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Predictors of Cause-Specific Hospital Readmission in Patients with Heart Failure

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Summary

Background: Repeated hospital readmissions are frequent and increasing over time in patients with heart failure (HF). The predictors for readmission in patients with HF are not completely understood.

Hypothesis: The study was undertaken to investigate the time course of readmission by specific cause in patients with HF, and to examine the independent effects of HF etiology and left ventricular (LV) function on cause-specific readmissions.

Methods: A retrospective cohort of 493 consecutive patients with HF was followed for readmission for 16.5 ± 12.3 months. Ischemic etiology of HF was defined as history of myocardial infarction (MI), coronary artery bypass graft (CABG), percutaneous transluminal coronary angioplasty (PTCA), or ≥ 70% coronary stenosis. Left ventricular function was assessed echocardiographically. Cause-specific readmissions were classified as HF, cardiovascular disease (CVD) other than HF, and other non-CVD.

Results: The annual readmission rate was 56.6%. Median time to readmission was 91 days, with 18.3% patients readmitted within 1 month after discharge. Ischemic etiology independently predicted all-cause readmission: Cox hazard ratio (95% confidence interval): 1.40 (1.11–1.79). This relationship was significant in women (1.83 [1.31–2.55]), but not in men (1.15 [0.82–1.62]), while readmissions were equally frequent in both genders. Similarly, ischemic etiology significantly predicted readmission for CVD in women (4.18 [2.14–8.19]), but not in men (1.49 [0.83–2.67]). However, LV dysfunction independently predicted readmission for recurrent HF (2.44 [1.46–4.08]), while ischemic etiology was not predictive in either gender.

Conclusions: Readmissions for recurrent HF comprise only one-third of total hospital readmissions in patients with HF. Ischemic etiology is a significant predictor of readmission, and most of this effect is mediated through a four-fold increased risk of readmission for CVD other than HF in women. Readmission for recurrent HF is predicted by LV dysfunction but not by ischemic etiology. Patients with HF can be accurately risk stratified for cause-specific readmission with available clinical data.

Key words: congestive heart failure, hospital readmission, ischemic etiology, gender

Introduction

As a chronic condition, heart failure (HF) has emerged as the leading cause of hospitalization in the U.S.[1] While ischemic etiology is a known predictor of mortality in patients with HF,[2–5] its independent relationship with hospital readmission has not been clearly established. The few previous studies found greater rates of hospital readmission[6, 7] in patients with ischemic HF. However, these studies did not identify other patient attributes to allow for a precise delineation of risk factors for hospital readmission and were performed in populations that differ significantly from U.S. metropolitan populations.

Moreover, it is unclear whether ischemic etiology, as a cause of hospital readmission, acts through the effect of impaired left ventricular (LV) function or through other mecha-

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nisms. Left ventricular function is a powerful predictor of prognosis in patients with symptomatic heart disease.[8] While loss of ejection power constitutes the most common cause of HF overall, increased ventricular stiffness with fluid overload attributed to diastolic dysfunction is particularly prominent in the elderly and in women.[9, 10]

Numerous clinical trials aimed at reduction of readmission rates demonstrate that frequent readmission can be prevented with a variety of interventions, ranging from specific pharmacotherapy to a multidisciplinary team approach.[11] Therefore, there is an increased interest in identifying the risk factors for hospital readmission in patients with HF.

Integrating the available clinical and administrative data with traditional epidemiologic methods, we retrospectively studied the cohort of consecutive patients with the primary diagnosis of HF. The purpose of this study was (1) to describe the patterns of readmission in patients with HF by specific cause and time; and (2) to investigate the independent effect of ischemic etiology of HF on cause-specific hospital readmission in a metropolitan, predominantly black population.

Methods

Design and Setting

The study cohort comprised 493 consecutive patients with the primary diagnosis of HF (DRG code 127) discharged alive between January 1, 1996, and December 31, 1997, from the Johns Hopkins Hospital (JHH). Johns Hopkins Hospital is a university-affiliated center that also serves as community hospital for the East Baltimore inner-city population. The study was approved by the Joint Committee on Clinical Investigation of the Johns Hopkins Medical Institutions.

Patient Selection

Nonreferred patients admitted through the emergency department (ED) were selected for the study. The rationale for selection of patients admitted through the ED was (1) to decrease the referral bias by excluding patients who were transferred from other hospitals, admitted electively, or referred from the outpatient setting; (2) to make this study population generalizable to other populations by assuring that the JHH patient mix reflects the neighborhood metropolitan population rather than referred patients; and (3) to diminish losses to follow-up. The final eligibility criteria included an admission presentation with evidence of HF as a primary condition, leading to hospitalization using the modified Framingham criteria for HF.[12]

Measurements and Definitions

Medical records of eligible patients were reviewed for confirmation of diagnosis of HF and for data collection. Data collection was performed using standardized data collection forms. Baseline (index hospitalization) variables included demographic characteristics, comorbidities, history of HF and other cardiovascular disease (CVD), history of major cardiovascular procedures such as coronary artery bypass graft (CABG), percutaneous transluminal coronary angioplasty (PTCA), coronary angiogram, and history of previous hospitalizations. Definitions of ischemic etiology of HF, LV systolic function, as well as specific causes of readmission used in this analysis are summarized in Table I.

Follow-Up Procedures

Follow-up data included information on subsequent hospital readmission, survival status, heart transplantation, and emergency department and outpatient visits in the entire co-

TABLE I Definitions of etiology, left ventricular function, and specific causes of readmission

Variables	Definitions
Ischemic etiology of HF [a]	• Documented history of acute MI • History of PTCA or CABG surgery • Significant (> 70%) narrowing of a major epicardial coronary artery on coronary angiogram
LV systolic function [b]	• Normal function (EF > 55%) • Mild dysfunction (EF = 45–54%) • Moderate dysfunction (EF = 30–44%) • Severe dysfunction (EF < 30%)
Specific causes of readmission	• Recurrent HF [c] • Other CVD excluding HF [d] • Other non-CVD [e]

[a] Ischemic etiology of heart failure was defined by the presence of at least one of the listed conditions.
[b] Interpretation of echocardiographic tapes was performed by two observers blinded to the design and objectives of this study.
[c] Readmissions for HF were defined as DRG code 127, consistent with the definition of HF in the initial cohort.
[d] Readmissions for CVD included readmissions for ischemic events such as acute MI, CABG, and PTCA (DRG codes 106, 107, 112, 121) consistent with the original definition of ischemic causes, as well as hospitalization for other major cardiovascular procedures (left and right cardiac catheterization, arrhythmia ablation, defibrillator implantation, cardiac valve repair, etc.); arrhythmias; hypertension; structural heart disease without HF; and cerebrovascular events.
[e] Other non-CVD, non-HF readmissions included the group of respiratory diseases; renal insufficiency, dialysis, and renal transplantation; and other diseases such as diabetes mellitus, infectious disease, diseases of gastrointestinal and genitourinary tract, alcohol and drug abuse.
Abbreviations: HF = heart failure, MI = myocardial infarction, PTCA = percutaneous transluminal coronary angioplasty, CABG = coronary artery bypass graft, LV = left ventricular, EF = ejection fraction, CVD = cardiovascular disease.

hort. All patients were followed until July 15, 1999. In addition, to account for possible readmission to other hospitals and death, a sample of 217 (44.0% of the total cohort) patients were contacted by phone for standardized interviews. Patients who were and were not contacted did not differ in terms of baseline characteristics, prevalence of ischemic etiology, LV dysfunction, comorbidities, or history of prior hospitalizations. There was a high and comparable incidence of readmission in both contacted and not contacted groups of patients.

Statistical Analysis

Baseline patient characteristics were expressed as mean ± standard deviation (SD) for continuous variables and as proportions for categorical variables. Subgroup comparisons were made with nonpaired *t*-test for continuous variables or with chi-square test for categorical variables. Stratified analysis was performed to test for interactions between ischemic etiology of HF and gender. Survival curves were constructed according to the method of Kaplan and Meier.[13] The effect of relevant covariates on cause-specific readmissions was evaluated by Cox proportional hazards regression models.[14] Two-sided probability of ≤ 0.05 was considered statistically significant for all analyses. Data management was performed with Access 97 (Microsoft, Inc., Redmond, Wash., USA). Statistical analyses were performed with Statistical Package for Social Sciences (SPSS) 8.0 software (SPSS, Inc., Chicago, Ill., USA).

TABLE II Baseline sociodemographic characteristics and prevalent comorbidities at index hospitalization in patients with ischemic and nonischemic heart failure

Baseline variables	Ischemic (n = 182)	Nonischemic (n = 311)	p Value
Age (years)	67.9 ± 11.9	59.9 ± 16.1	< 0.001
Gender (female) (%)	79 (43.4)	178 (57.2)	0.003
Race (black) (%)	118 (64.8)	272 (87.5)	< 0.001
Prior CHF (%)	124 (68.1)	167 (53.7)	0.002
Valvular heart disease (%)	19 (10.4)	40 (12.4)	0.424
Hypertension (%)	123 (67.6)	221 (71.1)	0.417
Diabetes mellitus (%)	85 (46.7)	114 (36.7)	0.028
Renal insufficiency (%)	67 (36.8)	108 (34.7)	0.640
Atrial fibrillation (%)	47 (25.8)	49 (15.8)	0.006
Pacemaker/AICD (%)	22 (12.1)	13 (4.2)	0.001
CVA (%)	40 (22.0)	40 (12.9)	0.008
COPD (%)	58 (31.9)	108 (34.7)	0.517
LV ejection fraction, %	34.0 ± 16.4	43.2 ± 19.4	< 0.001
LV systolic dysfunction (%)	137 (82.5)	180 (62.3)	< 0.001
Normal function (%)	29 (17.5)	109 (37.7)	
Mild dysfunction (%)	15 (9.0)	37 (12.8)	
Moderate dysfunction (%)	49 (29.5)	66 (22.5)	
Severe dysfunction (%)	73 (44.0)	77 (26.6)	

Abbreviations: CHF = congestive heart failure, AICD = automatic implantable cardioverter-defibrillator, CVA = cerebrovascular accident, COPD = chronic obstructive pulmonary disease, LV = left ventricular.

Results

Patient Characteristics at Index Hospitalization

The study population was predominantly (79.1%) black, with a mean age of 63 ± 15 years, and included 257 (52.1%) women. Ischemic etiology was documented in 182 (36.9%) patients. The baseline sociodemographic characteristics and prevalent comorbidities at index hospitalization in patients with ischemic and nonischemic HF are presented in Table II. Previous hospital admission was documented in 334 (67.7%) patients. In this cohort, 98 (19.9%) patients had been previously hospitalized for HF, 103 (20.9%) for CVD other than HF, and 184 (37.3%) for other noncardiovascular causes. After index hospitalization, 437 (88.6%) patients were discharged home for self-care. The remaining patients were discharged to various types of skilled nursing facilities.

Gender Differences

Given the focus of this study on the role of ischemic etiology of HF and the large gender difference in the proportion of patients with ischemic HF, we first compared women and men with respect to baseline characteristics (Table III). It is impor-

TABLE III Baseline sociodemographic characteristics and prevalent comorbidities at index hospitalization in women and men with heart failure

Baseline variables	Women (n = 257)	Men (n = 236)	p Value
Age (years)	64.5 ± 16.0	51.1 ± 14.0	0.003
Race (black) (%)	214 (83.3)	176 (74.6)	0.018
Ischemic etiology (%)	79 (30.6)	103 (43.6)	0.003
CABG (%)	21 (8.2)	43 (18.2)	0.001
PTCA (%)	18 (7.0)	17 (7.2)	0.931
MI (%)	52 (20.2)	68 (28.8)	0.027
CAD (%)	93 (36.2)	111 (47.0)	0.015
Prior CHF (%)	149 (58.0)	142 (60.2)	0.621
Valvular heart disease (%)	33 (12.8)	26 (11.0)	0.533
Hypertension (%)	198 (77.0)	146 (61.9)	< 0.001
Diabetes mellitus (%)	109 (42.4)	90 (38.1)	0.334
Renal insufficiency (%)	86 (33.5)	89 (37.7)	0.325
Atrial fibrillation (%)	42 (16.3)	54 (22.9)	0.067
Pacemaker/AICD (%)	18 (7.0)	17 (7.2)	0.931
CVA (%)	40 (15.6)	40 (16.9)	0.677
COPD (%)	85 (33.1)	81 (34.3)	0.770
LV ejection fraction, %	44.7 ± 19.2	34.4 ± 16.9	< 0.001
LV systolic dysfunction (%)	148 (61.2)	169 (79.3)	< 0.001
Normal function (%)	94 (38.8)	44 (20.7)	
Mild dysfunction (%)	36 (14.9)	16 (7.5)	
Moderate dysfunction (%)	54 (22.3)	61 (28.6)	
Severe dysfunction (%)	58 (24.0)	92 (43.2)	

Abbreviations: CAD = coronary artery disease. Other abbreviations as in Tables I and II.

TABLE IV Baseline sociodemographic and clinical characteristics of patients with ischemic and nonischemic heart failure by gender

	Women (n = 257)			Men (n = 236)		
Baseline variables	Ischemic (n = 79)	Nonischemic (n = 178)	p Value	Ischemic (n = 103)	Nonischemic (n = 133)	p Value
Age (years)	69.2 ± 13.5	62.4 ± 16.7	0.002	66.8 ± 10.4	56.7 ± 14.8	< 0.001
Race (black) (%)	60 (75.9)	154 (86.5)	0.036	58 (56.3)	118 (88.7)	< 0.001
Prior CHF (%)	51 (64.6)	98 (55.1)	0.155	73 (70.9)	69 (51.9)	0.003
Hypertension (%)	62 (78.5)	136 (76.4)	0.715	61 (59.2)	85 (63.9)	0.462
Diabetes mellitus (%)	43 (54.4)	66 (37.1)	0.009	42 (40.8)	48 (36.1)	0.462
Renal insufficiency (%)	31 (39.2)	55 (30.9)	0.191	36 (35.0)	53 (39.8)	0.441
LV ejection fraction , %	40.0 ± 18.6	46.7 ± 19.2	0.045	29.2 ± 12.6	38.3 ± 18.7	0.002
LV systolic dysfunction (%)	55 (74.3)	93 (55.4)	0.005	82 (89.1)	87 (71.9)	0.002
Normal function (%)	19 (25.7)	75 (44.6)	0.033	10 (10.9)	34 (28.1)	0.002
Mild dysfunction (%)	11 (14.9)	25 (14.9)	0.997	41 (4.3)	12 (9.9)	0.128
Moderate dysfunction (%)	21 (28.4)	33 (19.6)	0.134	28 (30.4)	33 (27.3)	0.615
Severe dysfunction (%)	23 (31.1)	35 (20.8)	0.086	50 (54.3)	42 (34.7)	0.004

Abbreviations as in Table II.

tant to note that women were older, had higher mean ejection fraction (EF), higher prevalence of hypertension, lower prevalence of ischemic HF, and were less likely to have prior CABG, while women had similar rates of PTCA compared with men. When we compared patients with ischemic and nonischemic HF in men and women separately, the differences resembled those described in the total cohort, with older age and worse LV systolic function in patients with ischemic HF (Table IV). There was no interaction between gender and ischemic etiology with respect to age, race, history of comorbidities, or other clinical characteristics at baseline.

All-Cause Readmission: Rates and Time Course

During the follow-up period of 16.5 ± 12.3 months (range 0–42.8 months, median 17.4 months), 341 (69.2% or 0.50 per person-years) hospital readmissions and 89 (18.1% or 0.13 per person-years) deaths occurred during the 679 person-years of follow-up. Among 341 identified readmissions, 317 (92.7%) occurred at JHH. Mean time from discharge at index hospitalization to first any-cause readmission was 195 ± 241 days. Of importance is the fact that the median time to first readmission was only 91 days. Therefore, 171 (50.1% of the total hospital readmissions and 34.7% of the total cohort) hospital readmissions occurred within the first 3 months after the index hospitalization. Figure 1 illustrates the time from index hospitalization to first hospital readmission in patients with HF. Within 1 year after index hospitalization, 279 (81.8% of all readmissions and 56.6% of the total cohort) patients were readmitted.

Remarkably, 90 (26.4% of all readmissions and 18.3% of total cohort) readmissions occurred within the first month after discharge at index hospitalization. These 31-day readmissions comprised 32.3% of annual readmissions in this cohort. Among the patients readmitted within the first postdischarge month, there were 40 (30.3%) ischemic and 50 (23.9%) nonischemic patients with HF (p = 0.193); 67 (29.4%) patients with LV dysfunction versus 20 (20.6%) patients with normal LV function (p = 0.102); 48 (53.3%) patients were women and 70 (77.8%) patients were black.

All-cause cumulative readmission rates did not differ by LV function, ischemic etiology, or gender. However, all-cause readmission rates for patients with ischemic HF were significantly higher in women: 65 (82.3%) versus 118 (66.3%) (p = 0.009), but not in men: 67 (65.0%) versus 91 (68.4%) (p = 0.585). There was no gender difference in time to readmission. However, mean time to readmission was significantly shorter in patients with ischemic than nonischemic HF: 158 ± 204 versus 218 ± 260 days (p = 0.023). This difference was statistically significant in women, but not in men.

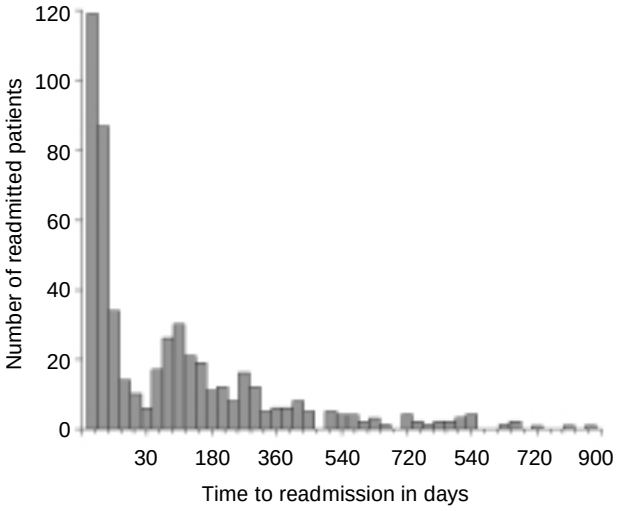

FIG. 1 Time in days from index hospitalization to hospital readmission in patients with heart failure.

TABLE V Cause-specific readmission in patients with ischemic and nonischemic heart failure in the total cohort, and in women and men with heart failure

Specific causes of hospital readmission	Ischemic	Nonischemic	Odds ratio (95% CI)	p Value
		Total cohort		
No readmission (%)	59 (28.6)	102 (34.7)	1.00	0.002
CHF (%)	40 (22.9)	56 (19.0)	1.46 (0.86–2.47)	
CVD (%)	47 (26.9)	42 (14.3)	2.28 (1.34–3.90)	
Other non-CVD (%)	38 (21.7)	94 (32.0)	0.82 (0.50–1.37)	
		Women		
No readmission (%)	14 (19.2)	60 (35.7)	1.00	0.002
CHF (%)	17 (23.3)	34 (20.2)	2.14 (0.94–4.88)	
CVD (%)	21 (28.8)	18 (10.7)	5.00 (2.12–11.78)	
Other non-CVD (%)	21 (28.8)	56 (33.3)	1.61 (0.75–3.46)	
		Men		
No readmission (%)	36 (35.3)	42 (33.3)	1.00	0.016
CHF (%)	23 (22.5)	22 (17.5)	1.22 (0.59–2.54)	
CVD (%)	26 (25.5)	24 (19.0)	1.26 (0.62–2.57)	
Other non-CVD (%)	17 (16.7)	38 (30.2)	0.52 (0.25–1.08)	

Abbreviation: CI = confidence interval. Other abbreviations as in Tables I and II.

Cause-Specific Hospital Readmissions

In the subgroup of 317 patients readmitted to JHH within the follow-up period, 96 (30.3%) readmissions were for recurrent HF (Table V). There were no differences for readmission for recurrent HF by gender or etiology. It is important to note that LV systolic dysfunction (Fig. 2) was significantly associated with readmission for recurrent HF (log-rank p = 0.0027).

Another 89 (28.1%) readmissions were for CVD other than HF. Patients with ischemic HF were readmitted more frequently for CVD than were patients with nonischemic HF (47 [26.9%] vs. 42 [14.3%]). Despite the fact that women tended to have lower rates of total CVD readmission than men: 39 (16.2%) versus 50 (21.9%), women with ischemic HF had higher rates of readmission for CVD (log rank p < 0.001); in men there was no significant difference by etiology (log rank p = 0.2161) (Fig. 3).

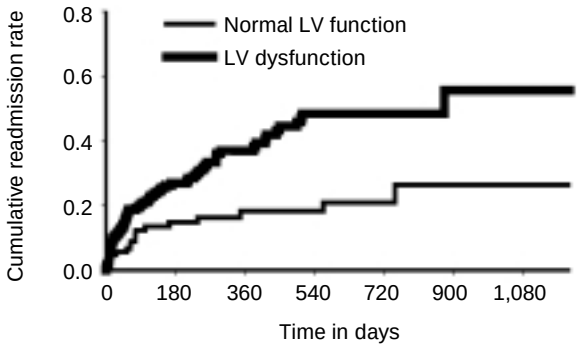

FIG. 2 Cumulative readmissions for recurrent heart failure in total cohort of patients with normal left ventricular (LV) function and with LV dysfunction.

Cox Regression Models for Cause-Specific Readmission

In the total cohort, ischemic etiology of HF was a significant predictor of all-cause readmission (1.40 [1.11–1.76]) and remained so even after controlling for age, gender, and LV dysfunction: (1.46 [1.13–1.87]). Most of this effect was mediated through history of MI or PTCA, but not CABG. Left ventricular systolic dysfunction was significantly associated with all-cause readmission (1.47 [1.14–1.88]), irrespective of gender. Ischemic etiology had no significant independent effect on readmissions for recurrent HF. The most significant predictor of readmission for recurrent HF was LV systolic dysfunction (2.44 [1.46–4.08]). Readmission for CVD other than HF was associated with ischemic etiology (2.48 [1.66–3.83]) and LV dysfunction (1.87 [1.13–3.10]). After controlling for ischemic etiology, LV systolic dysfunction was no longer predictive of hospital readmission for CVD in the total cohort.

Table VI summarizes the age-adjusted bivariate associations between LV dysfunction, ischemic etiology, and its components on cause-specific readmissions, stratified by gender. In women, ischemic etiology was the strongest predictor of readmission for CVD, and only history of PTCA had additional predictive value for recurrent HF. In men, there was no significant predictor of readmission for recurrent HF or CVD.

Discussion

Readmission Causes, Rates, and Time Course

The results of this study demonstrate that hospital readmission occurs frequently and early after discharge in patients with HF. Most readmissions occur within 1 year after discharge, with half occurring within the first 3 months after the

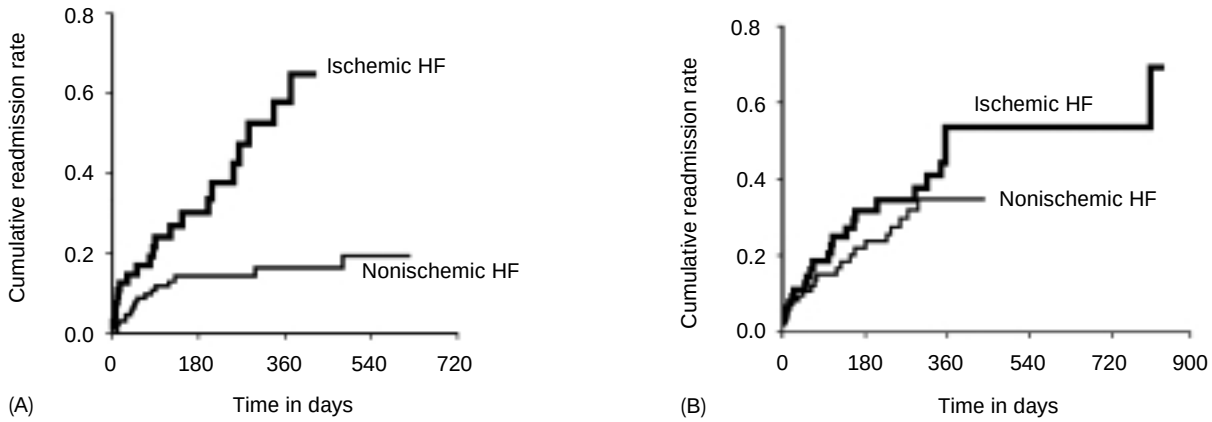

FIG. 3 Cumulative readmissions for cardiovascular disease other than heart failure (HF) in women (A) and men (B) with ischemic and nonischemic HF.

index hospitalization. These results are in agreement with previous reports demonstrating that patients with HF average at least one hospital admission per year, ranging from 0.95 to 2.10 per patient per year.[8, 15–20] In the analysis of cause-specific readmission, our rates of readmission for recurrent HF and CVD were comparable with those of other populations with prior reported rates of 7–57%.[16, 17, 19, 20]

Predictors of Cause-Specific Readmissions

Patients with ischemic HF have higher rates of readmission and shorter time to readmission than patients with nonischemic HF. Furthermore, women with ischemic HF have the highest risk for readmission compared with men and all other etiology groups. In women, most of the effect of ischemic etiology is mediated through hospital readmission for CVD other than HF. Interaction terms for female gender and ischemic etiology of HF for all-cause and CVD other than HF readmission were highly significant. Therefore, these results are not only in agreement with studies that identify ischemic HF as a predictor for hospital readmissions,[6, 7] but also provide an explanation for the association between hospital readmission and ischemic etiology in women. Similar to previous studies,[16, 18, 20] history of coronary heart disease, myocardial infarction (MI), or angina were associated with subsequent readmission in our study.

While ischemic etiology predicted all-cause and CVD readmission, we found no independent gender differences in readmission, contrary to previous studies[1, 21] that reported women to be more frequent users of medical services. In prior studies investigating predictors of readmission, both male and female genders have been associated with increased risk of readmission;[19, 20, 22] in other reports gender was not significant .[18, 23]

The intriguing finding of the predictive role of ischemic etiology of HF in women is possibly due to under-recognition, undertreatment, or treatment failure of ischemic heart disease

TABLE VI Age-adjusted bivariate predictors of cause-specific hospital readmission in women and men with heart failure. Cox proportional regression models hazards ratios (95% CI)

	All-cause readmission		Readmission for HF		Readmission for CVD	
Variables	Women	Men	Women	Men	Women	Men
Ischemic HF	1.83 (1.31–2.55)	1.15 (0.82–1.62)	1.53 (0.84–2.81)	1.43 (0.77–2.68)	4.18 (2.14–8.19)	1.49 (0.83–2.67)
Prior history of HF	1.65 (1.19–2.30)	1.24 (0.89–1.73)	2.21 (1.18–4.15)	1.67 (0.88–3.16)	1.11 (0.58–2.13)	1.27 (0.71–2.29)
LV function	1.61 (1.16–2.24)	1.30 (0.88–1.94)	3.03 (1.55–5.94)	1.85 (0.82–4.15)	1.53 (0.77–3.02)	2.14 (0.96–4.79)
Normal function	1.00	1.00	1.00	1.00	1.00	1.00
Mild dysfunction	1.92 (1.23–2.08)	1.33 (0.61–2.90)	3.02 (1.28–7.15)	2.11 (0.54–3.98)	1.50 (0.57–3.96)	2.37 (0.61–9.24)
Moderate dysfunction	1.36 (0.88–2.08)	1.27 (0.80–2.02)	2.34 (1.03–5.33)	1.58 (0.63–3.98)	1.15 (0.46–2.88)	2.06 (0.84–5.05)
Severe dysfunction	1.67 (1.11–2.53)	1.32 (0.86–2.04)	3.80 (1.79–8.10)	2.01 (0.86–4.72)	1.98 (0.88–4.46)	2.17 (0.92–5.10)
h/o MI	1.38 (0.94–2.02)	1.28 (0.89–1.83)	1.34 (0.68–2.64)	1.75 (0.94–3.26)	2.62 (1.32–5.22)	1.41 (0.77–2.58)
h/o CABG	1.63 (0.92–2.88)	0.94 (0.62–1.43)	1.14 (0.35–3.67)	1.14 (0.56–2.34)	2.10 (0.74–5.96)	1.06 (0.54–2.09)
h/o PTCA	1.36 (1.33–4.21)	0.80 (0.43–1.48)	3.71 (1.54–8.94)	0.51 (0.12–2.10)	5.07 (2.06–12.5)	1.37 (0.58–3.22)

Abbreviation: h/o = history of. Other abbreviations as in Table I.

in women, thus leading to a higher risk of complications and need for readmission. In patients with ischemic HF, history of PTCA but not CABG had the strongest independent effect on subsequent all-cause, recurrent HF and CVD readmission in women, but not in men. Thus, traditional cardiovascular interventions in women with ischemic etiology may not prevent subsequent readmission as well as they do in men.[24, 25]

The primary determinant of recurrent HF readmission was LV function, but not ischemic etiology. In our analysis, regional dysfunction was not associated with HF readmission, while global LV dysfunction was a strong predictor. Left ventricular dysfunction has been shown to be associated with higher costs and more frequent all-cause readmission in other studies.[8, 26] The association of LV dysfunction with readmission for CVD other than HF is probably the result of ischemic heart disease itself.

Methodological Considerations

The reliance on medical records could have led to incomplete information on baseline characteristics and outcomes. However, the advantage of using medical records in obtaining the relevant clinical and imaging data, and for verification of events, should be underscored.[27–29] Our definition of ischemic etiology of HF is consistent with that used in most prior studies[5, 7] and therefore allows generalizability of the results and comparisons across other published sources.

As expected, patients with ischemic HF were older and had more comorbidity associated with CAD than those with nonischemic HF. However, controlling for age, comorbidities, and prior history of HF did not substantially change the independent predictive role of ischemic etiology or other variables in estimating readmission risk. It is important to note that age was not a significant predictor of readmission in this and several other studies.[16, 18, 19, 30] Finally, we also investigated differential mortality as a potential mechanism for the relationship between ischemic etiology and hospital readmission. The deaths that occurred in our study population were not related to ischemic etiology, race, or gender, indicating that this is not the main explanatory factor.

Conclusions and Clinical Implications

This study contributes to our current understanding of the role played by etiology and LV function as risk factors for cause-specific hospital readmission in men and women with HF. In this metropolitan, predominantly black population of patients with HF, hospital readmission is frequent and tends to occur early after discharge. Only one-third of hospital readmissions in patients with HF occurs for recurrent cardiac decompensation; another one-third of readmissions occurs for CVD other than HF; and the remaining one-third of readmissions is for other noncardiovascular causes.

Ischemic etiology of HF is a significant predictor of hospital readmission, especially in women. Moreover, most of the effect of ischemic HF on all-cause readmissions is mediated through a four-fold risk of readmission for CVD other than HF. In this regard, to the best of our knowledge, this is the first study that documents the interaction between ischemic etiology of HF and female gender in relation to cause-specific hospital readmission. The severity of LV dysfunction was the only important predictor of readmission for recurrent HF in this population, regardless of gender.

Finally, patients with HF can be accurately risk stratified for cause-specific hospital readmission with relatively simple models utilizing routinely obtained clinical information. The results of this observational study have important implications for disease management, estimation and planning of healthcare resource utilization, and the conduction of specific interventions to reduce hospital readmission in patients with HF. Further observational studies and randomized trials involving more women are needed to investigate the observed interaction between ischemic etiology and gender, and to examine whether hospital readmission in this high-risk group can be altered by specific interventions.

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Images in Cardiology: Vintage Vineberg!

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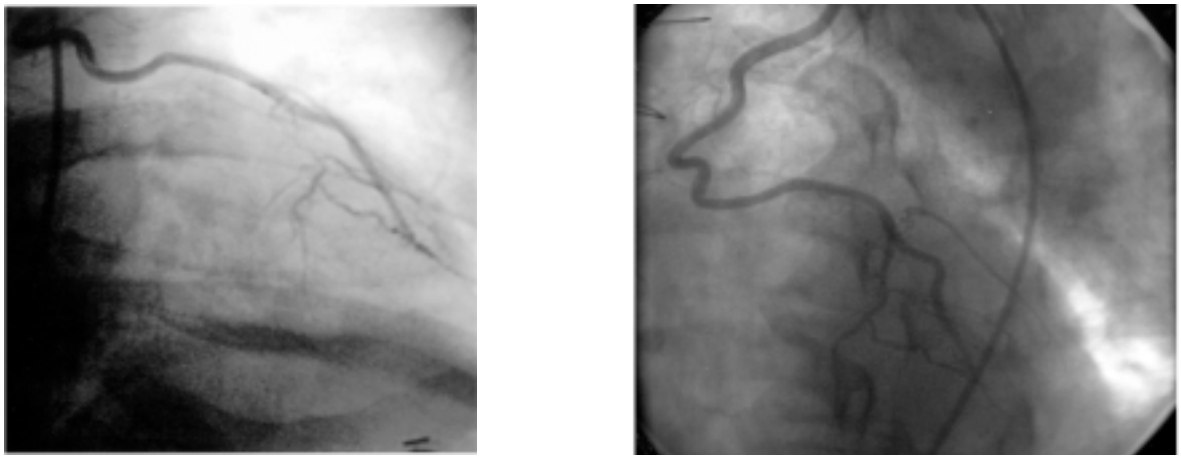

FIG. 1 Coronary angiograms of selective LIMA injections in the right anterior oblique (left) and in the left anterior oblique (right) projections demonstrate the filling of the LAD via attachment of the LIMA to the third diagonal artery.

A 74-year-old man presented with worsening angina. He underwent bilateral internal mammary implantation (IMA) to the myocardium in 1966 by Dr. Arthur Vineberg. Recent angiograms showed severe coronary disease. The left IMA (LIMA) implant was patent and connected to the third diagonal artery with TIMI 3 flow to the entire left anterior descending artery. Anterior wall motion was normal.

The Vineberg procedure was a true precursor to bypass surgery. It was thought to work by forming new collateral channels in the myocardium.[1] In our patient, the LIMA implant of over 35 years was still supplying most of the myocardium.

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