Assessment of Left Ventricular Function in Older Medicare Beneficiaries With Newly Diagnosed Heart Failure

Lesley H. Curtis, PhD; Melissa A. Greiner, MS; Alisa M. Shea, MPH; David J. Whellan, MD, MHS; Bradley G. Hammill, MS; Kevin A. Schulman, MD; Pamela S. Douglas, MD

Background—Assessment of left ventricular function is a recommended performance measure for the care of patients with newly diagnosed heart failure. Little is known about the extent to which left ventricular function is assessed in real-world settings.

Methods and Results—We analyzed a 5% national sample of data from the Centers for Medicare and Medicaid Services from 1991 through 2008. Patients were 65 years or older, with incident heart failure in 1995, 1999, 2003, or 2007. We searched for evidence of tests of left ventricular function from 30 days before through 60 days after an incident heart failure diagnosis. We used logistic regression to identify patient characteristics associated with assessment of left ventricular function. There were 45 005 patients with incident heart failure in 1995, 38 425 in 1999, 39 529 in 2003, and 32 629 in 2007. Assessment of left ventricular function increased from 46% to 60%, with rest echocardiography being the predominant mode. Patients diagnosed with heart failure during a hospitalization had the highest assessment rates (58% in 1995, 64% in 1999, 69% in 2003, and 73% in 2007). After adjustment for other patient characteristics, odds of assessment were 4 times higher among patients diagnosed in inpatient settings.

Conclusions—Nearly 40% of Medicare beneficiaries do not undergo assessment of left ventricular function when newly diagnosed with heart failure. Quality-improvement strategies are needed to optimize the care of these patients, especially in outpatient settings. (Circ Cardiovasc Qual Outcomes. 2011;4:00-00.)

Key Words: imaging ▪ heart failure ▪ left ventricular function ▪ outcome and process assessment ▪ health care ▪ survival

Assessment of left ventricular function is a critical component of the evaluation of patients with newly diagnosed heart failure. In addition to distinguishing patients with preserved systolic function from those with reduced systolic function, measurement of left ventricular function informs prognosis, guides therapeutic interventions, and establishes a baseline against which to measure the effects of therapy. Accordingly, the American College of Cardiology and the American Heart Association included assessment of left ventricular function in their set of clinical performance measures.1 The inpatient measure requires “documentation in the hospital record that [left ventricular systolic] function was assessed before arrival, during hospitalization, or is planned after discharge”; the outpatient measure requires “documentation that [left ventricular systolic] function has been assessed.” The inpatient measure is 1 of 4 process-based performance measures designated by the Centers for Medicare and Medicaid Services (CMS) and the Joint Commission and is used by CMS and other payers in pay-for-performance programs.1

Studies using quality-improvement registries have reported moderately high rates of compliance with the left ventricular function performance measure. Among 41 147 eligible patients enrolled in the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients With Heart Failure (OPTIMIZE-HF), the performance measure was achieved in 87% of hospitalizations.2 Similarly, an analysis of 159 168 hospitalizations from the Acute Decompensated Heart Failure National Registry (ADHERE) found that assessment of left ventricular function was documented or planned in more than 80% of hospitalizations and increased modestly over time.3 However, little is known about the extent to which left ventricular function is evaluated in real-world settings and how the practice has changed over time. Outpatient settings are of particular interest because they are not addressed by most quality-improvement programs.

Increasing use of diagnostic imaging services among Medicare beneficiaries has garnered substantial attention. From 2000 through 2006, Medicare spending for imaging

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services nearly doubled, and the volume of imaging services per beneficiary grew by 67%. Evidence suggests that growth in the use of cardiovascular imaging has far outpaced growth in noncardiovascular imaging. A recent analysis of Medicare Part B data from 1999 through 2004 found that the use of echocardiography in Medicare beneficiaries increased by 45%, an annualized rate of increase of 7.7%. Together with evidence of substantial geographic variation and a nominal increase in the prevalence of heart failure during the same period, growth patterns suggest that imaging may be overused.

In the context of limited information about the assessment of left ventricular function in real-world inpatient and outpatient settings and concerns about the increasing use of imaging services, we sought to quantify the assessment of left ventricular function in nationally representative cohorts of Medicare beneficiaries with newly diagnosed heart failure in 1995, 1999, 2003, and 2007 and to examine patient characteristics associated with the assessment of left ventricular function.

WHAT IS KNOWN

- Assessment of left ventricular systolic function is a level I guideline recommendation for patients with newly diagnosed heart failure and a performance measure for patients hospitalized with heart failure.
- Little is known about the extent to which left ventricular systolic function is assessed in real-world settings.

WHAT THE STUDY ADDS

- Two of 5 Medicare beneficiaries do not undergo assessment of left ventricular systolic function after a new diagnosis of heart failure.
- Although the proportion of patients who undergo assessment of left ventricular systolic function has increased over time, women, black patients, older patients, and outpatients are the least likely to undergo testing.

Methods

Data Sources

We obtained a 5% national sample of Medicare inpatient, outpatient, and carrier standard analytic files and the corresponding denominator files from CMS for 1991 through 2008. The inpatient files contain institutional claims for facility costs covered under Medicare Part A, and the outpatient files contain claims from institutional outpatient providers (eg, hospital outpatient departments, ambulatory surgery centers). The carrier files contain noninstitutional provider claims for services covered under Medicare Part B. The denominator files contain beneficiary demographic data and information about program eligibility and enrollment. We eliminated invalid records and restricted the analysis to persons 65 years or older living in the United States.

Patients

As described in detail elsewhere, we identified beneficiaries for whom a diagnosis of heart failure (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] code 428.xx, 402.x1, 404.x1, or 404.x3) was reported on a single inpatient claim or at least 3 outpatient claims submitted for services provided on different days within 20 consecutive months. The earlier of the date of the earliest inpatient heart failure diagnosis or the date of the third outpatient or carrier heart failure diagnosis was considered the “incident” date. To be considered an incident case, a beneficiary had to have continuous fee-for-service Medicare eligibility and no qualifying heart failure diagnosis for at least 12 months before the incident date. In addition, we required fee-for-service eligibility for at least 60 days after the incident date or until the death date (if death occurred within 60 days). We retained data for beneficiaries with incident heart failure in 1995, 1999, 2003, and 2007 for the analysis.

Statistical Analysis

We used descriptive statistics to describe the study population in each incident year. We present categorical variables as percentages and continuous variables as means with standard deviations. We used Cochran-Mantel-Haenszel nonzero correlation tests to test for temporal trends. We identified comorbid conditions using validated coding algorithms and searched all inpatient, outpatient, and carrier claims in the 365-day period preceding the incident date for evidence of cerebrovascular disease, chronic obstructive pulmonary disease, dementia, diabetes mellitus, hypertension, ischemic heart disease, metastatic cancer, peripheral vascular disease, and renal disease.

We used Current Procedural Terminology (CPT) codes to identify cardiac tests that could yield a measure of left ventricular function, including rest echocardiography (CPT codes 93307, 93308, and 93312 to 93314), stress echocardiography (93350), rest or stress nuclear test (78459, 78460, 78461, 78464, 78465, 78472, 78473, 78478, 78480, 78481, 78483, 78491, 78492, and 78494), rest or stress cardiac MRI (75552 to 75555), and left heart catheterization (93510 and 93511). For each newly diagnosed beneficiary, we examined claims for evidence of assessment of left ventricular function from 30 days before through 60 days after the incident date. We calculated the proportion of patients who underwent any assessment of left ventricular function in each incident year and the proportion of patients who underwent multiple assessments. We also calculated these proportions among patients with a history of diabetes mellitus (ICD-9-CM code 250.x) or ischemic heart disease (ICD-9-CM codes 410 to 414, 429.2, and V45.81), patients younger than 75 years, and patients with an incident diagnosis of heart failure. In a sensitivity analysis, we replicated the primary analysis after identifying assessments of left ventricular function from 365 days before through 60 days after the incident date. We used Cochran-Mantel-Haenszel nonzero correlation tests to test for trends.

We used logistic regression to identify patient characteristics associated with any assessment of left ventricular function 30 days before through 60 days after the incident date. In multivariable models, we included age, sex, race, comorbid conditions, geographic region, year of incident diagnosis, and an indicator variable noting whether the heart failure was diagnosed in an inpatient setting.

We used SAS software version 9.2 (SAS Institute Inc, Cary, NC) for all analyses. The institutional review board of the Duke University Health System approved the study.

Results

Table 1 shows the baseline characteristics of the 4 cohorts. There were 45 005 patients with incident heart failure in the 1995 cohort, 38 425 in the 1999 cohort, 39 529 in the 2003 cohort, and 32 629 in the 2007 cohort. Mean age was 79 years in all groups. In each cohort year, approximately 8% of the patients with incident heart failure were black and approximately 58% were women. Nearly two-thirds of the patients in each cohort had an incident diagnosis of heart failure in an inpatient setting. With the exception of metastatic cancer, the prevalence of all comorbid conditions increased steadily.
across cohorts during the study. Hypertension was the most frequently documented comorbid condition and increased from 67% of patients in the 1995 cohort to 90% of patients in the 2007 cohort. Close to two-thirds of the patients had a history of ischemic heart disease, approximately one-third had diabetes mellitus, and approximately 40% had chronic obstructive pulmonary disease.

As shown in Table 2, the proportion of patients who underwent an assessment of left ventricular function in the 30 days before through 60 days after the incident date increased with each cohort year (from 46% in 1995 to 60% in 2007). The predominant mode of testing was rest echocardiography. Among other tests that may provide information on left ventricular function, stress echocardiography and cardiac MRI were not commonly used and the proportion of patients who underwent these tests remained steady during the study period. Nuclear tests were more commonly used than left heart catheterization, though both increased steadily during the study period. By 2007, 12% of patients had a nuclear test and 9% underwent left heart catheterization. From 1995 through 2007, the use of multiple tests in the 30 days before through 60 days after diagnosis increased from 14% to 23%.

Among patients with a history of diabetes mellitus, the proportion of patients who underwent assessment of left ventricular function increased from 49% in 1995 to 61% in 2007 (P<0.001), and there was a similar increase among patients with a history of ischemic heart disease (52% in 1995 to 65% in 2007; P<0.001). Although the proportion of patients 75 years or older who had tests was low, this group experienced the largest increase in testing during the study period, from 42% in 1995 to 59% in 2007. In contrast, the proportion of patients who underwent testing was lowest among patients diagnosed on the basis of outpatient claims alone. In 2007, 39% were tested in the 30 days before through 60 days after the incident date. Patients diagnosed with heart failure during a hospitalization had the highest rate of assessment among any of the subgroups examined. By 2007, 73% of patients with an inpatient diagnosis were tested in the peri-incident window and, among those for whom heart failure was the primary inpatient diagnosis, 85% underwent assessment of left ventricular function.

In a sensitivity analysis in which we expanded the testing window to 365 days before through 60 days after the incident date, the proportion of patients who underwent an assessment of left ventricular function increased from 46% in 1995 to 60% in 2007, with similar results for other subgroups.

Table 1. Baseline Characteristics of the Study Population

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1995 (n=45,005)</th>
<th>1999 (n=38,425)</th>
<th>2003 (n=39,529)</th>
<th>2007 (n=32,629)</th>
<th>P Value for Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>79.1 (7.8)</td>
<td>79.2 (7.8)</td>
<td>79.1 (7.8)</td>
<td>79.6 (8.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td>65–69 years</td>
<td>5715 (12.7)</td>
<td>4838 (12.6)</td>
<td>5229 (13.2)</td>
<td>4416 (13.5)</td>
<td></td>
</tr>
<tr>
<td>70–74 years</td>
<td>8518 (18.9)</td>
<td>6999 (18.2)</td>
<td>7083 (17.9)</td>
<td>5292 (16.2)</td>
<td></td>
</tr>
<tr>
<td>75–79 years</td>
<td>9587 (21.3)</td>
<td>8377 (21.8)</td>
<td>8359 (21.1)</td>
<td>6365 (19.5)</td>
<td></td>
</tr>
<tr>
<td>≥80 years</td>
<td>21 185 (47.1)</td>
<td>18 211 (47.4)</td>
<td>18 858 (47.7)</td>
<td>16 556 (50.7)</td>
<td></td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>18 495 (41.1)</td>
<td>15 797 (41.1)</td>
<td>16 867 (42.7)</td>
<td>14 071 (43.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Race, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.09</td>
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<tr>
<td>Black</td>
<td>3788 (8.4)</td>
<td>3166 (8.2)</td>
<td>3404 (8.6)</td>
<td>2569 (7.9)</td>
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</tr>
<tr>
<td>Nonblack</td>
<td>41 217 (91.6)</td>
<td>35 259 (91.8)</td>
<td>36 125 (91.4)</td>
<td>30 060 (92.1)</td>
<td></td>
</tr>
<tr>
<td>Inpatient diagnosis of heart failure, n</td>
<td>28 714 (63.8)</td>
<td>22 928 (59.7)</td>
<td>24 990 (63.2)</td>
<td>20 529 (62.9)</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Comorbid conditions, n (%)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1995 (n=45,005)</th>
<th>1999 (n=38,425)</th>
<th>2003 (n=39,529)</th>
<th>2007 (n=32,629)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebrovascular disease</td>
<td>12 173 (27.0)</td>
<td>11 523 (30.0)</td>
<td>12 628 (31.9)</td>
<td>11 080 (34.0)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>17 505 (38.9)</td>
<td>15 925 (41.4)</td>
<td>17 943 (45.4)</td>
<td>15 420 (47.3)</td>
</tr>
<tr>
<td>Dementia</td>
<td>4325 (9.6)</td>
<td>4329 (11.3)</td>
<td>4783 (12.1)</td>
<td>4225 (12.9)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>12 781 (28.4)</td>
<td>12 219 (31.8)</td>
<td>14 585 (36.9)</td>
<td>13 301 (40.8)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>30 007 (66.7)</td>
<td>29 094 (75.7)</td>
<td>33 257 (84.1)</td>
<td>29 267 (89.7)</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>27 790 (61.7)</td>
<td>23 935 (62.3)</td>
<td>25 074 (63.4)</td>
<td>20 644 (63.3)</td>
</tr>
<tr>
<td>Metastatic solid tumor</td>
<td>2091 (4.6)</td>
<td>1697 (4.4)</td>
<td>1753 (4.4)</td>
<td>1491 (4.6)</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>11 670 (25.9)</td>
<td>10 581 (27.5)</td>
<td>12 398 (31.4)</td>
<td>11 493 (35.2)</td>
</tr>
<tr>
<td>Renal disease</td>
<td>3745 (8.3)</td>
<td>3714 (9.7)</td>
<td>5591 (14.1)</td>
<td>7577 (23.2)</td>
</tr>
<tr>
<td>US geographic region, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>12 307 (27.3)</td>
<td>10 478 (27.3)</td>
<td>10 497 (26.6)</td>
<td>8 369 (25.6)</td>
</tr>
<tr>
<td>Northeast</td>
<td>10 195 (22.7)</td>
<td>8164 (21.3)</td>
<td>7837 (19.8)</td>
<td>6 669 (20.4)</td>
</tr>
<tr>
<td>South</td>
<td>16 590 (36.9)</td>
<td>14 707 (38.3)</td>
<td>15 614 (39.5)</td>
<td>12 588 (38.6)</td>
</tr>
<tr>
<td>West</td>
<td>5913 (13.1)</td>
<td>5056 (13.2)</td>
<td>5581 (14.1)</td>
<td>5003 (15.3)</td>
</tr>
</tbody>
</table>
Table 2. Assessment of Left Ventricular Function by Incident Cohort

<table>
<thead>
<tr>
<th>Subgroup and Assessment Type</th>
<th>1995</th>
<th>1999</th>
<th>2003</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, n</td>
<td>45 005</td>
<td>38 425</td>
<td>39 529</td>
<td>32 629</td>
</tr>
<tr>
<td>Any assessment, n (%)</td>
<td>20 677 (45.9)</td>
<td>19 853 (51.7)</td>
<td>22 625 (57.2)</td>
<td>19 695 (60.4)</td>
</tr>
<tr>
<td>Rest echocardiogram</td>
<td>19 038 (42.3)</td>
<td>18 189 (47.3)</td>
<td>20 850 (52.7)</td>
<td>18 334 (56.2)</td>
</tr>
<tr>
<td>Stress echocardiogram</td>
<td>364 (0.8)</td>
<td>475 (1.2)</td>
<td>439 (1.1)</td>
<td>295 (0.9)</td>
</tr>
<tr>
<td>Nuclear test</td>
<td>3768 (8.4)</td>
<td>3746 (9.7)</td>
<td>4688 (11.9)</td>
<td>3858 (11.8)</td>
</tr>
<tr>
<td>Cardiac MRI</td>
<td>23 (0.1)</td>
<td>51 (0.2)</td>
<td>2945 (9.0)</td>
<td>7388 (22.6)</td>
</tr>
<tr>
<td>Left heart catheterization</td>
<td>2628 (5.8)</td>
<td>2899 (7.5)</td>
<td>3602 (9.1)</td>
<td>2473 (7.2)</td>
</tr>
<tr>
<td>≥2 assessments, n (%)</td>
<td>6470 (14.4)</td>
<td>6640 (17.3)</td>
<td>8479 (21.5)</td>
<td>7388 (22.6)</td>
</tr>
<tr>
<td>With diabetes mellitus, n</td>
<td>12 781 12 219</td>
<td>14 585 13 301</td>
<td>23 (0.1)</td>
<td>51 (0.2)</td>
</tr>
<tr>
<td>Any assessment, n (%)</td>
<td>6310 (49.4)</td>
<td>5686 (54.7)</td>
<td>8567 (58.7)</td>
<td>8095 (60.9)</td>
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<tr>
<td>Rest echocardiogram</td>
<td>5751 (45.0)</td>
<td>6062 (47.3)</td>
<td>7843 (53.8)</td>
<td>7467 (56.1)</td>
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<tr>
<td>Stress echocardiogram</td>
<td>120 (0.9)</td>
<td>180 (1.5)</td>
<td>167 (1.1)</td>
<td>121 (0.9)</td>
</tr>
<tr>
<td>Nuclear test</td>
<td>3768 (10.4)</td>
<td>3746 (9.7)</td>
<td>4688 (11.9)</td>
<td>3858 (11.8)</td>
</tr>
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<td>Cardiac MRI</td>
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<td>6640 (17.3)</td>
<td>8479 (21.5)</td>
<td>7388 (22.6)</td>
</tr>
<tr>
<td>With ischemic heart disease, n</td>
<td>27 790</td>
<td>23 935</td>
<td>25 074</td>
<td>20 644</td>
</tr>
<tr>
<td>Any assessment, n (%)</td>
<td>14 524 (52.3)</td>
<td>13 708 (57.3)</td>
<td>15 566 (62.1)</td>
<td>13 319 (64.5)</td>
</tr>
<tr>
<td>Rest echocardiogram</td>
<td>13 093 (47.1)</td>
<td>12 265 (51.2)</td>
<td>14 068 (56.1)</td>
<td>12 188 (59.0)</td>
</tr>
<tr>
<td>Stress echocardiogram</td>
<td>296 (1.1)</td>
<td>366 (1.5)</td>
<td>323 (1.3)</td>
<td>211 (1.0)</td>
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<tr>
<td>Nuclear test</td>
<td>3063 (11.0)</td>
<td>2890 (12.5)</td>
<td>3599 (14.4)</td>
<td>2930 (14.2)</td>
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<td>Cardiac MRI</td>
<td>42 (0.2)</td>
<td>11 (0.1)</td>
<td>26 (0.2)</td>
<td>20 (0.2)</td>
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<tr>
<td>Left heart catheterization</td>
<td>2490 (9.0)</td>
<td>2713 (11.3)</td>
<td>3388 (13.5)</td>
<td>2743 (13.3)</td>
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<tr>
<td>≥2 assessments, n (%)</td>
<td>5283 (19.4)</td>
<td>5312 (22.2)</td>
<td>6741 (26.9)</td>
<td>5779 (28.0)</td>
</tr>
<tr>
<td>Age ≥75 years, n</td>
<td>30 772 26 588</td>
<td>27 217 22 921</td>
<td>23 (0.1)</td>
<td>51 (0.2)</td>
</tr>
<tr>
<td>Any assessment, n (%)</td>
<td>12 982 (42.2)</td>
<td>13 085 (49.2)</td>
<td>15 043 (55.3)</td>
<td>13 599 (59.3)</td>
</tr>
<tr>
<td>Rest echocardiogram</td>
<td>12 192 (43.6)</td>
<td>12 220 (46.0)</td>
<td>14 063 (51.7)</td>
<td>12 843 (56.0)</td>
</tr>
<tr>
<td>Stress echocardiogram</td>
<td>185 (0.6)</td>
<td>237 (0.9)</td>
<td>246 (0.9)</td>
<td>164 (0.7)</td>
</tr>
<tr>
<td>Nuclear test</td>
<td>1880 (6.1)</td>
<td>2035 (7.7)</td>
<td>2750 (10.1)</td>
<td>2304 (10.1)</td>
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<td>Cardiac MRI</td>
<td>42 (0.2)</td>
<td>11 (0.1)</td>
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<td>6741 (26.9)</td>
<td>5779 (28.0)</td>
</tr>
<tr>
<td>Inpatient heart failure diagnosis, n</td>
<td>28 714</td>
<td>22 928</td>
<td>24 990</td>
<td>20 529</td>
</tr>
<tr>
<td>Any assessment, n (%)</td>
<td>16 649 (58.0)</td>
<td>14 640 (63.9)</td>
<td>17 205 (68.8)</td>
<td>14 946 (72.8)</td>
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<td>Rest echocardiogram</td>
<td>15 419 (53.7)</td>
<td>13 555 (59.1)</td>
<td>16 094 (64.4)</td>
<td>14 140 (68.9)</td>
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<td>Stress echocardiogram</td>
<td>253 (0.9)</td>
<td>302 (1.3)</td>
<td>269 (1.1)</td>
<td>198 (1.0)</td>
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<tr>
<td>Nuclear test</td>
<td>3016 (10.5)</td>
<td>2631 (11.5)</td>
<td>3263 (13.1)</td>
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<td>Cardiac MRI</td>
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<td>3388 (13.5)</td>
<td>2743 (13.3)</td>
</tr>
<tr>
<td>≥2 assessments, n (%)</td>
<td>5283 (19.4)</td>
<td>5312 (22.2)</td>
<td>6741 (26.9)</td>
<td>5779 (28.0)</td>
</tr>
<tr>
<td>Outpatient heart failure diagnosis, n</td>
<td>16 291</td>
<td>15 497</td>
<td>14 539</td>
<td>12 100</td>
</tr>
<tr>
<td>Any assessment, n (%)</td>
<td>40 284 (24.7)</td>
<td>5213 (33.6)</td>
<td>5420 (37.3)</td>
<td>4749 (39.2)</td>
</tr>
<tr>
<td>Rest echocardiogram</td>
<td>36 192 (22.2)</td>
<td>4634 (29.9)</td>
<td>4756 (32.7)</td>
<td>4194 (34.7)</td>
</tr>
<tr>
<td>Stress echocardiogram</td>
<td>111 (0.7)</td>
<td>173 (1.1)</td>
<td>170 (1.2)</td>
<td>97 (0.8)</td>
</tr>
<tr>
<td>Nuclear test</td>
<td>752 (4.6)</td>
<td>1115 (7.2)</td>
<td>1425 (9.8)</td>
<td>1249 (10.3)</td>
</tr>
<tr>
<td>Cardiac MRI</td>
<td>42 (0.2)</td>
<td>11 (0.1)</td>
<td>26 (0.2)</td>
<td>20 (0.2)</td>
</tr>
<tr>
<td>Left heart catheterization</td>
<td>2490 (9.0)</td>
<td>2713 (11.3)</td>
<td>3388 (13.5)</td>
<td>2743 (13.3)</td>
</tr>
<tr>
<td>≥2 assessments, n (%)</td>
<td>5283 (19.4)</td>
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<td>6741 (26.9)</td>
<td>5779 (28.0)</td>
</tr>
</tbody>
</table>

Values not shown for cell sizes <11.
diagnosis, the proportion of patients who underwent testing increased in all categories except cardiac MRI. In the wider window, the proportion of patients who underwent any assessment of left ventricular function increased from 59% in 1995 to 79% in 2007. Among patients diagnosed on the basis of outpatient claims alone, the proportion increased from 45% (7313/16 291) in 1995 to 70% (8507/12 100) in 2007. The use of nuclear testing nearly doubled from 14% in 1995 to 25% in 2007. From 1995 to 2007, the proportion of patients with multiple assessments in the 365 days before through 60 days after the incident diagnosis increased from 25% to 44%. The increase in multiple assessments was most pronounced among patients diagnosed as outpatients, from 17% (2763/16 291) in 1995 to 39% (4673/12 100) in 2007. In contrast to the roughly 30% greater use of testing in most subgroups, expansion of the testing window among patients diagnosed as inpatients resulted in a relative increase of ~15% over the estimate in the narrower peri-incident window. Expansion of the testing window among patients diagnosed in outpatient settings nearly doubled the proportion of patients who underwent testing in 2007, from 39% to 70% (8507/12 100).

Controlling for age, sex, race, geographic region, incident cohort year, and baseline comorbid conditions, the odds of assessment of left ventricular function were 4 times higher among patients diagnosed in inpatient settings than among patients diagnosed in outpatient settings (Table 3). The odds of undergoing assessment of left ventricular function were higher among men and patients with a history of ischemic heart disease. Dementia, older age, and black race were associated with significantly lower odds of testing. Among patients living in the northeastern United States, the odds of assessment were 23% higher than among patients in the western United States.

### Discussion

Assessment of left ventricular function in patients with symptoms of heart failure differentiates systolic from diastolic dysfunction and guides therapeutic interventions with proven benefit, including angiotensin-converting enzyme inhibitors and β-blockers in patients with systolic dysfunction. Therefore, it is widely recognized as a critical component of the initial evaluation of heart failure and is included in clinical performance measures sets broadly endorsed by professional societies, quality-improvement organizations, and payers. Despite evidence of rapid growth and possible overuse of cardiovascular imaging services, we found that 40% of patients with newly diagnosed heart failure in 2007 had no assessment of left ventricular function in the 30 days before through 60 days after the incident diagnosis. The proportion of patients undergoing testing was also low among patients with a history of diabetes mellitus or ischemic heart disease and among outpatients. The proportion was highest among patients hospitalized with a primary diagnosis of heart failure. In contrast to previous studies, these findings reflect the spectrum of providers who care for a nationally representative sample of Medicare beneficiaries.

Previous estimates of compliance with the recommendation for assessment of left ventricular function vary. In the OPTIMIZE-HF registry, hospital records documented that left ventricular function had been assessed before arrival or during the hospitalization or was planned after discharge in nearly 90% of patients hospitalized with heart failure.² Our findings are similar in that 85% of patients with a primary inpatient diagnosis of heart failure were assessed during the peri-incident period. However, the proportion of patients who underwent testing was lower (73%) among patients hospitalized with a heart failure diagnosis in any position on the claim. A community-based analysis of patients receiving an initial diagnosis of heart failure in Olmsted County found that 63% of patients underwent echocardiography alone within 3 weeks before or after the initial diagnosis, including 74% of inpatients and 40% of outpatients.10 Our overall estimate was similar (60%), as were the rates of assessment in inpatients and outpatients. However, our analysis included a longer window (ie, 30 days before through 60 days after the incident diagnosis) and a broader range of imaging studies that could yield a measure of ejection fraction. Suboptimal assessment was also noted in the Valsartan in Acute Myocardial Infarc-

### Table 3. Predictors of Assessment of Left Ventricular Function

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 65–69 years</td>
<td>1.00 [Reference]</td>
</tr>
<tr>
<td>Age 70–74 years</td>
<td>1.04 (1.00–1.08)</td>
</tr>
<tr>
<td>Age 75–79 years</td>
<td>0.96 (0.92–1.00)</td>
</tr>
<tr>
<td>Age ≥80 years</td>
<td>0.72 (0.69–0.74)</td>
</tr>
<tr>
<td>Male sex</td>
<td>1.13 (1.10–1.15)</td>
</tr>
<tr>
<td>Race Black</td>
<td>0.91 (0.87–0.95)</td>
</tr>
<tr>
<td>Race Nonblack</td>
<td>1.00 [Reference]</td>
</tr>
<tr>
<td>Inpatient diagnosis of heart failure</td>
<td>4.04 (3.95–4.13)</td>
</tr>
<tr>
<td>Comorbid conditions</td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>0.94 (0.92–0.97)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>1.01 (0.99–1.03)</td>
</tr>
<tr>
<td>Dementia</td>
<td>0.47 (0.46–0.49)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.00 (0.98–1.02)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.09 (1.07–1.13)</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>1.58 (1.54–1.61)</td>
</tr>
<tr>
<td>Metastatic solid tumor</td>
<td>0.70 (0.67–0.74)</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>0.90 (0.88–0.92)</td>
</tr>
<tr>
<td>Renal disease</td>
<td>1.01 (0.98–1.05)</td>
</tr>
<tr>
<td>US geographic region</td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>1.08 (1.04–1.12)</td>
</tr>
<tr>
<td>Northeast</td>
<td>1.23 (1.18–1.12)</td>
</tr>
<tr>
<td>South</td>
<td>1.06 (1.03–1.10)</td>
</tr>
<tr>
<td>West</td>
<td>1.00 [Reference]</td>
</tr>
<tr>
<td>Incident year</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>1.00 [Reference]</td>
</tr>
<tr>
<td>1999</td>
<td>1.40 (1.35–1.44)</td>
</tr>
<tr>
<td>2003</td>
<td>1.72 (1.66–1.77)</td>
</tr>
<tr>
<td>2007–2008</td>
<td>2.03 (1.97–2.10)</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; OR, odds ratio. C statistic, 0.72.
tion Trial (VALIANT) and the Global Registry of Acute Coronary Events (GRACE). In VALIANT, an international registry of patients with myocardial infarction complicated by heart failure or left ventricular systolic dysfunction, 60% of patients with heart failure at admission underwent cardiac catheterization or echocardiography during hospitalization.\textsuperscript{11} Of patients who presented with heart failure in GRACE—an international registry of patients admitted for acute coronary syndromes—71% had left ventricular ejection fraction measured during the hospital stay.\textsuperscript{12}

Other findings are also noteworthy. First, the proportion of patients who underwent assessment of left ventricular function increased steadily during the study period. Overall, the proportion increased by approximately 15 percentage points from 1995 through 2007, perhaps reflecting a growing emphasis on clinical performance measures and adherence to evidence-based guidelines. The proportion also increased among patients with documented coronary heart disease, and a history of ischemic heart disease was associated with a 58% increase in the odds of undergoing peri-diagnostic assessment of left ventricular function. Of note, the proportion of patients who had multiple assessments nearly doubled from 1995 through 2007. It is unclear whether this finding reflects a lack of coordination among care providers, fear of medical malpractice claims, exploration of cardiac abnormalities other than ejection fraction, or a less stable heart failure population.

Second, the proportion of patients who did not undergo assessment of left ventricular function decreased by half (from 40% to 21% in 2007) when we expanded the testing window to 365 days before through 60 days after the incident diagnosis. Criteria for appropriate use deem routine annual evaluations of ejection fraction to be inappropriate in the absence of a change in clinical status.\textsuperscript{13} Adherence to these criteria would suggest that stable patients need not have a repeat study, which could explain why the percentage of patients who did not undergo testing dropped measurably when the testing window was expanded. Assuming that patients diagnosed on the basis of outpatient claims alone were, in fact, stable, it is noteworthy that 30% had no assessment of ventricular function even during the expanded testing window.

In contrast, a hospital admission with a new primary diagnosis of heart failure can reasonably be assumed to be a surrogate for clinical instability, and the appropriate use criteria would suggest that a repeat study is indicated. However, among even these patients in 2007, 15% did not receive either an initial assessment or a repeat assessment of left ventricular function in the 30 days before through 60 days after the inpatient diagnosis.

Patients whose diagnosis of heart failure occurred during an inpatient stay had 4 times the odds of undergoing assessment of left ventricular function than did patients diagnosed in outpatient settings. Although this finding may reflect the availability of diagnostic equipment and expertise, as well as “sicker” patients, it may also reflect the influence of established inpatient care maps and care processes incorporating evidence-based care. The high level of compliance reported in OPTIMIZE-HF probably represents an upper bound of compliance in “best practice” sites, but the inpatient rate we observed may reflect an upper bound of compliance in the overall community. The differential use among hospitalized patients as compared with outpatients, as well as increases over time, suggests that hospital-based quality-improvement efforts have achieved some success.

Our analysis has some limitations. First, we identified incident heart failure using ICD-9-CM diagnosis codes recorded in Medicare claims data, not medical chart review. Although we relied on a validated claims-based algorithm,\textsuperscript{14} such algorithms may misclassify prevalent cases as incident.\textsuperscript{15} Second, we only included Medicare beneficiaries 65 years or older with fee-for-service coverage, so the results may not be generalizable to managed-care beneficiaries or to all patients with heart failure. Third, claims data do not include detailed clinical information, so we were unable to assess the severity of heart failure or other comorbid illnesses. Fourth, because assessment of left ventricular function is common, the odds ratios from the logistic regression probably overestimate the relative risks. Fifth, because we used administrative data, we could not determine whether the imaging tests truly assessed and reported left ventricular function. For example, some left heart catheterizations may have included coronary angiography only and not ventriculography. However, to the extent that this occurred, the true proportion of patients who underwent assessment would be lower than we observed. Moreover, we assumed that tests performed were coded correctly in the administrative data. Finally, our analysis could not address whether the increased use of imaging over time was appropriate and was associated with improved patient outcomes or merely reflected an improvement in coding. The analysis is strengthened, however, by the use of a nationally representative sample of Medicare beneficiaries and longitudinal information about care received during a 13-year period.

In summary, nearly 40% of Medicare beneficiaries do not undergo assessment of left ventricular function after a diagnosis of new-onset heart failure, despite broad consensus that this approach represents the standard of care. These findings reflect the spectrum of providers who care for a nationally representative sample of Medicare beneficiaries. Although the proportion of patients who undergo left ventricular assessment has risen over time, women, black patients, older patients, and outpatients are least likely to undergo testing. Growth in the use and costs of imaging services are urgent concerns for policy makers and the health care community, but this study suggests that some imaging services with proven benefit may be underused. Quality-improvement programs, particularly in outpatient settings, may be useful in eliminating disparities and optimizing imaging use and the care of patients with heart failure.

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References
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