Original Article

Prognostic Role of the Six-Minute Walk Test at Discharge for Predicting Readmission in Acute Decompensated Heart Failure

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Abstract

Background: Despite improvements in treatment approaches, acute decompensated heart failure (ADHF) continues to have a high rate of early readmissions. Currently, the majority of prognostic models examining ADHF patients utilize static clinical parameters to identify patients who are at risk, but they tend to miss the patients categorized as "high-risk." The 6-minute walk test (6MWT) is simple, inexpensive, and effective in measuring an individual's functional capacity and might provide more prognostic information. **Material and Methods:** A Prospective Observational Study was conducted on 51 patients admitted for First-Episode ADHF to Teerthanker Mahaveer Medical College and Research Centre, Moradabad, India. Information regarding demographics, clinical, laboratory, and echocardiographic values was taken. All patients performed a standardized 6MWT before discharge, and the 6MWD was recorded. All patients were followed for the outcome of all-cause readmissions for 90 days post-discharge. Statistical tests included Welch's t-tests, Pearson's correlation, Receiver Operating Characteristics (ROC) curve analysis, and logistic regressions. **Results:** The mean age was 56.3 ± 11.3 years, with 51% male. The mean 6MWD was 364.6 ± 122.2 m. Of the 90 days after discharge, 33 patients (64.7%) were readmitted. Readmitted patients had a mean lower 6MWD than patients without readmission (298.5 ± 90.3 m vs 485.8 ± 67.5; $p < 0.001$). The ROC analysis identified a 360 m threshold to determine readmission status with the highest accuracy (AUC = 0.76; sensitivity = 69%, specificity = 72%). Logistic regression demonstrated that a 10 m decrease in 6MWD increased the odds of readmission by 40% (OR = 1.40; 95% CI 1.14–1.72; $p = 0.001$). **Conclusion:** Decreased discharge 6MWD significantly predicts early readmission in ADHF. Assessing 6MWT during discharge may help identify patients at high risk of readmission for further follow-up and targeted intervention.

Keywords: Acute Decompensated Heart Failure, Six-Minute Walk Test, Functional capacity, Hospital readmission, Prognostic marker.

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Introduction

Globally, heart failure (HF) continues to be a large proportion of hospitalizations and re-hospitalizations, a public health concern for the healthcare system and individuals. Even with progress in the delivery and implementation of evidence-based therapies, almost one in three patients with acute decompensated heart failure (ADHF) will be readmitted within 90 days of release, which has devastating implications on morbidity and mortality.[1,2] Currently used risk prediction models only consider clinical parameters (age, comorbidities, or left ventricular ejection fraction (LVEF) at a fixed point in time and often neglect the overall residual burden of disease or functional recovery status at discharge.[3,4]

Many studies now support the importance of assessing functional capacity as a dynamic and holistic marker of prognosis in HF. Functional performance, which incorporates cardiac reserve and musculoskeletal, pulmonary, and metabolic status, influences outcomes and events after hospital discharge.[5,6] The Six-Minute Walk Test (6MWT), although fluidly defined, can be viewed as a simple, safe, and reproducible bedside assessment of submaximal exercise capacity, requiring minimal equipment that can be easily utilized before discharge and correlates with many important outcomes, including symptom burden, quality of life, rehospitalization, and mortality.[7,8]

Several studies have shown that lower six-minute walk distance (6MWD) at discharge is independently associated with increased risk of rehospitalization. For instance, McCabe N et al. demonstrated that each 100-foot increase in 6MWD decreased the odds of 30-day readmission by 16%.[9] Likewise, Kommuri NV et al. and Teramatsu H et al. demonstrated that 6MWD ≤400

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meters strongly predicted early rehospitalization.[10,11] A threshold of distance between 300-400 m has been well-established to discriminate high-risk from lower-risk patients in an ACOS clinical setting, even when conventional clinical markers and indicators are included.[12]

However, the standard lower-limit-of-normal values (< 153 m for men and <139 m for women) are likely to be insensitive in acutely decompensated populations where many high-risk patients walk a distance in the "normal" range.[13] Cut-offs driven by outcomes, such as an approximate 360 m distance revealed via Receiver operating characteristic (ROC) analysis, are likely a more appropriate estimate of prognosis in this patient cohort.[14] In addition, various studies indicate that incorporating 6MWD with other clinical indices, such as NT-proBNP and LVEF, increases the prognostic accuracy of risk prediction models.[15,16]

The 6MWT is a positive method for discharge-based risk stratification in patients with acute heart failure owing to its practicality, low cost, and comprehensive nature. The present study builds on this promising evidence by examining whether the 6MWD document at discharge can predict 90-day readmission in patients with ADHF, and can assess the prognostic utility of the 360-meter pragmatic decision threshold.

Materials and Methods

Study Design and Setting: This is a prospective observational cohort study in the Department of Internal Medicine at Teerthanker Mahaveer Medical College and Research Centre, located in Moradabad, Uttar Pradesh, India, that aimed to study the prognostic significance of the Six-Minute Walk Test (6MWT) at the time of discharge for predicting the risk of 90-day readmission relating to Acute Decompensated Heart Failure (ADHF).

Study Population: All consecutive patients who were clinically diagnosed & admitted with ADHF based on Framingham criteria were screened for participation eligibility.[17]

Inclusion criteria:

- Age ≥18 years
- First-time hospitalization for acute decompensated heart failure
- Medically stable at discharge and able to perform the 6MWT
- Able to ambulate independently or with minimal assistance

Exclusion criteria:

- Prior enrolment in the study or repeat HF hospitalizations
- Severe musculoskeletal or neurological impairment limiting ambulation
- Unstable angina or recent myocardial infarction
- Inability to provide informed consent or adhere to follow-up

Sample Size: Given the relatively low anticipated prevalence for ADHF (~1%) and all logistical challenges, a convenience sample of 51 patients was used and considered sufficient for exploratory predictive modelling and hypothesis development.[18]

Ethical Considerations

The Institutional Ethics Committee of Teerthanker Mahaveer Medical College and Research Centre approved the study protocol. Written informed consent was obtained from every participant before the completion of enrolment in accordance with the Declaration of Helsinki.[19]

Data Collection and Procedure

All eligible patients underwent an informed assessment that included:

- Medical history and clinical assessment.
- Baseline assessments include electrocardiograph (ECG), echocardiography for LVEF, NT-proBNP, complete blood count, liver and renal function tests, electrolytes, and viral markers as clinically indicated.

Each patient completed a prescribed 6MWT to hospital discharge, with total distance walked (6MWD) collected in meters. Physiology predicted that 6MWD was also derived sex-specifically from reference equations to derive peer-predicted 6MWD using age, height, and weight. As well, we applied a constant LLN of < 153 m for men and < 139 m for women and a derived outcome threshold of 360 meters as reference classifications of functional capacity.[13,14]

Follow-Up and Outcomes: Participants were followed up via outpatient clinic visits and telephone contact for 90 days after discharge. The primary outcome was all-cause hospital readmission due to worsening heart failure or cardiovascular-related causes.[1,2]

Statistical Analysis: Statistical analyses were performed using SPSS version 25.0 (IBM, Armonk, New York, USA). Summary statistics included means ± standard deviation (SD) for continuous variables and frequencies and percentages for categorical variables. Group comparisons were evaluated using Welch's t-test or chi-square test where appropriate. The associations of 6MWD with continuous clinical variables (age, NT-proBNP, LVEF) were determined using Pearson's correlation coefficient.[21]

Univariable and multivariable logistic regression analyses were conducted to determine independent predictors of 90-day readmission. 6MWD was modeled as both a continuous variable (for every 10-meter decline) and as a dichotomous variable (based on Receiver operating characteristic [ROC] curve analysis), with a cutoff at 360 meters.[14] All statistical tests were two-sided; $p < 0.05$ was considered statistically significant.

Results

1. Baseline Characteristics

Fifty-one patients who had been admitted for ADHF were included in this study. The mean age was 56.3 ± 11.3 years, with close to even distribution by gender, with 26 males (51%) and 25 females (49%). At discharge, the mean systolic blood pressure (SBP) was 116.3 ± 20.2 mmHg, and the diastolic blood pressure (DBP) was 71.8 ± 14.6 mmHg. The mean left ventricular ejection fraction (LVEF) was 37.1 ± 13.7%, reflecting predominantly reduced systolic function.

2. 6-Minute Walk Test (6MWT) Performance

All 51 patients completed the Six-Minute Walk Test (6MWT) at discharge. The mean six-minute walk distance (6MWD) was 364.6 ± 122.2 m. Using conventional lower-limit-of-normal

(LLN) thresholds (<153 m for men and <139 m for women),[13] only one patient (2.0%) was classified as functionally impaired.

Table 1: Baseline characteristics of study population (n = 51)

Variable	Mean ± SD	Range
Age (years)	56.3 ± 11.3	25 – 77
SBP (mmHg)	116.3 ± 20.2	88 – 200
DBP (mmHg)	71.8 ± 14.6	50 – 120
Hemoglobin (g/dL)	10.9 ± 2.8	3.2 – 18.0
Sodium (mmol/L)	135.7 ± 5.4	117.3 – 148.4
Potassium (mmol/L)	4.5 ± 0.8	3.1 – 6.4
NT-proBNP (pg/mL)	5927.6 ± 8236.1	480 – 25000
LVEF (%)	37.1 ± 13.7	15 – 57.5
6MWD (m)	364.6 ± 122.2	120 – 600

Table 2: 6MWT performance at discharge

Parameter	Value
Number of patients	51
Mean 6MWD (m)	364.6 ± 122.2
Range (m)	120 – 600
Below LLN threshold	1 (2.0%)
At or above LLN threshold	50 (98.0%)

3. 90-Day Readmission Rates

Within 90 days of discharge, 33 patients (64.7%) experienced readmission due to worsening Heart Failure (HF) or related cardiovascular events, while 18 patients (35.3%) remained free of hospitalization.

Table 3: 90-day readmission status

Readmission Status	n	%
Readmitted	33	64.7%
Not readmitted	18	35.3%

4. Association of 6MWD with Readmission

Readmitted patients had markedly lower 6MWD at discharge (298.5 ± 90.3 m) than those not (485.8 ± 67.5 m). The difference was statistically significant (Welch's $t = -8.38$, $p < 0.001$; Cohen's $d = -2.26$, indicating a large effect size.

Table 4: 6MWD by readmission status

Group	n	Mean 6MWD (m)	SD
Readmitted	33	298.5	90.3
Not readmitted	18	485.8	67.5

5. Correlation Analysis

Pearson's correlation showed A weak, non-significant inverse correlation between 6MWD and NT-proBNP ($r = -0.058$, $p = 0.685$). A moderate inverse correlation between 6MWD and age ($r = -0.348$, $p = 0.012$)

Table 5: Correlation between 6MWD and selected variables

Variable 1	Variable 2	Pearson r	p-value
6MWD (m)	NT-proBNP (pg/mL)	–0.058	0.685
6MWD (m)	Age (years)	–0.348	0.012

6. Threshold-Based Risk Stratification

Receiver operating characteristic (ROC) curve analysis identified 360 m as the optimal 6MWD cut-off to predict readmission (Youden index = 0.41; sensitivity = 69%, specificity = 72%).

Table 6: Predictive performance of 360 m threshold

Threshold (6MWD)	Sensitivity (%)	Specificity (%)	Youden Index
360 m	69	72	0.41

7. Logistic Regression Analysis

Univariate analysis showed that: Each 10 m decrement in 6MWD increased the odds of readmission by 40% (OR = 1.40; 95% CI 1.14–1.72; $p = 0.001$). Higher LVEF was protective (OR = 0.87 per 1% increase; 95% CI 0.81–0.93; $p < 0.001$). Age showed borderline association (OR = 1.05; $p = 0.068$). NT-proBNP and sex were not significant predictors Multivariable analysis, including 6MWD, age, sex, NT-

proBNP, and LVEF (Nagelkerke R^2 = 0.90), showed: Adjusted OR for 6MWD (per 10 m decrement) = 1.39 (95% CI 0.89–2.15; p = 0.14). Adjusted OR for LVEF = 0.78 (95% CI 0.54–1.10; p = 0.16). Other predictors were non-significant

Table 7: Logistic regression for predictors of 90-day readmission

Predictor	Unadjusted OR (95% CI)	p	Adjusted OR (95% CI)	p
6MWD (per 10 m ↓)	1.40 (1.14–1.72)	0.001	1.39 (0.89–2.15)	0.144
LVEF (per % ↑)	0.87 (0.81–0.93)	<0.001	0.78 (0.54–1.10)	0.157
Age (years)	1.05 (0.99–1.11)	0.068	1.27 (0.89–1.82)	0.187
NT-proBNP (per 1000 ↑)	1.04 (0.96–1.12)	0.378	1.20 (0.91–1.58)	0.187
Male sex	1.50 (0.47–4.76)	0.491	29.57 (0.10–8727.2)	0.243

Discussion

This study utilized the Six-Minute Walk Test (6MWT) at discharge to predict 90-day readmission risk among patients with Acute Decompensated Heart Failure (ADHF). It was revealed that a lower six-minute walk distance (6MWD) at discharge was significantly related to higher early readmission risk. Readmitted patients had a mean 6MWD 186 m lower than non-readmitted patients (298.5 m vs. 485.8 m, large effect size). Receiver operating characteristic (ROC) analysis identified a 360 m cut-off with good discriminative ability (AUC 0.76) to predict readmission risk.

Comparison with Existing Literature

The 90-day readmission rate of 64.7% in our study is greater than the 30-40% readmission rates that others have observed in large cohorts.[1,2] We believe this may be due to our examination of only first-episode ADHF patients and the sample size. Prior studies consistently established that decreased functional capacity strongly predicts worse outcomes in HF. In their research, McCabe N. et al. reported that each additional 100 ft in 6MWD was associated with a 16% lower risk of 30-day readmission.[9] Similarly, Kommuri N. V. et al. found that patients with a 6MWD ≤400 m had a greater risk of readmission.[10] Our study adds to the existing literature because our readmission analyses are focused on the context of first-episode ADHF.

Interestingly, we also find only a weak correlation of 6MWD and NT-proBNP; this raises the possibility that functional limitation may reflect broader systemic deconditioning beyond hemodynamic congestion. This dissociation was also noted by Fuentes-Abolafio I. J. et al., who found that performance measures, like physical performance, were associated with mortality independent of biochemical measures.[6] LVEF, a traditional prognostic marker, was protective in univariate analysis, but not significant after adjustments. This finding was expected, given that LVEF alone has poor specificity as a predictive marker for post-discharge outcomes.[3,4,22]

Cut-points for Risk Stratification

Most prior studies have utilized the lower-limit-of-normal (LLN) (< 153 m in men, < 139 m in women) cut-point as the cut-point,[13] however, this cut-off did not have very good sensitivity in our cohort (only one patient was characterized as impaired). As noted previously, this reflects the difficulty of normative cut-points in acutely decompensated populations, in which many high-risk patients are within the "normal" walking distance. Cut-points grounded in outcome are probably more appropriate. Our 360 m cut-point is consistent with La Rovere, M. T. et al.'s suggestion that 360 m was the cut-point to predict events post-discharge (≈350 m).[14] These data support the rationale of using 6MWD for discharge readiness and risk assessment in patients with ADHF.

Clinical implications

There are several advantages to using the 6MWT as a risk stratification method: low cost, minimal training required, and global functional reserve rather than isolated cardiac information.[5,7,8] If we can identify high-risk patients before discharge, we can ensure intensified follow-up, optimize guideline-directed therapy, and consider early enrolment in cardiac rehabilitation. This is consistent with contemporary guidance recommending clinicians perform multimodal discharge risk assessment instead of purely static clinical variables.[22,23]

Strengths and Limitations

The key strength of this study is our recruitment of a homogeneous first-episode ADHF cohort, which likely minimized confounding due to prior HF hospitalizations. Moreover, standardized 6MWT procedures were followed based on the American Thoracic Society guidelines,[20] improving reliability and reproducibility.

It is also important to highlight a few limitations. The study was conducted in a small sample size, which limited power and likely contributed to the loss of statistical significance for the 6MWD variable in multivariable analysis. Despite a strong univariate association, our single-centre design and lack of external validation limit generalizability. In addition, we did not capture data on comorbidities, frailty indices, or which patients adhered to their medical therapy through follow-up, which could have impacted the risk of readmission.

Future Directions

It would be important to conduct larger multicentre studies to confirm the prognostic threshold of 360 m, and examine if a combination of 6MWD, with biomarkers (NT-proBNP, troponin) and echocardiographic parameters would improve the feasibility of risk models. Serial 6MWT measures completed during hospitalization may also identify patients with poor functional recovery despite being clinically stable. They might benefit from a delayed discharge or inpatient rehabilitation until they can safely perform the 6MWT.[24]

Conclusion

The current investigation shows that the Six-Minute Walk Test (6MWT) completed at discharge is an easy, safe, and useful tool for predicting 90-day readmission for patients hospitalized for Acute Decompensated Heart Failure (ADHF). Readmitted

patients had significantly shorter six-minute walk distances (6MWD) than patients who remained free from readmission, with a distance threshold of nearly 360 meters providing good discriminative precision for high-risk patients.

Including the 6MWT in discharge risk evaluations could help identify patients at risk early, allowing for modification of follow-up, intensification of therapy, and the design of specific rehabilitation plans pending discharge. This is a rationale for larger multicenter studies to validate our findings and incorporate functional capacity into risk prediction models in abnormal heart failure management.

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Conflicts of interest

There are no conflicts of interest.

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