VARIATION IN THE USE OF CARDIAC PROCEDURES AFTER ACUTE MYOCARDIAL INFARCTION

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Abstract *Background. There are large geographic differences in the frequency with which coronary angiography and revascularization are performed. We attempted to assess whether differences in case mix or in the treatment of specific groups of patients may explain this variability. We also assessed the consequences of various patterns of treatment.*

Methods. We studied patients covered by Medicare who were 65 to 79 years of age and were admitted to 478 hospitals with acute myocardial infarctions during 1990 in New York (1852 patients), where the rate of use of cardiac procedures is low, and in Texas (1837 patients), where the rate of use of such procedures is high. We compared the patterns of treatment of clinically similar groups of patients in the two states. We also compared mortality rates and measures of the health-related quality of life.

Results. Coronary angiography was performed more often in Texas than in New York (45 percent vs. 30 percent, $P<0.001$). The frequency of use in Texas was significantly higher than that in New York for all the clinical subgroups of patients analyzed except those at greatest risk for reinfarction. Over a two-year period, the adjusted likelihood of death was lower in New York than in Texas (hazard ratio, 0.87; 95 percent confidence interval, 0.78 to 0.98). Patients from Texas were 41 percent more likely to report angina ($P=0.002$) and 62 percent more likely to say they could not perform activities requiring energy expenditure of 5 or more metabolic equivalents than patients from New York approximately two years after infarction ($P<0.001$).

Conclusions. Physicians in Texas were more likely to perform angiography than physicians in New York for patients whose conditions allowed more discretion in the use of cardiac procedures. On average, there appears to be no advantage with respect to mortality or health-related quality of life to performing the procedures at the higher rate used in Texas. (N Engl J Med 1995; 333:573-8.)

THERE are substantial geographic differences in the rates at which patients with cardiac disease undergo diagnostic procedures and treatments, but there is little evidence that these variations are related to survival.[1-6] Although studies of such geographic differences in rates are provocative, they cannot answer important clinical and policy questions about patterns of the use of procedures and their consequences because they lack data on patients' clinical status and functional outcomes.

Thus, studies have so far not provided answers to questions such as these: Are all types of patients with acute myocardial infarction who present for care in areas with higher rates of procedure use more likely to undergo cardiac catheterization than patients who present in areas with lower rates, or is the use of procedures higher among specific subgroups? Is cardiac disease found more often in areas with higher rates of cardiac catheterization than in areas with lower rates? Does the likelihood of having revascularization procedures among those who undergo cardiac catheterization differ in different areas, when the result of catheterization is controlled for? Finally, what is the relation between the state in which one is treated and health-related quality of life?

To address these questions, we studied Medicare patients admitted to the hospital for treatment of acute myocardial infarction in two states with different rates of use of cardiac procedures — New York and Texas.

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METHODS

Patient Sample

We used the Medicare Provider Analysis and Review file of the Health Care Financing Administration to identify all Medicare patients with a principal diagnosis of acute myocardial infarction who were treated in hospitals in New York (a state with low rates of procedure use) and Texas (a state with high rates of procedure use) between February and May 1990. We excluded patients who (1) were not representative of the Medicare population in general — that is, those under the age of 65 and those with end-stage renal disease; (2) were not likely to have undergone cardiac catheterization — that is, those over 79[7,8]; (3) were not likely to have complete longitudinal data — those who belonged to health maintenance organizations and those who resided outside New York and Texas; and (4) were likely to have been incorrectly coded as having an acute myocardial infarction — those discharged alive in less than five days and those transferred to another hospital within two days of admission whose records at the receiving hospital showed no coding for acute myocardial infarction.[7] We also excluded any patient who had had an acute myocardial infarction within a year before the start of the study.

We identified 3437 eligible patients in New York and 2528 in Texas. On the basis of power analyses performed before data were collected, our target sample size for each state was approximately 1000 patients who underwent cardiac catheterization and 1000 patients who did not. Within each state we selected all those who underwent cardiac catheterization within 90 days of their index hospitalization (the period during which the procedure is most likely to be associated with a patient's infarction) and a random sample of those who did not undergo catheterization. The New York sample consisted of 1021 patients who underwent cardiac catheterization and 986 patients who did not. The comparable numbers in the Texas sample were 1127 and 999.

Sources of Data

Medicare Claims Data

From Medicare data we obtained information about each patient's diagnosis and procedure codes, age, sex, treating hospital or hospitals, state of residence, and survival status as of March 31, 1993.

Hospital-Records Data

From the hospital record associated with each patient's index hospitalization, we abstracted the symptoms present on admission, the

presence of coexisting conditions, findings from electrocardiograms, and the results of cardiac catheterization. In the case of consecutive admissions, we requested the hospital records for all hospitalizations and used information from all records to complete the data-collection form.

Reviewers of the records were nurses with experience in cardiac care who attended a two-day training session in Boston and completed the data-collection forms according to a standard protocol. A quality-control nurse performed a reliability check on a random sample of each reviewer's cases.

Data on Health-Related Quality of Life

We attempted to interview, by telephone, all patients who were alive approximately two years after their infarctions. The interview took an average of 20 minutes and included standardized measures of patients' perceptions of their own general health,[9-11] ability to perform instrumental activities of daily living,[10,11] angina,[12,13] and cardiac capacity.[13,14] A copy of the interview is available from the authors on request.

Analysis of Data

Weighting of Data

All analyses used data weighted to adjust for the effects of unequal-sample probabilities for patients who underwent cardiac catheterization and those who did not.

Assessing the Representativeness of the Sample

We compared the demographic characteristics, coexisting diseases (identified through diagnosis codes), and procedure use of patients for whom we obtained hospital records with those of patients for whom we did not obtain such records, using chi-square tests. We also compared patients who were alive at the time of follow-up assessment and who agreed to be surveyed with those who were alive but did not agree to be surveyed.

Classifying Patients in Clinically Similar Subgroups

We stratified patients according to their risk of having further ischemic events on the basis of the type of infarction — new or evolving Q-wave infarction or non–Q-wave infarction — documented in each patient's electrocardiogram reports, and on the basis of the presence or absence of angina more than 24 hours after admission, documented by physicians' or nurses' notes. Early mortality rates are higher among patients with Q-wave infarctions; the infarctions tend to be larger and are associated with a higher incidence of congestive heart failure and cardiogenic shock.[15] Historically, patients with non–Q-wave myocardial infarctions have higher reinfarction rates but similar mortality rates after one year.[16,17] Patients in whom early postinfarction angina develops are at higher risk for early reinfarction than those in whom it does not.[18-23] The combination of these factors yielded four subgroups of patients. We did not include patients who presented with a left bundle-branch block in our classification because its presence prevents the identification of a Q-wave infarct.

Within each clinical subgroup of patients, we used chi-square tests to compare the case-mix characteristics of patients in the two states.

Comparing the Use of Procedures in the Two States

For each clinical subgroup, we compared the proportions of patients in the two states who underwent cardiac catheterization during their hospital stays or within 90 days of admission, using logistic regression and adjusting for age; sex; history of cardiac arrest, hypertension, congestive heart failure, angina, or diabetes; initial heart rate; initial systolic blood pressure; congestive heart failure complicating the infarction; and cardiogenic shock.

Among the patients who underwent cardiac catheterization during their index hospitalizations, we compared the proportion with three-vessel disease or left main coronary artery disease within each clinical subgroup in the two states, using chi-square tests. We defined vessels with more than 50 percent stenosis as diseased.

Using chi-square tests, we compared the rates of coronary-artery bypass surgery and coronary angioplasty in the two states separately for patients with one or two diseased vessels and for patients with three diseased vessels or left main coronary artery disease.

Comparing Mortality Rates and Health-Related Quality of Life

We used Cox regression analysis to assess differences between the states in mortality rates, controlling for age; sex; the type of infarct; serious chest pain more than 24 hours after admission; a history of cardiac arrest, hypertension, congestive heart failure, angina pectoris, or diabetes; initial heart rate; initial systolic blood pressure; congestive heart failure complicating the infarction; and cardiogenic shock.

We transformed the scores for the patients' perceptions of their own general health and their ability to perform instrumental activities of daily living to fit within a range from 0 (worst health) to 100 (best health). We compared these scores in the two states using analysis of covariance to adjust for the influence of potential confounding variables.

We converted the scores for angina to two categories — reported angina and no reported angina; we also converted the cardiac-capacity score to two categories — the ability to perform activities requiring energy expenditure of 5 or more metabolic equivalents (1 metabolic equivalent is defined as the amount of energy expended per minute by a resting subject) and the inability to perform those activities. We compared the likelihood of these outcomes according to state using logistic regression, controlling for potential confounding variables.

Assessing the Influence of Selection Bias

There was a potential bias due to nonresponse because data from hospital records and from surveys were not available for all patients in the sample. We used a two-stage model developed by Heckman[24,25] and applied by Grotzinger et al.[26] to assess and control for response bias in our multivariate models that involved continuous dependent variables. The two-equation system involves one equation that estimates response status (whether a case is missing or present) and another that assesses the substantive question of interest, taking into account the probability of being selected for analysis.[26]

Approval for Study Protocol

The study protocol was approved by the institutional review board of Harvard Medical School. The study was also approved and reviewed by the Health Care Financing Administration, and all patients who were alive at the time of the follow-up survey were sent a packet containing a letter from the administrator of the Health Care Financing Administration explaining how their names were selected for participation, explaining the voluntary nature of their participation, and asking that they participate in the telephone interview. Also included in the packet was a letter from the study investigators requesting participation in the study.

Results

Availability of Data

We obtained medical records for 3760 (91 percent) of the 4133 eligible patients. We eliminated the records of 49 patients who did not have clinical evidence of acute myocardial infarction, as verified by a study physician. We also eliminated the records of 22 patients for whom acute myocardial infarctions within the year before the index hospitalization were documented in their medical records. The final sample of patients with medical records comprised 1852 patients from New York (94 percent of the eligible New York sample, n = 1975) treated at 209 hospitals and 1837 patients from Texas (88 percent of the eligible Texas sample, n = 2087) treated in 269 hospitals.

The 373 eligible patients for whom we were not able to obtain hospital records were more likely than the patients for whom we were able to obtain them to have cardiac arrest or congestive heart failure listed as one of

their diagnoses, to die during the index hospitalization, and to be from Texas. They were less likely to have undergone cardiac catheterization within 90 days of the index infarction (Table 1).

Of the 2820 patients who were alive at the time of our survey, 2282 (81 percent) agreed to be interviewed by telephone. The patients we interviewed were more likely than those we did not interview to be male, to be under the age of 75, to be white, and to have undergone cardiac catheterization; they were less likely to have received a diagnosis of congestive heart failure or diabetes (Table 1).

*Table 1. Characteristics of Patients According to Whether Hospital and Interview Data Were Obtained.**

Characteristic	Hospital Data		Interview Data	
	No (N = 388)	Yes (N = 3671)	No† (N = 555)	Yes (N = 2085)
	number (percent)			
Texas resident	261 (67)	1826 (50)‡	278 (50)	1075 (52)
Age 75–79 yr	134 (35)	1211 (33)	215 (39)	570 (27)‡
Male sex	216 (56)	2085 (57)	285 (51)	1243 (60)‡
White race	345 (89)	3289 (90)	477 (86)	1879 (90)§
Diagnoses¶				
Congestive heart failure	162 (42)	1277 (35)‖	189 (34)	545 (26)‡
Angina	114 (29)	1059 (29)	162 (29)	737 (35)‖
Cardiac arrest	39 (10)	252 (7)§	8 (1)	29 (1)
Hypertension	61 (16)	674 (18)	124 (22)	473 (23)
Diabetes	47 (12)	527 (14)	98 (18)	269 (13)‖
Cardiac catheterization				
In hospital	83 (21)	797 (22)	105 (19)	618 (30)‡
Within 90 days of index admission	119 (31)	1546 (42)‡	207 (37)	1156 (55)‡
Death during index hospitalization	68 (18)	498 (14)§	—	—

*Total numbers of patients in the four categories have been weighted to adjust for unequal sample probabilities for patients who underwent cardiac catheterization and those who did not.

†Numbers include only those alive at the time of interviewing.

‡P<0.001.

§P<0.05.

¶Data are based on diagnosis codes of the *International Classification of Diseases, 9th Revision,* from the Medicare Provider Analysis and Review (MEDPAR) file.

‖P<0.01.

Characteristics of Patients

Among the patients whose hospital records were abstracted, 208 (6 percent) had left bundle-branch blocks on their initial electrocardiograms, and for 249 (7 percent), data on the type of infarct were missing. The demographic and clinical characteristics of patients who could be classified in the four clinical subgroups are shown according to state in Table 2. Among the patients with Q-wave infarctions, those treated in New York presented with lower systolic blood pressure (the group with no chest pain only) and were more likely to have congestive heart failure develop than those treated in Texas. Among patients with non–Q-wave infarctions and no chest pain during their hospital stay, those from New York were more likely to have a history of congestive heart failure or diabetes than those from Texas, but patients from Texas were more likely to have cardiogenic shock. Among those with non–Q-wave infarctions and chest pain,

Table 2. Characteristics of Patients Admitted to the Hospital for Acute Myocardial Infarction between February and May 1990, According to Patient Group and State.

Characteristic	No Chest Pain*				Chest Pain†			
	Q-wave infarction‡		non–Q-wave infarction		Q-wave infarction‡		non–Q-wave infarction	
	N.Y. (n = 525)	Tex. (n = 434)	N.Y. (n = 529)	Tex. (n = 626)	N.Y. (n = 306)	Tex. (n = 201)	N.Y. (n = 296)	Tex. (n = 273)
Age — no. (%)								
65–74 yr	360 (69)	312 (72)	340 (64)	433 (69)	205 (67)	140 (70)	188 (64)	186 (68)
75–79 yr	165 (31)	122 (28)	189 (36)	193 (31)	101 (33)	61 (30)	108 (36)	87 (32)
Male sex — no. (%)	331 (63)	265 (61)	281 (53)	367 (59)	155 (51)	119 (59)	151 (51)	146 (53)
History of congestive heart failure — no. (%)	33 (6)	38 (9)	82 (16)	60 (10)§	20 (7)	15 (7)	43 (15)	37 (14)
History of angina pectoris — no. (%)	103 (20)	91 (21)	126 (24)	141 (23)	89 (29)	47 (23)	126 (43)	80 (29)¶
History of hypertension — no. (%)	258 (49)	215 (50)	307 (58)	326 (52)	168 (55)	103 (51)	174 (59)	153 (56)
History of cardiac arrest — no. (%)	4 (<1)	2 (<1)	6 (1)	6 (1)	3 (1)	1 (<1)	5 (2)	1 (<1)
History of diabetes — no. (%)	155 (30)	109 (25)	172 (33)	159 (25)‖	93 (30)	56 (28)	116 (39)	82 (30)‖
Initial heart rate (beats/min)**	83±28	82±26	87±27	85±27	81±20	82±20	85±19	82±18
Initial systolic blood pressure (mm Hg)**	132±39	138±41‖	147±43	148±37	141±32	140±31	152±29	149±31
Congestive heart failure complicating infarction — no. (%)	181 (34)	121 (28)‖	121 (23)	145 (23)	137 (45)	68 (34)‖	88 (30)	73 (27)
Cardiogenic shock — no. (%)	181 (34)	136 (31)	72 (14)	126 (20)¶	94 (31)	65 (32)	60 (20)	51 (19)

*No serious chest pain more than 24 hours after admission.

†Serious chest pain more than 24 hours after admission.

‡New or evolving Q-wave infarction.

§P<0.01 for the comparison between the states.

¶P<0.001 for the comparison between the states.

‖P<0.05 for the comparison between the states.

**Plus–minus values are means ±SD.

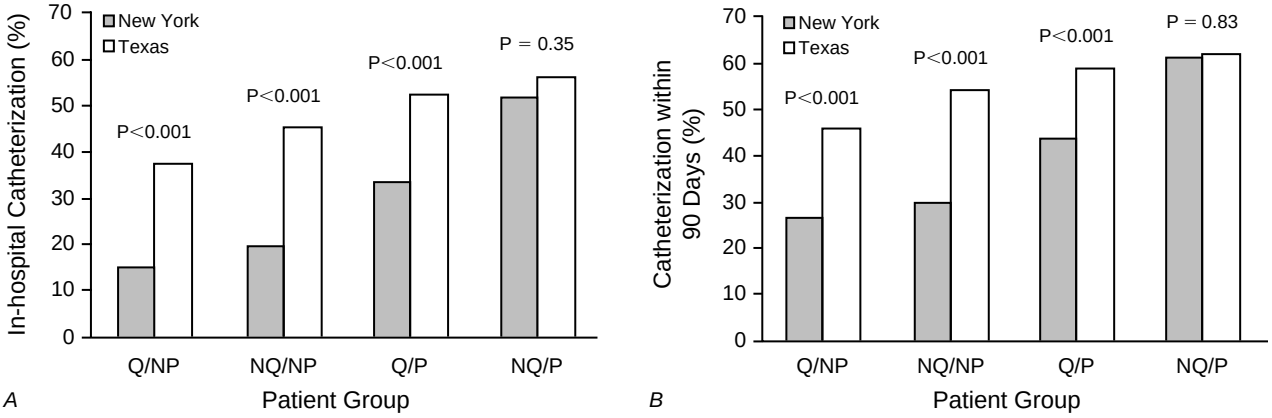

Figure 1. Use of Cardiac Catheterization during the Index Hospitalization (Panel A) and within 90 Days of the Index Hospitalization (Panel B), According to State and Patient Group.

Q denotes new or evolving Q-wave infarction, NQ non–Q-wave infarction, NP no serious chest pain more than 24 hours after admission, and P serious chest pain more than 24 hours after admission.

patients from New York were more likely to have a history of angina or diabetes.

Use of Cardiac Catheterization

Overall, the rate of cardiac catheterization within 90 days of the index admission was 45 percent in Texas and 30 percent in New York. Figure 1 shows the in-hospital and 90-day catheterization rates according to state within the patient subgroups, adjusted for potential confounding variables. Among all the patients except those with non–Q-wave infarctions and serious chest pain during hospitalization, those treated in Texas were significantly more likely than those treated in New York to undergo catheterization either in the hospital or within 90 days of admission.

Identification of Three-Vessel Disease or Left Main Coronary Artery Disease

Among the patients who underwent catheterization during their index hospitalizations, the proportion who were given a diagnosis of three-vessel disease or left main coronary artery disease was greater in New York than in Texas for patients with Q-wave infarctions and no chest pain (43 percent vs. 39 percent, P=0.52); for patients with non–Q-wave infarctions and no chest pain (55 percent vs. 43 percent, P=0.05); for patients with Q-wave infarctions and chest pain (60 percent vs. 48 percent, P=0.09); and for patients with non–Q-wave infarctions and chest pain (57 percent vs. 46 percent, P=0.07).

Use of Revascularization Procedures

Overall, the rate of coronary-artery bypass surgery within 90 days of admission was higher in Texas than in New York (15 percent vs. 13 percent, P=0.04), as was the rate of coronary angioplasty (15 percent vs. 7 percent, P<0.001). Among patients with one or two diseased vessels, the rates of coronary-artery bypass surgery were low, but patients in New York underwent the procedure more often than patients in Texas (Table 3). The rate of coronary angioplasty in this group of patients did not differ significantly in the two states, nor did the overall rate of revascularization (by either procedure).

Among patients with three diseased vessels or left main coronary artery disease, those treated in New York and those treated in Texas were equally likely to undergo coronary-artery bypass surgery (Table 3). Patients in this group who were treated in Texas were more likely to undergo coronary angioplasty than patients treated in New York, but the difference in the overall rates of revascularization was not statistically significant.

*Table 3. Percentages of Patients Who Underwent Revascularization Procedures, According to the Results of Cardiac Catheterization during the Index Hospitalization.**

Finding	Revascularization Procedure					
	Coronary-artery bypass surgery		Coronary angioplasty		Either	
	N.Y.	Tex.	N.Y.	Tex.	N.Y.	Tex.
	number (percent)					
One or two diseased vessels	33 (19)	35 (9)†	61 (35)	155 (43)	95 (54)	190 (52)
Three diseased vessels or left main coronary artery disease	124 (56)	154 (51)	23 (10)	50 (17)‡	147 (66)	204 (68)

*Patients included were those classified in one of the four patient subgroups on the basis of the type of infarction and the presence or absence of angina. Revascularization procedures occurred within 90 days of the index admission. Numbers in parentheses represent the percentages of patients with particular cardiac-catheterization findings who underwent revascularization procedures.

†P<0.01 for the comparison between the states.

‡P<0.05 for the comparison between the states.

Comparison of Mortality and Health-Related Quality of Life

The unadjusted rate of death at 90 days in both New York and Texas was 23 percent (P=0.80); at 2 years the rates were 36 percent and 37 per-

Table 4. Unadjusted and Adjusted Scores for Health Status an Average of 24 Months after Hospitalization for Acute Myocardial Infarction, According to State.

CATEGORY	UNADJUSTED SCORE		ADJUSTED SCORE*	
	N.Y.	TEX.	N.Y.	TEX.
	mean ±SE			
Perception of own general health	46.3±0.76	46.1±0.90	46.8±0.85	45.6±0.86
Ability to perform instrumental activities of daily living	77.6±0.68	76.2±0.78	78.3±0.72†	75.8±0.74

*Scores have been adjusted for age; sex; evidence of a new or evolving Q-wave infarction; serious chest pain more than 24 hours after admission; a history of cardiac arrest, hypertension, congestive heart failure, angina pectoris, or diabetes; congestive heart failure complicating the infarction; and cardiogenic shock.

†$P<0.05$ for the comparison between the states.

cent ($P=0.80$), respectively. Using a Cox proportional-hazards regression, we determined that the adjusted risk of death was lower for patients treated in New York than for those treated in Texas (hazard ratio, 0.87; 95 percent confidence interval, 0.78 to 0.98).

The adjusted scores for the patients' perceptions of their own general health did not differ between states, but the scores for the ability to perform instrumental activities of daily living were significantly better for New York patients than for Texas patients (Table 4).

The adjusted likelihood of reporting angina was greater among patients in Texas than in New York (odds ratio, 1.41; 95 percent confidence interval, 1.13 to 1.76), and they were more likely to report that they could not perform activities requiring energy expenditure of 5 or more metabolic equivalents (odds ratio, 1.62; 95 percent confidence interval, 1.26 to 2.07).

Selection models did not indicate a significant selection effect due to nonresponse in our analyses of perceived general-health status and the ability to perform instrumental activities of daily living.

DISCUSSION

We combined data from several sources — Medicare files, hospital records, and the patients themselves — to explore the patterns of the use of procedures to treat acute myocardial infarction in New York and Texas. We examined variations in practice and their consequences, controlling for important clinical characteristics of patients (for example, the type of infarction and the results of cardiac catheterization). Our data are representative of Medicare patients treated for acute myocardial infarction in two large states, not just of patients who consent to participate in randomized clinical trials[5] or who are cared for in specific hospitals.[27]

The rate of angiography was significantly higher in Texas than in New York for all the clinical subgroups of patients we studied except those at greatest risk for reinfarction. Although the overall rate of revascularization was greater in Texas than in New York, the likelihood of a procedure's being performed was similar in the two states for patients with similar angiographic results. The likelihood that three-vessel disease or left main coronary artery disease would be detected was no greater in Texas than in New York, and mortality rates and measures of the health-related quality of life were no better.

Differences in the use of cardiac catheterization may arise out of differences in the expectations of New York and Texas physicians regarding its benefits for patients at lower risk for reinfarction. This hypothesis could be explored further by surveying physicians in a manner similar to that used to assess physicians' practices with regard to drug therapy for acute myocardial infarction.[28]

Despite the greater use of cardiac catheterization in Texas, the rate of three-vessel disease or left main coronary artery disease identified in patient subgroups tended to be higher in New York than in Texas. This suggests that physicians in New York may be more discerning in selecting patients for cardiac catheterization than are physicians in Texas. However, without knowing the rate of severe cardiac disease among the patients who did not undergo cardiac catheterization, we cannot know which state is doing the better job of selecting patients.

Patients treated in Texas were 41 percent more likely than those treated in New York to report angina at the time of follow-up assessment. This result contradicts the findings of studies of differences between the United States and Canada.[4,27] In those comparisons, patients treated in the country with the higher rate of procedure use (the United States) reported less angina than patients in the country with the lower rate (Canada). Similarly, patients in Texas were less likely than those in New York to report being able to perform activities requiring energy expenditure of 5 or more metabolic equivalents. Treatment following the index admission may be responsible for a portion of the differences in these outcomes. For example, we have shown that physicians practicing in New York are more likely to treat myocardial infarctions with beta-blocker therapy than are physicians in Texas.[28]

This study has several limitations. First, its results may not be generally applicable to other states. Second, we do not know whether our results reflect the pattern of care for younger patients in these states. Third, we excluded patients treated in health maintenance organizations, where the patterns of care may be different from those reported here. In 1990, however, the proportion of eligible Medicare patients in health maintenance organizations was low in each state (7 percent in New York and 2 percent in Texas). Fourth, our assessment of differences in mortality and measures of the health-related quality of life did not adjust for base-line assessment of patients' functional status. Although the case-mix variables we included in our models overlap substantially with measures of base-line functional status, we cannot be sure whether unmeasured factors account for some of the differences we observed between states. Finally, although we attempted to assess the effect of selection bias in our analyses, there is no universally accepted method to do this, and we may not have been able to adjust completely for selection effects.

In summary, the frequency of use of angiography was higher in Texas than in New York for patients whose conditions allowed greater discretion in the use of this procedure. There appears to be no advantage to using procedures at the higher rate with respect to mortality or patients' health-related quality of life.

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