Variation in Use of Left Ventriculography in the Veterans Affairs Health Care System

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Background—Contrast left ventriculography is a method of measuring left ventricular function usually performed at the discretion of the invasive cardiologist during cardiac catheterization. We sought to determine variation in the use of left ventriculography in the Veterans Affairs (VA) Health Care System.

Methods and Results—We identified adult patients who underwent cardiac catheterization including coronary angiography between 2000 and 2009 in the VA Health Care System. We determined patient and hospital predictors of the use of left ventriculography as well as the variation in use across VA facilities. Results were validated using data from the VA's Clinical Assessment, Reporting, and Tracking (CART) program. Of 457,170 cardiac catheterization procedures among 336,853 patients, left ventriculography was performed on 263,695 (58%) patients. Use of left ventriculography decreased over time (64% in 2000 to 50% in 2009) and varied markedly across facilities (<1–95% of cardiac catheterizations). Patient factors explained little of the large variation in use between facilities. When the cohort was restricted to those with an echocardiogram in the prior 30 days and no intervening event, left ventriculography was still performed in 50% of cases.

Conclusions—There is large variation in the use of left ventriculography across VA facilities that is not explained by patient characteristics. (Circ Cardiovasc Qual Outcomes. 2013;6:00-00.)

Key Words: cardiac catheterization ■ cardiac imaging techniques ■ small-area analysis

Left ventriculography, imaging of the left ventricle with a contrast injection, was one of the first methods of measuring left ventricular function and wall motion and is usually performed at the discretion of the cardiologist during cardiac catheterization (eg, coronary angiography). The procedure may increase reimbursement, although the amount is small compared with the reimbursement for coronary angiography. The invasive nature of left ventriculography, including need for arterial access, contrast dye, and radiation, has led many clinicians to favor other measures of ventricular function such as echocardiography, nuclear scintigraphy, and magnetic resonance imaging (MRI), which are less invasive. A recent study found that left ventriculography is used in the community in 80% of cardiac catheterization procedures despite the lack of clinical guidelines recommending the procedure for particular clinical scenarios. Although clinical practice guidelines have been published for performance of coronary angiography and left heart catheterization, they do not directly address the use of left ventriculography.

The purpose of this study was to examine the current use of left ventriculography during cardiac catheterization in the VA, a healthcare system without financial incentives to perform additional procedures. In particular, we sought to determine the variation in use across all hospitals performing cardiac catheterization in the VA Health Care System and to see whether any observed variation in left ventriculography use was explained by patient or hospital characteristics.

Methods

Patient Population
We identified adult patients (≥18 years of age) undergoing cardiac catheterization in the years 2000 to 2009 in the VA Health Care System. Thus, a patient could be included in >1 year’s cohort but only once for any given year. This design allows comparisons of use across years. The population also included patients treated at non-VA facilities where care was paid by the VA. Cardiac catheterization was defined as any of the following International Classification of Diseases, Ninth Revision (ICD-9) procedure codes (3722, 3723, 8853–8858) or Current Procedural Terminology (CPT) codes (93510, 93511, 93555, 93543, 91920, 93539, 93540, 93545, 93556, 93508). The study was approved by the institutional review board at Stanford University.

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WHAT IS KNOWN

- Left ventriculography can be used during coronary angiography to evaluate left ventricular function.
- The procedure is performed at the discretion of the physician performing angiography.
- In a study of patients with private insurance, the procedure was performed over 80% of the time an angiography was performed.

WHAT THE STUDY ADDS

- In the Veterans Affairs system, left ventriculography was performed during 58% of coronary angiography cases but varied markedly across facilities (<1%–95% of cases).
- These findings suggest wide variation in views among invasive cardiologists regarding the appropriateness of left ventriculography.

Left Ventriculography

Left ventriculography was defined as one of the following codes (ICD-9 8853, 8854, CPT 93543) occurring on the same day as the cardiac catheterization.

Prior Ejection Fraction Measurement

An ejection fraction measurement was defined as echocardiography (CPT 93306, 93307, 93308, 93312, 93314, 93350), cardiac nuclear scintigraphy for ejection fraction (CPT 78468, 78472, 78473, 78480, 78481, 78483), and cardiac MRI (CPT 75552–75555, 75557–75564). We calculated the frequency of an ejection fraction measurement in the prior 30 and 90 days before cardiac catheterization.

Diagnoses and Procedures

Prior inpatient and outpatient claims were used to determine ICD-9 diagnoses for diabetes mellitus (250.0–250.3, 250.7), hypertension (401–405), heart failure (428, 429.3, 402.01, 402.11, 402.91, 425), renal failure (582, 583, 585, 586, 588), hypotension (458, 758.5), acute myocardial infarction (410, 412), ischemic heart disease (410–414), and cerebrovascular disease (430–438). To estimate the number of patients with a change in clinical status between a noninvasive measurement of ejection fraction and cardiac catheterization, we determined the frequency of inpatient encounters for heart failure, ischemic heart disease, or hypotension. The use of percutaneous coronary intervention on the same day as left ventriculography and within the subsequent week was determined.

Facility Characteristics

VA complexity was graded as tertiary or nontertiar care. Bed size, membership in the Council on Teaching Hospitals, geographic location, and presence of program accredited by the Accreditation Council for Graduate Medical Education program were determined from American Hospital Association data.

Creatinine Measurement

Baseline creatinine levels were determined for patients undergoing cardiac catheterization in VA facilities by using the creatinine value closest to the date of cardiac catheterization that was no more than 2 days before the cardiac catheterization. Follow-up peak creatinine values were determined using the highest value that was documented during the 7 days after cardiac catheterization. We used the definition of contrast-induced acute kidney injury of a rise in creatinine of ≥20.5 mg/dL or a 25% increase from baseline.5–7

Validation of Administrative With Clinical Data

We validated the administrative data using clinical data from the VA Clinical Assessment, Reporting, and Tracking (CART) program, a national clinical quality initiative. The program uses a clinical software application embedded in the VA electronic health record designed to collect standardized data on all coronary angiograms and percutaneous coronary interventions in all catheterization laboratories throughout the VA. CART began capturing complete data in 2008, so we could only validate those procedures performed from 2008 to 2010. CART data were available for >90% of catheterization laboratory facilities during this time period, although some facilities were not entering consecutive patients.

Statistics

We determined the use of left ventriculography during cardiac catheterization for different VA facilities, patient characteristics, and hospital subgroups. The frequency of left ventriculography was also stratified by a recent measure of ejection fraction excluding those with an intervening inpatient encounter for heart failure, acute myocardial infarction, or hypotension. Pearson χ² analysis was used to evaluate categorical variables, and t tests were used to evaluate differences in continuous variables. Pearson correlation was used to determine the association between rates of left ventriculography for VA facilities and the local non-VA facilities that they reimburse for care.

We created multivariate models to determine those patient and provider factors significantly associated with left ventriculography use. This evaluation used generalized estimating equations that control for clustering of patients within facilities. Variables used in the model were year of the procedure, location (outpatient versus inpatient), age, sex, recent test for measure of ejection fraction, baseline creatinine ≥1.5 mg/dL, baseline blood urea nitrogen ≥30 mg/dL, performance of percutaneous coronary intervention the same day, history of diabetes mellitus, hypertension, acute myocardial infarction, ischemic heart disease, cerebrovascular disease, heart failure, renal dysfunction, and shock/hypotension. In addition, we included use of each of the following medications in the prior 6 months as separate variables: angiotensin-converting enzyme inhibitor, angiotensin receptor blocker, β-blocker, calcium antagonists, statin, and nonstatin lipid-lowering agent. Hospital level variables included membership in the Council on Teaching Hospitals, accreditation for graduate medical education, facility type (VA facility versus non-VA but paid by the VA), facility level (tertiary versus other as defined by the VA), quartile based on number of catheterization procedures per year, and region of the country (East, Midwest South, and West).

In a secondary analysis, we used sequential logistic regression models to determine the χ² of the facility identifier (fixed effect) with and without patient characteristics. Model discrimination was evaluated using the c-statistic.

We created a similar multivariate model with the above listed covariates to evaluate the association between left ventriculography use and acute kidney injury as defined above. For the model of acute kidney injury, we included all variables listed above as controls regardless of significance. These generalized estimating equation models (of left ventriculography use and acute kidney injury) control for clustering of patients within facilities. For multivariate analyses, variables with missing values were assigned the mean or most common value. Nonlaboratory patient data were missing in <1%. American Hospital Association data were missing in 1.9%. For categorical laboratory data (missing before 2002), we created a separate category of missing. A 2-sided P value <0.05 was considered statistically significant. All analyses were conducted using SAS 9.1 (Cary, NC).

Results

Patient Characteristics

We identified 457,170 cardiac catheterizations among 336,153 patients in the VA Health Care System from 2000 to 2009. The
The mean age of those undergoing cardiac catheterization was 64 years, and 98% were male (Table 1).

### Use of Left Ventriculography During Cardiac Catheterization

Left ventriculography was performed during 263,715 (58%) cardiac catheterizations. Patients undergoing left ventriculography were slightly older and had less hypertension, heart failure, renal failure, diabetes mellitus, and cerebrovascular disease than patients not undergoing left ventriculography (Table 1). Left ventriculography was less likely to be performed if a percutaneous coronary intervention was performed the same day. The use of left ventriculography decreased steadily during the decade from 64% in 2000 to 50% in 2009 (Figure 1; *P* <0.001 for trend). However, there was marked variation in the use of left ventriculography across facilities (Figure 2), with some using the test in <1% and others in >95% of cardiac catheterizations.

### Validation of Administrative Data With Clinical Database

We examined clinical data from the VA CART program from 2008 to 2010. Overall rates of left ventriculography use were similar to estimates from administrative data during the periods of overlapping data (2008 and 2009; Figure 1). The CART data indicated that the decline in left ventriculography

### Table 1. Characteristics of Patients Who Did and Did Not Undergo Left Ventriculography

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Left Ventriculography</th>
<th>No Left Ventriculography</th>
<th><em>P</em> Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n (% of total)</td>
<td>457,170</td>
<td>263,715 (58)</td>
<td>193,455 (42)</td>
<td></td>
</tr>
<tr>
<td>Age, y, mean±SD</td>
<td>63.4±10</td>
<td>64.3±10</td>
<td>63.3±10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male sex, no. (%)</td>
<td>446,024 (98)</td>
<td>256,975 (97)</td>
<td>189,049 (98)</td>
<td></td>
</tr>
<tr>
<td>Prior diagnoses, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>156,358 (34)</td>
<td>89,565 (34)</td>
<td>66,793 (35)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>426,950 (93)</td>
<td>245,956 (93)</td>
<td>180,994 (94)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension</td>
<td>392,021 (86)</td>
<td>223,889 (85)</td>
<td>168,132 (87)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Heart failure</td>
<td>144,514 (32)</td>
<td>78,654 (30)</td>
<td>65,860 (34)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Renal failure</td>
<td>49,506 (11)</td>
<td>23,004 (9)</td>
<td>26,502 (14)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>193,653 (42)</td>
<td>109,050 (41)</td>
<td>84,603 (44)</td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>77,243 (17)</td>
<td>42,758 (16)</td>
<td>34,485 (18)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PCI same day</td>
<td>90,423 (20)</td>
<td>41,418 (16)</td>
<td>49,005 (25)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Medications**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Left Ventriculography</th>
<th>No Left Ventriculography</th>
<th><em>P</em> Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE inhibitor</td>
<td>195,910 (43)</td>
<td>108,159 (41)</td>
<td>87,751 (45)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Angiotensin receptor blocker</td>
<td>29,990 (6.5)</td>
<td>15,512 (5.9)</td>
<td>14,488 (7.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>β-Blocker</td>
<td>242,362 (53)</td>
<td>132,159 (50)</td>
<td>110,203 (57)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Statin</td>
<td>240,671 (53)</td>
<td>132,156 (50)</td>
<td>108,515 (56)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Calcium antagonist</td>
<td>108,005 (24)</td>
<td>59,012 (22)</td>
<td>48,993 (25)</td>
<td></td>
</tr>
</tbody>
</table>

**Laboratory**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Left Ventriculography</th>
<th>No Left Ventriculography</th>
<th><em>P</em> Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUN ≥30 mg/dL*</td>
<td>36,793 (11)</td>
<td>16,863 (9)</td>
<td>19,930 (13)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Creatinine ≥1.5 mg/dL*</td>
<td>51,941 (15)</td>
<td>23,105 (12)</td>
<td>28,836 (19)</td>
<td></td>
</tr>
</tbody>
</table>

ACE indicates angiotensin-converting enzyme, BUN, blood urea nitrogen, and PCI, percutaneous coronary intervention.

*BUN and creatinine unavailable in years 2000 to 2002.

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**Figure 1.** Use of left ventriculography is shown from 2000 to 2010. Use decreased steadily over time from 64% in 2000 to 50% in 2009 (*P* <0.001 for trend). Data from the clinical catheterization laboratory database confirmed the administrative data findings and suggest that the decline in use extends to 2010. LV indicates left ventricular.

**Figure 2.** The distribution of left ventriculography use is displayed for each of the Veterans Affairs (VA) Cardiac Catheterization Laboratories. The range varies from <1% to >95% use of left ventriculography during a cardiac catheterization.
continued to 2010. When analyzed at the facility level, the correlation between CART rates and administrative data rates was 0.86 (2008) and 0.85 (2009). When the 57 facilities with data in both clinical and administrative databases in 2009 were ranked on left ventriculography use, 7 of the top 10 facilities ranked with clinical data were the top 7 users of left ventriculography using the administrative data. Similarly, the 7 lowest users of left ventriculography using clinical data were in the bottom 10 of those ranked by administrative data.

Facility Characteristics

Catheterization was performed during a hospitalization in 56%, with left ventriculography more likely during inpatient catheterization (60%) than with an outpatient catheterization (55%; \( P<0.001 \); Table 2). Left ventriculography was more commonly performed at non-VA hospitals where care was paid by the VA (7% of all cardiac catheterizations) than at VA hospitals. In addition, tertiary care facilities (79%), hospitals that were members of the Council on Teaching Hospitals (83%), and those with accreditation for graduate medical education (Accreditation Council for Graduate Medical Education, 93%) were less likely to perform angiography than nontertiary and nonacademic facilities. Left ventriculography was more often performed in Midwest and Southern VA facilities than in the East and West Coast VA facilities. There was a slight U-shaped relationship between volume of angiography at the facility and use of left ventriculography, with highest uses noted at the highest and lowest volume facilities.

There were 39 VA facilities with ≥20 cardiac catheterizations performed within the facility and 20 performed by local non-VA facilities but paid for by the VA in 2009. The correlation in left ventriculography rate for these facilities was 0.32 (Figure 3). The corresponding \( R^2 \) value of 0.10 suggests that 10% of the variation in catheterization laboratory rate can be explained by rates at local facilities (ie, regional effect).

Table 2. Facility Characteristics and Use of Left Ventriculography

<table>
<thead>
<tr>
<th>Location of Catheterization</th>
<th>Total, No. (%)</th>
<th>Use of Left Ventriculography</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inpatient</td>
<td>199873 (44)</td>
<td>196784 (55)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Non-VA facility</td>
<td>33174 (7)</td>
<td>22281 (67)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Facility complexity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tertiary care</td>
<td>338274 (79)</td>
<td>179512 (53)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nontertiary care</td>
<td>87715 (21)</td>
<td>61915 (71)</td>
<td></td>
</tr>
<tr>
<td>Volume (coronary angiograms per year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥700</td>
<td>131116 (30)</td>
<td>80885 (62)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>500–699</td>
<td>127077 (30)</td>
<td>67249 (53)</td>
<td></td>
</tr>
<tr>
<td>300–499</td>
<td>104480 (24)</td>
<td>56980 (55)</td>
<td></td>
</tr>
<tr>
<td>100–299</td>
<td>52973 (2)</td>
<td>31525 (60)</td>
<td></td>
</tr>
<tr>
<td>0–99</td>
<td>8359 (2.0)</td>
<td>4785 (57)</td>
<td></td>
</tr>
<tr>
<td>ACGME programs</td>
<td>389052 (93)</td>
<td>220978 (57)</td>
<td></td>
</tr>
<tr>
<td>No ACGME programs</td>
<td>29691 (7)</td>
<td>17685 (60)</td>
<td></td>
</tr>
<tr>
<td>COTH member</td>
<td>347257 (83)</td>
<td>192908 (56)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Non-COTH member</td>
<td>71486 (17)</td>
<td>45755 (64)</td>
<td></td>
</tr>
<tr>
<td>US region</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>East</td>
<td>63867 (15)</td>
<td>34370 (54)</td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>118762 (27)</td>
<td>74840 (63)</td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>166186 (38)</td>
<td>97241 (59)</td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>84151 (19)</td>
<td>44895 (53)</td>
<td></td>
</tr>
</tbody>
</table>

ACGME indicates Accreditation Council for Graduate Medical Education; COTH, Council on Teaching Hospitals; and VA, Veterans Affairs.

Prior Assessment of Left Ventricular Ejection Fraction

Use of other imaging modalities that would provide information on the left ventricular ejection fraction (LVEF) before cardiac catheterization is shown in Table 3. Patients with a recent imaging study likely to provide the LVEF were slightly less likely to undergo left ventriculography. However, even those with an imaging study in the prior 30 days had left ventriculography performed in 53%. There were 19804 (4%) patients with an intervening event (myocardial infarction, heart failure hospitalization, hospitalization for hypotension or shock) between prior imaging and cardiac catheterization in whom the LVEF may have changed. Use of left ventriculography was actually lower in this group (52%) than in the overall population. When this small group of patients was excluded, the use of left ventriculography remained at 58%.

Independent Predictors of Left Ventriculography Use

After adjustment for patient, facility, and location characteristics (with adjustment for clustering of patients with facilities), left ventriculography was less likely to be performed in older patients, outpatients, those with comorbidities, those treated with a β-blocker or statin, and those with a recent LVEF from another test (Table 4). Facility characteristics associated with less left ventriculography use included tertiary care capability and fewer catheterization studies per year.

In a separate logistic regression model using the facility as the only variable, the discrimination defined as the c-statistic

![Figure 3](http://circoutcomes.ahajournals.org/)

**Figure 3.** The correlation in left ventriculography use between Veterans Affairs (VA) and non-VA catheterization laboratories is shown for 2009. Each data point represents a different VA facility (total, 39) where care was both provided at the VA facility and provided at local non-VA facilities (but paid by the VA). Left ventriculography use in the non-VA laboratories is higher than in VA laboratories, although the correlation is small (\( R^2 \) of 0.10; \( P=0.048 \)), indicating that only a small amount of the variation in left ventriculography use between VA and non-VA facilities can be explained by regional variation. Removing the outlier point (<20% non-VA usage) further reduced the correlation (\( R^2 \) to 0.07, \( P=0.12 \)).
was 0.71. Patient characteristics alone had limited discrimination (c-statistic, 0.61). Adding patient characteristics to the facility model further increased the \( \chi^2 \) (decreased the \( P \) value) of the facility variable. These findings indicate that observed patient characteristics did not explain the variation in left ventriculography use across facilities.

### Creatinine Levels After Left Ventriculography

Contrast use was higher among those undergoing left ventriculography (median, 116 mL; interquartile range, 90–150 mL) compared with those not undergoing left ventriculography (median, 90 mL; interquartile range, 61–134 mL; \( P < 0.0001 \)). Creatinine data were captured beginning in 2002 and were available both at baseline (within the 2 days before the procedure) and in the 7 days after cardiac catheterization in 107,685 (29% of patients during years 2002–2009) had both. Acute kidney injury, defined as a creatinine increase of 25% or absolute rise of ≥0.5 mg/dL during the 7 days after catheterization, occurred in 19,694 (18%) of those with measurements available. In unadjusted analyses, the rates of acute kidney injury were similar for those undergoing (18.0%) and those not undergoing left ventriculography (18.6%). However, after adjustment for patient and facility baseline characteristics including baseline renal function, the use of left ventriculography was associated with a small but significant increase in acute kidney injury (adjusted odds ratio of 1.18; 95% confidence interval, 1.03–1.05).

### Discussion

Cardiac imaging has come under increasing scrutiny by payers concerned that there is substantial overuse of these technologies. Some of this concern was because of the large increase in cardiac imaging that occurred through 2005. Although the use of some imaging technologies (eg, nuclear medicine) have leveled off during the last several years, there is concern that some of the cardiac imaging tests performed have limited value.

To help optimize the use of cardiac imaging, the American College of Cardiology created appropriateness use criteria for multiple tests, including cardiac catheterization, single-photon emission computed tomography myocardial perfusion imaging, echocardiography, computed tomography, and magnetic resonance. These criteria are created using a RAND/University of California of Los Angeles methodology that defines the use of a technology for a given clinical scenario as appropriate, uncertain, or inappropriate. Although appropriateness criteria for left ventriculography have not been created as of this writing, results from a recent study of a large health maintenance organization indicated that a sizable number of left ventriculograms may be inappropriate. In that study of >96,000 patients in a health maintenance organization undergoing cardiac catheterization, 82% had a left ventriculogram. When the
sample was limited to those with a recent echocardiogram and no intervening admission for heart failure or acute myocardial infarction (ie, no clear reason to repeat an assessment of left ventricular function), the use of left ventriculography was even higher (88%). Other findings suggesting potential overuse were noted in a study of hospitalized patients with acute myocardial infarction where 17% underwent left ventriculography despite having an echocardiogram earlier in the day with a measure of wall motion and LVEF.15 Although for any particular patient it may be appropriate to obtain both imaging tests, there may be overuse of imaging given the high rates of dual testing.

The use of left ventriculography during cardiac catheterization in the VA system (56%) was much less than in a private health maintenance organization population (85%) previously described.1 In addition, the use of left ventriculography was lower among veterans treated at VA hospitals compared with non-VA hospitals where care was paid by the VA. Other studies have shown that procedures are less likely to be performed in the VA compared with non-VA settings.16 However, there is still potential for overuse in the VA system in that 50% of patients undergoing cardiac catheterization also had a left ventriculogram despite having had an echocardiogram in the prior 30 days without an intervening event.

The use of left ventriculography during cardiac catheterization has declined over time with an absolute drop of 15% in 10 years. This decline was seen both within VA hospitals and at non-VA hospitals performing left ventriculography for veterans with care paid by the VA. In a non-VA community study of patients hospitalized with myocardial infarction, left ventriculography as a percent of angiography studies decreased from 76% in 1997 to 45% in 2005.15 However, actual use of left ventriculography increased from 25% to 38% because angiography use increased markedly during this time.

Left ventriculography is unusual in that it is typically not ordered by clinicians at the time of cardiac catheterization; instead, it is performed at the discretion of the invasive cardiologist usually after a coronary angiogram. Alternatives to left ventriculography include echocardiography (noninvasive and uses only ultrasound waves) and, in some situations, nuclear scintigraphy (uses radiation but does not require cardiac catheterization, although it does not provide data on mitral regurgitation). In controlled settings, left ventriculography, echocardiography, and nuclear scintigraphy studies have been shown to produce comparable measures of ejection fraction.17,18

We observed a dramatic variation in the use of left ventriculography across the 86 catheterization laboratories within the VA Health Care system. The large range of 0.2% to 95% suggests that variation cannot be explained by patient characteristics or preferences but is instead likely attributable to different opinions on the value of left ventriculography among invasive cardiologists.

Potential reasons for performing a left ventriculography include inadequate noninvasive images, inability to wait to have an echocardiogram or other noninvasive measure of left ventricular function performed, the need to train future invasive cardiologists to perform left ventriculography, and the belief that the best catheterization study is a complete study that includes left ventriculography even if other imaging options are adequate. Left ventriculography can provide immediate assessment of complications of acute myocardial infarction ventricular septal defect, cardiac rupture, or severe mitral regurgitation where outcome will be improved with a rapid diagnosis. Furthermore, noninvasive methods may be suboptimal for several hours after cardiac catheterization because of limited patient mobility. If only a measure of wall motion is needed, proceeding with left ventriculography may be less costly than performing an echocardiogram after coronary angiography. Although our study could not determine the reasons that left ventriculography was performed, it is unlikely that financial gain was a significant factor because VA physicians receive a salary and have less financial incentive to perform more procedures. However, the physicians may wish to maintain or increase the workload of their laboratory to justify staffing levels.

Observable facility-level characteristics explained only a small fraction of the variation across VA facilities. Of note, VA facilities that were members of the Council on Teaching Hospitals were less likely to perform left ventriculography than other hospitals. This argues against the value of teaching as the procedure as a primary reason for the use of left ventriculography.

Although the health risks associated with a left ventriculogram are often thought to be negligible, the potential for harm has not been well studied. The extra contrast load is often ≈20 to 40 mL, although high doses can double the total contrast used for a diagnostic cardiac catheterization study. We observed a small but significant increase in creatinine for patients undergoing left ventriculography during cardiac catheterization. Whether this acute rise in creatinine will cause long-term health consequences is unclear.

Our study has potential limitations. Although some clinical data were available (eg, laboratory test results), we could not determine why the invasive cardiologist chose to perform a left ventriculogram. Given the lack of guidelines for left ventriculography, it is difficult to state that use in any particular case was inappropriate. For example, although those with baseline renal dysfunction (creatinine >1.5 mg/dL) are at higher risk for contrast-induced nephropathy, other clinical factors may have made the performance of left ventriculography worth the risk. Similarly, we cannot know whether facilities that rarely performed left ventriculography could have improved care by increasing their use of the procedure. Although our primary analysis used administrative data to determine the use of left ventriculography and therefore susceptible to coding errors, we confirmed these results in recent years with clinical data from the VA CART program. Although coding errors in patient characteristics may have occurred, a prior VA study found reasonable accuracy for many common diagnoses.19 We had data on a change in creatinine in a minority of patients. This was primarily attributable to our requirement that the baseline creatinine must be during the 2 days before left ventriculography. Although increasing this window would have increased the fraction of patients with data on a change in creatinine, it may have included patients whose renal function changed before cardiac catheterization. Larger studies would be needed to demonstrate any impact on outcome of these small rises in creatinine associated with left ventriculography.20 Finally, our analysis was primarily of men undergoing cardiac catheterization, and it is unclear whether rates of left ventriculography use and any impact on renal function are different in women.
In summary, we found that left ventriculography was used in at least half of cardiac catheterization studies in the VA system despite a recent measure of left ventricular function. Use was less in the VA than in non-VA care paid by the VA and less than in a prior report from a non-VA managed care organization. There was marked variation across VA facilities, with some using left ventriculography in >90% and others in <1%. Patient and facility characteristics explained little of this variation, indicating that local culture and attitudes toward left ventriculography are likely important factors. Worsening renal function was slightly more common for those undergoing left ventriculography. Clinical guidelines such as appropriateness criteria should be developed to help decrease the variation and limit any overuse of left ventriculography.

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Disclosures
None.

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