucose monitoring (CGM) could

provide a more nuanced understanding of glycemic variability and its relationship with cardiovascular events in patients with HF and T2DM. Despite these limitations, the current results contribute to the emerging evidence that early glycemic control should be prioritized in managing HF with DM. The findings highlight that HbA1c measurement within the first three months after discharge can serve as a clinically actionable tool for identifying patients at high risk of cardiovascular readmission. By applying both landmark and competing-risk analytical approaches, this study provides robust evidence supporting the prognostic role of short-term glycemic control in this vulnerable population [27].

Summary

In summary, this single-center retrospective cohort study demonstrated that poor glycemic control during the early post-discharge period was significantly associated with an increased risk of cardiovascular event readmission in patients with HF and type 2 diabetes mellitus (T2DM). The integration of landmark and Fine–Gray analyses confirmed the stability and clinical significance of this relationship, underscoring the importance of early glycemic optimization to improve long-term cardiovascular outcomes.

By applying a three-month landmark analysis to exclude patients who experienced early events, the present study reduced the potential for survival time bias and ensured that HbA1c was evaluated as a true post-discharge prognostic indicator. In addition, to address potential competing risks such as death, a supplementary Fine–Gray competing-risk regression analysis was performed. The cumulative incidence function (CIF) analysis yielded results consistent with both the Kaplan–Meier survival estimates and the multivariable Cox regression models, further confirming the robustness and reliability of the findings. Together, these methodological refinements reinforce the clinical significance of the observed relationship between short-term glycemic control and cardiovascular readmission.

Hong Xu, Yuhua Ma and Xiaofei Han contributed equally to this work and share first authorship. Liqin Zhao is the corresponding author for this work.

No conflict of interest is reported.

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