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Citation

Petersen, Laura A., Sharon-Lise Normand, Lucian Leape, Barbara McNeil. "Regionalization and the Underuse of Angiography in the Veterans Affairs Health Care System as Compared with a Fee-for-Service System." *New England Journal of Medicine* 348, no. 22 (2003): 2209-2217. DOI: 10.1056/nejmsa021725

Published Version

doi:10.1056/NEJMsa021725

Permanent link

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SPECIAL ARTICLE

Regionalization and the Underuse of Angiography in the Veterans Affairs Health Care System as Compared with a Fee-for-Service System

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ABSTRACT

BACKGROUND

Policies to concentrate or regionalize invasive procedures at high-volume medical centers are under active consideration. Such policies could improve outcomes among those who undergo procedures while increasing their underuse among those who never reach such centers. We compared the underuse of needed angiography after acute myocardial infarction in a traditional Medicare fee-for-service system with underuse in the regionalized Department of Veterans Affairs (VA) health care system.

METHODS

We studied 1665 veterans from 81 VA hospitals and 19,305 Medicare patients from 1530 non-VA hospitals, all of whom were elderly men. We compared adjusted angiography use and one-year mortality among patients for whom angiography was rated as clinically needed. We compared underuse in models before and after controlling for the on-site availability of cardiac procedures.

RESULTS

After adjustment for the need for angiography, underuse was present in both groups, but VA patients remained significantly less likely than Medicare patients to undergo angiography (43.9 percent vs. 51.0 percent; odds ratio, 0.75; 95 percent confidence interval, 0.57 to 0.96). After also controlling for on-site availability of cardiac procedures at the admitting hospital, we found no significant difference in the underuse of angiography among VA patients as compared with Medicare patients (odds ratio, 1.02; 95 percent confidence interval, 0.82 to 1.26) or in one-year mortality (odds ratio, 1.08; 95 percent confidence interval, 0.89 to 1.28).

CONCLUSIONS

There is underuse of needed angiography after acute myocardial infarction in both the VA and Medicare systems, but the rate of underuse is significantly higher in the VA. These differences appear to be associated with limited on-site availability of cardiac procedures in the regionalized VA health care system. Further work should focus on how regionalization policies could be improved with effective referral and triage processes.

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N Engl J Med 2003;348:2209-17.

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INVASIVE CARDIAC PROCEDURES SUCH AS angiography are profitable for hospitals, so fee-for-service reimbursement incentives have led competing hospitals to duplicate cardiac services.¹ Other types of health care financing, such as globally budgeted allocations to networks of providers (as in the Canadian system or the Veterans Health Administration), create the opposite incentive — to avoid duplication of services by regionalizing^{2,3} or consolidating complex or costly procedures at referral institutions. These organizational incentives are likely to affect patient care, because the availability of on-site cardiac procedures influences the use of such procedures⁴ and the rates of cardiac procedures in these health care systems are lower than those in fee-for-service systems.⁵⁻⁷ A key question is the extent to which such differences in utilization rates are driven by incentives to provide services of marginal benefit under fee-for-service care or by the limited availability of vital cardiac procedures in non-fee-for-service systems. The study of utilization rates alone or even retrospective assessment of the appropriateness of procedures performed⁸ does not provide information regarding the underuse^{9,10} of needed procedures, because in the former assessments, only patients who undergo a procedure are evaluated rather than those who are eligible for the procedure.

Questions about underuse are of increasing importance, because policies to concentrate invasive procedures at high-volume centers are being implemented by some payers.^{3,11} Such policies could improve outcomes among those who undergo procedures while increasing underuse among those who never reach such centers. Underuse as a corollary of either volume standards or regionalization has not been extensively studied.

Our goal was to compare the underuse of angiography in the Medicare fee-for-service system with that in the Department of Veterans Affairs (VA) health care system, the largest regionalized health care system in the United States. The VA represents a globally budgeted, regionalized health care system, and fee-for-service Medicare represents a non-regionalized, dispersed format.¹²

METHODS

We identified two cohorts of men who were at least 65 years old and who had had an acute myocardial infarction within the preceding eight weeks (as defined by *International Classification of Diseases*, 9th revision,

Clinical Modification, code 410 without a fifth digit of 2)¹³: one from fee-for-service Medicare beneficiaries and the other from a national random sample of veterans.¹⁴ To ensure that we were comparing diagnostic angiography and not therapeutic emergency primary angioplasty, we included only patients who became eligible for angiography more than 12 hours after the onset of symptoms but before hospital discharge, according to the criteria of the American College of Cardiology–American Heart Association (ACC-AHA).¹⁵

MEDICARE SAMPLE

The Medicare fee-for-service sample was obtained through the Cooperative Cardiovascular Project undertaken by the Centers for Medicare and Medicaid Services (CMS).¹³ We identified 29,249 male patients discharged between February 1, 1994, and July 30, 1995, in California, Florida, Massachusetts, New York, Ohio, Pennsylvania, and Texas.^{16,17} Of these, we excluded 6960 patients (23.8 percent) who were not candidates for revascularization (e.g., those who died on the first hospital day or had a terminal illness), 1440 patients (4.9 percent) who underwent angiography within 12 hours after the index event, and 3283 patients (11.2 percent) for whom information needed to determine eligibility for angiography was missing (e.g., the duration of angina at the time of arrival or the ejection fraction). This left 19,305 male patients who had been discharged from 1530 nonfederal acute care hospitals. (For some patients, there was more than one reason for exclusion.)

VA SAMPLE

Because the number of VA hospitals in the seven states of the Medicare cohort was too small to provide adequate analytic power, we used a national hospital-based VA sample. Of the 2486 men who were at least 65 years old and who had been discharged with confirmed^{13,18} acute myocardial infarction from 81 of 139 nonpsychiatric VA hospitals between January 1, 1994, and September 30, 1995, we excluded 663 (26.7 percent) who were not candidates for revascularization, 23 (0.9 percent) who underwent angiography within 12 hours after admission, and 293 (11.8 percent) for whom information needed to determine eligibility for angiography was missing, leaving 1665 male patients discharged from 81 VA facilities. (For some patients, there was more than one reason for exclusion.)

DATA SOURCES

For all patients, the hospital to which the patient was first admitted was the index hospital, and all subsequent care for the patient was linked to this hospital. We used the data-abstraction instrument of the Cooperative Cardiovascular Project¹³ for both samples. The rate of agreement between abstracters was 96 percent for VA data¹⁴ and 95 percent for Medicare data.¹³

The CMS Provider of Service File, the American Hospital Association, and the VA Cardiac Services Directory data bases were used to determine whether the study hospitals performed invasive cardiac procedures and were affiliated with a university as well as the number of beds. Because a large percentage of the VA cohort might have undergone cardiac procedures in non-VA hospitals under Medicare financing,⁵ we linked VA patients with the CMS Medicare Provider Analysis and Review Part A and Denominator files to identify any patients who had undergone such procedures at non-VA hospitals in the 90 days after the index admission.

We used the Health Insurance Master File to identify Medicare patients who had died, and we used the inpatient discharge status from the VA Patient Treatment File as well as the VA Beneficiary Identification and Record Location Subsystem to identify VA patients who had died. These sources have a high rate of sensitivity for the ascertainment of death.¹⁹

IDENTIFICATION OF PATIENTS WITH CLINICAL NEED FOR ANGIOGRAPHY

We defined patients with a clinical need for angiography as patients in class I of the ACC-AHA guidelines,¹⁵ which encompasses “conditions for which there is evidence and/or general agreement that a given procedure or treatment is beneficial, useful, and effective.” Specific class I criteria⁷ were the presence of one or both of the following: an episode of myocardial ischemia (manifested as chest pain after arrival at the hospital, ischemia on a stress test, or both) and persistent hemodynamic instability (manifested as cardiogenic shock on arrival at the hospital or during the hospital stay, hypotension during the hospital stay, congestive heart failure or pulmonary edema with an ejection fraction of 40 percent or less, or a combination of these findings).

PROCEDURE UTILIZATION

Because angiography is a diagnostic rather than a therapeutic procedure, its use alone should not be

expected to improve mortality. However, because the purpose of angiography is to identify patients who might benefit from revascularization procedures, we assessed the use of coronary-artery bypass grafting and percutaneous transluminal coronary angioplasty among patients who were judged to need angiography before discharge. Some patients in both cohorts may have been discharged and readmitted for a planned revascularization procedure. Thus, we assessed the use of percutaneous transluminal coronary angioplasty or coronary-artery bypass grafting during the index hospitalization as well as in the 90 days after the index admission in VA and non-VA hospitals among patients who required and actually underwent angiography. Because percutaneous transluminal coronary angioplasty and coronary-artery bypass grafting might be used interchangeably in some clinical situations, we also assessed the combined variable of “any revascularization” to reflect the use of either procedure.

STATISTICAL ANALYSIS

We calculated the frequency of coexisting conditions, admission characteristics, and other inclusion characteristics²⁰ among patients eligible for diagnostic angiography in each of the two cohorts. Chi-square tests and t-tests were used to examine differences between the two groups for discrete and continuous variables, respectively. We used a Mantel-Haenszel statistic to estimate age-adjusted relative risks (and corresponding 95 percent confidence intervals) for the use of angiography and death among VA patients as compared with Medicare patients.

We focused on the clinical need for angiography rather than revascularization to evaluate the potential underuse of cardiac procedures, because variation in the rates of coronary angiography almost completely explains variation in revascularization rates.^{21,22} Because the decision to perform angiography is influenced by the underlying health of the patient,^{23,24} we also performed adjusted analyses. We estimated the odds of the use of angiography when it was clinically needed for VA patients, as compared with Medicare patients, using a hierarchical model.²⁵ The hierarchical model accounts for within-hospital clustering of observations and is used because patients from the same hospital tend to be more likely to undergo (or not undergo) a procedure than patients chosen at random from different hospitals.²⁵

We used a propensity score to adjust for patients'

Table 1. Characteristics of All Patients Treated in the Veterans Affairs (VA) Health Care System and the Medicare Fee-for-Service System Who Were Eligible for Angiography According to the Guidelines of the American College of Cardiology–American Heart Association (ACC-AHA) and Patients Who Met the Criteria for ACC-AHA Class I Angiography.*

Characteristic	Medicare Patients (N=19,305)	VA Patients (N=1665)	P Value	Medicare Patients in ACC-AHA Class I (N=10,464)	VA Patients in ACC-AHA Class I (N=1104)	P Value
ACC-AHA recommendation for angiography — no. (%)			<0.001			
Class I	10,464 (54.2)	1104 (66.3)				
Class IIa	4,788 (24.8)	332 (19.9)				
Class IIb	4,053 (21.0)	229 (13.8)				
Sociodemographic characteristics						
Mean age — yr	74.8±6.7	72.7±5.2	<0.001	74.8±6.6	72.6±5.1	<0.001
Age — no. (%)			<0.001			<0.001
65–69 yr	4,914 (25.5)	579 (34.8)		2608 (24.9)	383 (34.7)	
70–74 yr	5,335 (27.6)	582 (35.0)		2918 (27.9)	399 (36.1)	
75–79 yr	4,214 (21.8)	338 (20.3)		2340 (22.4)	217 (19.7)	
80–84 yr	3,015 (15.6)	126 (7.6)		1624 (15.5)	79 (7.2)	
85–89 yr	1,400 (7.3)	36 (2.2)		766 (7.3)	25 (2.3)	
>89 yr	427 (2.2)	4 (0.2)		208 (2.0)	1 (0.1)	
Race — no. (%)			<0.001			<0.001
White	17,591 (91.1)	1362 (81.8)		9555 (91.3)	916 (83.0)	
Black	751 (3.9)	239 (14.4)		394 (3.8)	149 (13.5)	
Other or unknown	963 (5.0)	64 (3.8)		515 (4.9)	39 (3.5)	
Coexisting conditions — no. (%)						
Congestive heart failure	3,540 (18.3)	304 (18.3)	0.94	2153 (20.6)	189 (17.1)	0.007
Prior myocardial infarction	6,411 (33.2)	623 (37.4)	<0.001	3641 (34.8)	420 (38.0)	0.03
Hypertension	11,240 (58.2)	1116 (67.0)	<0.001	6121 (58.5)	744 (67.4)	<0.001
Diabetes	5,607 (29.0)	604 (36.3)	<0.001	3103 (29.7)	399 (36.1)	<0.001
Diabetes treated with insulin	1,437 (7.4)	212 (12.7)	<0.001	770 (7.4)	132 (12.0)	<0.001
Asthma or chronic obstructive pulmonary disease	4,339 (22.5)	501 (30.1)	<0.001	2421 (23.1)	343 (31.1)	<0.001
Ejection fraction <35%	3,264 (16.9)	194 (11.7)	<0.001	2709 (25.9)	165 (15.0)	<0.001

characteristics within the hierarchical model.^{14,17} Using logistic regression, we estimated the propensity for each patient in the sample to belong to the VA system (vs. Medicare) as a function of demographic characteristics, coexisting conditions, and the severity of illness at the time of admission. The hierarchical models were limited to hospitals that

treated more than four study patients during the study period.

In model 1, we included only the estimated propensity score and a binary variable indicating whether the patient was part of the VA cohort or the Medicare cohort. Model 2 included the variables from model 1 plus dummy variables indicating whether

Table 1. (Continued.)

Characteristic	Medicare Patients (N=19,305)	VA Patients (N=1665)	P Value	Medicare Patients in ACC-AHA Class I (N=10,464)	VA Patients in ACC-AHA Class I (N=1104)	P Value
Hospital characteristics — no. (%)						
Type of admitting hospital			<0.001			<0.001
No on-site angiography	5,681 (29.4)	776 (46.6)		3046 (29.1)	507 (45.9)	
On-site angiography only	4,501 (23.3)	451 (27.1)		2444 (23.4)	304 (27.5)	
On-site angiography and cardiac surgery	9,123 (47.3)	438 (26.3)		4974 (47.5)	293 (26.5)	
University-affiliated	6,667 (34.5)	1353 (81.3)	<0.001	3652 (34.9)	906 (82.1)	<0.001
Size†			<0.001			<0.001
<100 Beds	1,449 (7.5)	44 (2.6)		714 (6.8)	33 (3.0)	
100–500 Beds	13,352 (69.2)	1247 (74.9)		7226 (69.1)	829 (75.1)	
>500 Beds	4,502 (23.3)	374 (22.5)		2523 (24.1)	242 (21.9)	

* Patients were included in the analysis only if they became eligible for angiography more than 12 hours after the onset of symptoms but before discharge. Data on the ACC-AHA guidelines are from Ryan et al.¹⁵ Plus–minus values are means ±SD.

† Data were missing for two Medicare patients and for one Medicare patient in ACC-AHA Class I.

the admitting hospital had on-site angiography facilities alone or could also perform revascularization procedures. Models were estimated with use of BUGS software.²⁶ All reported P values are based on two-sided tests.

To assess whether our findings were consistent with the use of different methods for determining the clinical need for angiography, we also used consensus ratings based on the RAND methods to evaluate the underuse of angiography among those for whom it was deemed clinically necessary.^{8,16,17}

RESULTS

CHARACTERISTICS OF THE PATIENTS

Table 1 shows the characteristics of patients who were eligible for angiography more than 12 hours after the onset of symptoms according to the ACC-AHA criteria. Patients cared for in the VA system were younger and less likely to be white than those in the Medicare fee-for-service system. VA patients were significantly more likely than Medicare patients to have a number of coexisting conditions such as hypertension, asthma or chronic obstructive pulmonary disease, diabetes, or prior myocardial infarction. VA patients were also significantly more

likely than Medicare patients to meet the criteria for clinically needed angiography before hospital discharge. More of the patients in the Medicare sample were initially admitted to hospitals with on-site facilities for cardiac surgery.

USE OF CARDIAC PROCEDURES AND MORTALITY

The rates of all cardiac procedures during the index hospital stay were higher among Medicare patients than among VA patients (Table 2). Angiography was performed in 38.0 percent of VA patients and 48.8 percent of Medicare patients (age-adjusted relative risk, 0.69; 95 percent confidence interval, 0.66 to 0.73). Similarly, VA patients were less likely to undergo revascularization during the index admission. When the interval studied was expanded to 90 days after the index admission and both Medicare and VA data sources were used to assess the rate of procedures in the VA cohort, VA patients remained significantly less likely than Medicare patients to undergo angiography or revascularization (Table 2). Thus, neither the decision to discharge and readmit VA patients for procedures nor patients' preferences to leave the VA system and undergo procedures under Medicare financing accounted for the differences in the rates of procedures between VA and Medicare

Table 2. Crude and Age-Adjusted Rates of Cardiac Procedures and Death among Medicare and Veterans Affairs (VA) Patients.*

Variable	Medicare Patients (N=19,305)	VA Patients (N=1665)	Relative Risk (95% CI)†
	<i>no. of patients (%)</i>		
Procedures during index hospital stay			
Diagnostic angiography	9,418 (48.8)	632 (38.0)	0.69 (0.66–0.73)
PTCA	3,247 (16.8)	158 (9.5)	0.50 (0.43–0.58)
CABG	2,631 (13.6)	96 (5.8)	0.37 (0.31–0.44)
Any revascularization	5,674 (29.4)	246 (14.8)	0.44 (0.40–0.49)
Procedures within 90 days after index admission			
Diagnostic angiography	10,741 (55.6)	772 (46.4)	0.75 (0.71–0.78)
PTCA	3,820 (19.8)	213 (12.8)	0.58 (0.51–0.65)
CABG	3,561 (18.4)	168 (10.1)	0.48 (0.42–0.55)
Any revascularization	7,056 (36.6)	361 (21.7)	0.52 (0.48–0.57)
Mortality			
30-Day	1,352 (7.0)	100 (6.0)	0.98 (0.80–1.20)
1-Year	3,925 (20.3)	315 (18.9)	1.09 (0.98–1.21)

* CI denotes confidence interval, PTCA percutaneous transluminal coronary angioplasty, and CABG coronary-artery bypass grafting.

† The Mantel–Haenszel statistic was used to estimate the age-adjusted relative risk among VA patients as compared with Medicare patients.

patients. The age-adjusted 30-day and 1-year mortality rates did not differ significantly between the two groups (Table 2).

CLINICALLY NEEDED ANGIOGRAPHY

Two thirds of VA patients (1104 of 1665) and half of Medicare patients (10,464 of 19,305) met the criteria for clinically needed angiography. There was significant underuse of angiography among both Medicare and VA patients, but VA patients were significantly less likely than Medicare patients to undergo needed angiography (43.9 percent vs. 51.0 percent; age-adjusted relative risk, 0.77; 95 percent confidence interval, 0.72 to 0.82) (Table 3). When the study interval was expanded to 90 days after the index admission and both Medicare and VA data sources were used to assess the rates of procedures in the VA cohort, the findings were similar (Table 3), suggesting that discharge and readmission for procedures among the VA patients were not responsible

for the findings, nor was the preference of VA patients to undergo procedures under Medicare financing. Patients cared for in the VA system remained less likely to undergo revascularization, even when the analysis was adjusted to include only patients who required and actually underwent angiography in the 90 days after the index admission (Table 3).

ADJUSTED ANGIOGRAPHY AND MORTALITY RATES

When a hierarchical model was adjusted for patients' characteristics alone (Table 4), VA patients remained less likely than Medicare patients to undergo angiography when it was clinically needed (odds ratio, 0.75; 95 percent confidence interval, 0.57 to 0.96), suggesting that differences in patients' characteristics alone between the two groups did not explain the underuse of angiography. When the availability of on-site cardiac procedures in the admitting hospital was included in the model, the differences between the two groups were no longer significant (odds ratio, 1.02; 95 percent confidence interval, 0.82 to 1.26). There was no significant difference between the two groups in adjusted one-year mortality in either model.

To test the robustness of our findings, we repeated our analyses using the modified RAND criteria for the clinical necessity of angiography instead of the ACC-AHA criteria. Our findings did not change. To assess whether our findings were an artifact of sampling, we repeated our analyses in the subgroup of VA patients who were cared for in the same seven states as the Medicare patients in our cohort. In this subgroup, we found the same degree of underuse of angiography; for example, the adjusted odds ratio for VA patients as compared with Medicare patients was 0.59 (95 percent confidence interval, 0.46 to 0.76).

DISCUSSION

In this population-based study of acute myocardial infarction, we compared the use of angiography among patients treated under fee-for-service Medicare financing with the use among patients treated in the VA health care system. As in studies carried out in Canada,⁶ we found that the overall rates of angiography in a regionalized, globally budgeted health care system were significantly lower than those under fee-for-service financing. Unlike other studies, however, we examined rates after accounting for the need for angiography by using two meth-

Table 3. Crude and Age-Adjusted Rates of Cardiac Procedures and Death among Medicare and Veterans Affairs (VA) Patients in American College of Cardiology–American Heart Association Class I.*

Variable	Medicare Patients (N=10,464)	VA Patients (N=1104)	Relative Risk (95% CI)†
Diagnostic angiography during index hospital stay	5336 (51.0)	485 (43.9)	0.77 (0.72–0.82)
Procedures among patients who underwent angiography during index hospitalization			
PTCA	1791 (33.6)	131 (27.0)	0.80 (0.69–0.92)
CABG	1595 (29.9)	79 (16.3)	0.53 (0.44–0.64)
Any revascularization	3232 (60.6)	202 (41.6)	0.68 (0.62–0.74)
Procedures within 90 days after index admission among patients who underwent angiography during index hospitalization			
PTCA	1905 (35.7)	152 (31.3)	0.87 (0.76–1.00)
CABG	1838 (34.4)	102 (21.0)	0.59 (0.51–0.70)
Any revascularization	3526 (66.1)	237 (48.9)	0.73 (0.67–0.79)
Diagnostic angiography within 90 days after index admission	5965 (57.0)	577 (52.3)	0.82 (0.78–0.87)
Procedures within 90 days among patients who underwent angiography within 90 days after index admission			
PTCA	2053 (34.4)	171 (29.6)	0.86 (0.75–0.97)
CABG	2038 (34.2)	123 (21.3)	0.61 (0.52–0.70)
Any revascularization	3871 (64.9)	276 (47.8)	0.72 (0.67–0.78)
Mortality			
30-Day	1033 (9.9)	96 (8.7)	1.00 (0.82–1.23)
1-Year	2557 (24.4)	239 (21.6)	1.02 (0.91–1.15)

* CI denotes confidence interval, PTCA percutaneous transluminal coronary angioplasty, and CABG coronary-artery by-pass grafting.

† The Mantel–Haenszel statistic was used to estimate the age-adjusted relative risk among VA patients as compared with Medicare patients.

ods. Even among patients for whom angiography was clearly indicated, VA patients remained significantly less likely to undergo it. This finding persisted in hierarchical models controlling for patients' characteristics that might explain differences in practice patterns^{23,24} between the two groups. That this underuse of procedures appeared to extend to revascularization once angiography had been performed is even more worrisome, although this is speculative because we were unable to assess the clinical need for revascularization.

However, when we also controlled for the on-site availability of cardiac procedures, VA patients were no less likely than Medicare patients to undergo clinically needed angiography (odds ratio, 1.02; 95 percent confidence interval, 0.82 to 1.26). This finding suggests that a key factor in the underuse of angiography in the VA system is the on-site availability of cardiac procedures.

The lack of availability of invasive services at every VA hospital is partly a byproduct of regionalization.

The VA performs invasive cardiac procedures in a few centers in each of its 22 networks. Regionalization promotes efficiency and prevents duplication of expensive invasive services. It may also improve the outcomes of procedures by increasing the volume at a particular site.^{27–30}

Because better results might also be achieved by underusing procedures¹⁰ in high-risk groups or by overusing them in low-risk groups, it was critically important for us to control for clinical need. To do this, we used accepted clinical guidelines¹⁵ and confirmed our findings with the RAND methods. We defined underuse as the failure to perform angiography in a patient for whom it was classified as needed on the basis of clinical criteria.^{9,10} An example of such a clinically needed procedure would be angiography in a patient with no contraindications to revascularization who has persistent cardiac ischemia after myocardial infarction.³¹ Using this definition of underuse, we found evidence of greater underuse in the VA health care system than in the

Table 4. Adjusted Odds Ratios for Angiography and Death.*

Model	Adjusted Odds Ratio (95% CI)
Model 1	
Angiography	0.75 (0.57–0.96)
1-Yr mortality	1.10 (0.92–1.33)
Model 2	
Angiography	1.02 (0.82–1.26)
1-Yr mortality	1.08 (0.89–1.28)

* The odds ratios are for the comparison of Veterans Affairs patients and Medicare patients in American College of Cardiology–American Heart Association Class I. Model 1 was adjusted for age; race; body-mass index; presence or absence of a history of congestive heart failure, prior myocardial infarction, diabetes, hypertension, percutaneous transluminal coronary angioplasty, stroke, chronic obstructive pulmonary disease or asthma, cancer, and dementia; severity of illness at admission as defined by the mean arterial pressure and the presence or absence of shock, pulmonary edema, cardiomegaly, ST elevation on electrocardiogram, cardiac arrest, and chest pain 60 minutes after arrival; the presence or absence of stress-induced cardiac ischemia and conduction disturbance on electrocardiography; the creatinine concentration; and the ejection fraction (receiver-operating-characteristic curve, 0.80). Model 2 was adjusted for all variables listed for model 1 as well as for the availability of angiography and cardiac surgery on site. CI denotes confidence interval.

Medicare system. Our sensitivity analyses suggest that neither our choice of the method of determination of underuse nor our choice of the Medicare sample was the sole explanation for our findings.

Some limitations of our study should be addressed. Because our study population consisted of elderly men, the findings are not necessarily generalizable to younger patients or women. Despite the use of two independent methods for studying the clinical need for angiography, our study could have suffered from misclassification bias. As in any observational study, residual confounding is always possible.

Our results suggest that the lack of availability of cardiac services resulting from regionalization of invasive cardiac procedures within the VA health care system may be an important factor in the underuse of such services. Our findings are timely, because policies to concentrate or regionalize invasive procedures at high-volume centers are being implemented.^{3,11,32} Yet because regionalization is an important feature of efficient and high-quality health care systems and may be one key to improving outcomes by increasing the volume of invasive procedures, we believe that the solution to the problem of underuse is not to provide such services in more hospitals but to improve the efficiency of the referral and transfer process for patients with heart disease. The VA has successfully implemented standards for the use of effective therapies for acute myocardial infarction, including aspirin and beta-blockers.³³ Devising similar standards for effective referral and triage for needed procedures³⁴ within a regionalized system should also be possible. The development of such policies could benefit patients in all health care settings, because the majority of patients nationwide who present with myocardial infarction are admitted to facilities without cardiac-surgery services on site.³⁵

Supported by a grant (IIR 94-054) from the VA Health Services Research and Development Service and a grant (R01-HS08071) from the Agency for Healthcare Research and Quality. Dr. Petersen was the recipient of a grant (RCD 95-306) from the Research Career Development Award Program of the VA Health Services Research and Development Service and is a Robert Wood Johnson Foundation Generalist Physician Faculty Scholar.

The views expressed are solely those of the authors and do not necessarily represent those of the VA.

We are indebted to Rita Volya, M.Sc., Harvard Medical School, and Caterina Brown, Boston VA Health Care System, for expert SAS programming and data management.

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