Study objectives: To investigate in older patients with congestive heart failure (CHF) associated with prior myocardial infarction or hypertension the relationship between normal left ventricular (LV) ejection fraction and age, gender, hypertension, prior myocardial infarction, and atrial fibrillation.

Design: A prospective study was performed in 572 older patients (age >60 years) with CHF associated with prior myocardial infarction or hypertension and technically adequate two-dimensional echocardiograms for measuring LV ejection fraction.

Setting: A long-term health-care facility.

Patients: One hundred seventy-seven men and 395 women, mean age 82±8 years, with CHF associated with prior myocardial infarction or hypertension.

Measurements and results: Normal LV ejection fraction (≥50%) occurred in 66 of 177 men (37%) and in 221 of 395 women (56%) (p<0.0001). Multiple logistic regression analysis showed that independent risk factors for normal LV ejection fraction in patients with CHF were no prior myocardial infarction (p=0.0001; odds ratio=3.048), female gender (p=0.0004; odds ratio=1.978), and age (p=0.016; odds ratio=1.029).

Conclusions: Normal LV ejection fraction occurred in 50% of 572 older patients with CHF associated with prior myocardial infarction or hypertension. Independent risk factors for normal LV ejection fraction in patients with CHF were no prior myocardial infarction, female gender, and age.

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Key words: age; atrial fibrillation; congestive heart failure; female gender; hypertension; left ventricular ejection fraction; myocardial infarction

Abbreviations: CHF=congestive heart failure; LV=left ventricular

Congestive heart failure (CHF) patients with normal systolic function should also be considered for appropriate therapy.1,2 The prevalence of normal left ventricular (LV) ejection fraction associated with CHF in older patients has been reported to be 41% in a study including 54 patients,3 41% in 166 patients with coronary artery disease,4 47% of 247 patients,4 and 34% of 501 patients.5 We are reporting in 572 older patients (age >60 years) with CHF associated with prior myocardial infarction or systemic hypertension the relationship between normal LV ejection fraction and age, gender, systemic hypertension, prior myocardial infarction, and atrial fibrillation.

Materials and Methods

In a prospective study, CHF associated with prior myocardial infarction or systemic hypertension was diagnosed in 677 of 2,535 persons (27%) in a long-term health-care facility. CHF was diagnosed if two criteria were satisfied: (1) pulmonary basilar rates were heard by two physicians, including the senior author; and (2) pulmonary vascular congestion was present on the chest radiographs interpreted by both an experienced radiologist and the senior author.

Technically adequate two-dimensional echocardiograms for measuring LV ejection fraction were obtained in 572 of 677 patients (84%) at the time CHF was diagnosed. Except for diuretic therapy, therapy for CHF was instituted after the two-dimensional echocardiograms were obtained. The 572 persons included 177 men and 395 women, with a mean age of 82±8 years. All echocardiograms were interpreted by an experienced echocardiographer (I.K.). LV volumes at end-diastole and end-systole were calculated by planimetry from the two-dimensional study. LV ejection fraction was calculated as follows: (LV end-diastolic volume minus LV end-systolic volume)/LV end-diastolic

*From the Hebrew Hospital Home (Dr. Aronow), Bronx, NY; the Department of Geriatrics and Adult Development, Mount Sinai School of Medicine (Dr. Aronow), New York; the Division of Clinical Epidemiology, University of Texas Medical School (Dr. Ahn) at Houston, Houston; and the Department of Medicine, New York University School of Medicine (Dr. Kronzon), New York.

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Reprint requests: Wilbert S. Aronow, MD, Medical Director, Hebrew Hospital Home, 501 Co-op City Blvd, Bronx, NY 10475
volume×100%. A normal LV ejection fraction was ≥50%. Ethical standards were used in performing this research.

Patients were considered at entry into the study to have had prior myocardial infarction if they had a documented clinical history of myocardial infarction or ECG evidence of Q-wave myocardial infarction. A systolic BP ≥160 mm Hg on three occasions was considered systolic hypertension. A diastolic BP ≥90 mm Hg on three occasions was considered diastolic hypertension.

For group comparisons among patients with normal or abnormal LV ejection fraction, Fisher’s Exact Tests or χ² tests were used for dichotomous variables. Student’s t tests were used for continuous variables. The Cochran-Armitage trend test was used to see if there is an increasing trend of normal LV ejection fraction in CHF as the age increases in men, in women, and in men plus women. Multiple logistic regression analysis was done to examine the relationship between normal LV ejection fraction associated with CHF and the baseline characteristics.

**RESULTS**

Table 1 lists the baseline characteristics of patients with CHF associated with normal vs abnormal LV ejection fraction and p values. Except for having a lower LV ejection fraction, the patients with prior myocardial infarction and no hypertension were similar to the patients with hypertension and no prior myocardial infarction. Atrial fibrillation was as frequent in older patients with CHF and normal LV ejection fraction as in older patients with CHF and abnormal LV ejection fraction. Table 2 shows the association of CHF with normal LV ejection fraction with gender for different age groups and p values. Table 3 shows the multiple logistic regression analysis for relationship between normal LV ejection fraction associated with CHF and baseline characteristics. Patients without a prior myocardial infarction had a three times higher chance of having normal LVEF than those with prior myocardial infarction after controlling the confounding effects of other baseline variables (p=0.0004). There was a 1.3 times higher chance of having normal LV ejection fraction for an increment of 10 years of age after controlling the confounding effects of other baseline variables (p=0.016). Atrial fibrillation and hypertension were not independent risk factors for LV ejection fraction in older patients with CHF.

**DISCUSSION**

Wong et al3 found in 54 older persons with CHF that the mean LV ejection fraction increased with age and that there was a female preponderance in persons with normal LV ejection fraction. The prevalence of atrial fibrillation was higher in persons with normal LV ejection fraction than in persons with abnormal LV ejection fraction. There was no significant difference in the prevalence of hypertension or coronary artery disease between persons with normal or abnormal LV ejection fraction. Pernenkil et al5 demonstrated that older persons with CHF and normal LV ejection fraction had a higher mean age, a higher prevalence of women, and a higher prevalence of no prior myocardial infarction than older persons with abnormal LV ejection fraction. The prevalence of systemic hypertension was similar in older persons with normal vs abnormal LV ejection fraction, but the mean systolic BP was higher in older persons with normal LV ejection fraction than in older persons with abnormal LV ejection fraction.

The present study showed that no prior myocardial infarction, female gender, and increasing age were independently associated with normal LV ejection fraction in older persons with CHF. Systemic hypertension was associated with normal LV ejection fraction by univariate analysis but not by multivariate analysis. The prevalence of atrial fibrillation was similar in older persons with normal vs abnormal LV ejection fraction.

### Table 1—Baseline Characteristics of Patients With CHF Associated With Normal vs Abnormal LV Ejection Fraction

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normal LVEF* (n=287)</th>
<th>Abnormal LVEF (n=285)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>83±7</td>
<td>81±8</td>
<td>0.002</td>
</tr>
<tr>
<td>Women</td>
<td>221 (77)</td>
<td>174 (61)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Men</td>
<td>66 (23)</td>
<td>111 (39)</td>
<td>0.138</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>86 (30)</td>
<td>102 (36)</td>
<td>0.015</td>
</tr>
<tr>
<td>Hypertension</td>
<td>202 (70)</td>
<td>173 (61)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Prior myocardal infarct</td>
<td>215 (75)</td>
<td>261 (92)</td>
<td></td>
</tr>
</tbody>
</table>

*LVEF=LV ejection fraction.

### Table 2—Association of CHF With Normal LV Ejection Fraction With Age and Gender

<table>
<thead>
<tr>
<th>Normal LV Ejection Fraction</th>
<th>Men</th>
<th>Women</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80-89</td>
<td>4/18 (22)</td>
<td>14/38 (37)</td>
<td>0.364</td>
</tr>
<tr>
<td>70-79</td>
<td>18/54 (33)</td>
<td>35/79 (44)</td>
<td>0.204</td>
</tr>
<tr>
<td>≥90</td>
<td>35/86 (41)</td>
<td>129/219 (59)</td>
<td>0.004</td>
</tr>
<tr>
<td>All ages</td>
<td>66/177 (37)</td>
<td>221/305 (56)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

*p values by Cochran-Armitage trend test for normal LV ejection fraction with increasing age=0.085 for men, <0.0001 for women, and <0.0001 for men plus women.
Older patients with CHF and normal LV ejection fraction have LV diastolic dysfunction. In addition to a decrease in LV diastolic relaxation and early diastolic filling caused by aging, older persons are more likely to have LV diastolic dysfunction because they have an increased prevalence of hypertension, myocardial ischemia due to coronary artery disease, and LV hypertrophy associated with hypertension, coronary artery disease, valvular aortic stenosis, hypertrophic cardiomyopathy, and other cardiac disorders. The increased stiffness of the LV and prolonged LV relaxation time impair LV early diastolic filling and cause higher LV end-diastolic pressures at rest and during exercise in older persons.

A normal LV ejection fraction is frequent in older patients with CHF. A normal LV ejection fraction was present in 215 of 476 older patients (45%) with CHF and a prior myocardial infarction, in 202 of 375 older patients (54%) with CHF and hypertension with and without prior myocardial infarction, and in 72 of 96 older patients (75%) with CHF, hypertension, and no prior myocardial infarction. Women more frequently have a normal LV ejection fraction than men in CHF associated with prior myocardial infarction or with hypertension. The therapy of CHF associated with normal LV ejection fraction is different from the therapy of CHF associated with abnormal LV ejection fraction and is discussed elsewhere.

### References