A RAND NOTE

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How Coronary Angiography Is Used

Clinical Determinants of Appropriateness

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David H. Solomon, MD; Robert H. Brook, MD, ScD

Using ratings of appropriateness derived from an expert physician panel, we measured how appropriately physicians in 1981 performed coronary angiography in a randomly selected, community-based sample of cases in the Medicare population. We studied large geographic areas (three sites) in three states, representing regions of high and low use. The high-use site had fewer procedures classified as appropriate (72%) than either low-use site (77% and 81%, respectively). Over all sites, 17% of procedures were classified as inappropriate. Patients in the high-use site were older, had less severe angina, and were less intensively medically treated than patients in either of the low-use sites. Patients without angina who had not undergone exercise testing constituted the most common subgroup of inappropriate cases. Although overall differences in appropriateness were not large, practice differences do exist. This analysis of practice differences among study sites provides the clinical basis for understanding the small, but significant, differences in the appropriateness of use of coronary angiography. The finding of 17% inappropriate use may be cause for concern.

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CORONARY angiography is an invaluable diagnostic tool; no other available technique can delineate the anatomy of the coronary circulation as precisely. Yet it is also an expensive procedure, with rates of major complications that are low but clinically important.[1-6]

Substantial differences exist from one geographic area to another in the population-based rates at which this procedure is performed.[7] Questions have been raised concerning the extent to which it is used inappropriately.[8] While many studies have contributed to our knowledge about the circumstances under which coronary angiography is efficacious, we know little about how the procedure is actually used in community practice.

See also pp 2533, 2538, and 2568.

We measured the appropriateness with which coronary angiography was performed in the elderly Medicare population of three large geographic areas in 1981. In the first article in this series, we have reported the relationship between appropriateness and rates of use in these three areas.[9] We report herein the clinical characteristics of the patients who underwent coronary angiography, the importance of these clinical factors in determining appropriateness, and how they differed among the three geographic areas.

Methods

We used Medicare physician claims data to measure population-based rates of use in 1981 of coronary angiography and other health care services in 13 large geographic areas across the United States. The methods and results of this analysis have been reported previously.[7] The mean rate of coronary angiography among these 13 sites in 1981 was 33 per 10 000 (adjusted for age and sex differences). The rates we observed ranged from a low of 22 to a high of 51 per 10 000; the differences among the 13 sites were statistically significant ($P<.001$, χ^2).

We selected three sites with rates at both extremes of the distribution in which to carry out the study of appropriateness. Site 1 had a high-use rate, and is a mixed urban and rural area. We selected two low-use sites for study because these two sites have contrasting demographic characteristics; site 3 is relatively rural, while site 2 is more urban.

We have reported the methods by which we reviewed the medical literature, developed a catalog of indications for coronary angiography, and convened a panel of expert physicians to rate each indication on a nine-point scale of appropriateness.[6,9-11] The panel was composed of three cardiologists, two internists, one family physician, two cardiac surgeons, and one radiologist. They rated 300 separate indications for

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coronary angiography.[6] (Rand reports are available at nominal cost on request from The Rand Corporation, Santa Monica, Calif.) The definition of appropriateness the panel used, the method by which it was conducted, and the way indications were classified as appropriate, equivocal, and inappropriate are described in the first article in this series.[9] In general, we used median ratings to classify indications as appropriate (ratings of 7 to 9), equivocal (ratings of 4 to 6), or inappropriate (ratings of 1 to 3). Where our panelists disagreed on appropriateness ratings, however, we classified such indications as equivocal, regardless of median rating.

Using the claims data from which we calculated overall rates of use, we selected a random sample of cases from each of the three sites. We have described in the preceding article in this series how we obtained the participation of the community-based sample of physicians who performed these coronary angiograms.[12] The overall physician participation rate for coronary angiography was 91%, comprising some 219 physicians. There were no significant differences among sites in the rates of physician participation (89%, site 1; 96%, site 2; and 93%, site 3). Participating physicians had performed 95% of sampled procedures (N = 1810).

We sought the medical records of all 1810 cases represented by participating physicians. We developed a detailed abstraction form to collect the data necessary to assign indications to each case. For example, we collected data on the nature of any chest pain (its quality, location, severity, provoking factors, and stability); results of exercise tests (treadmill, thallium, or gated–blood pool scan); medication schedules; occurrence, dates, sites, and complications of prior myocardial infarctions; and occurrence of previous coronary artery bypass graft surgery and which vessels were bypassed. We obtained photocopies of the results of all exercise tests and of the coronary angiography reports of all studied procedures. The abstraction form and guidelines for its use have been published elsewhere.[6]

Our panel used the Canadian Cardiovascular Society classification to grade the severity of angina. They defined maximal medical therapy as the use of any long-acting nitrate and any β-blocker (or a documented history of intolerance to either). We defined angina as present if any three of the following four conditions were met: chest pain present in typical location (eg, substernal, left side of the chest), pain of typical quality (eg, pressing or tight), pain typically produced by exertion, and pain typically relieved by sublingual nitroglycerin therapy. A positive exercise treadmill test result was defined as 1 mm or more of horizontal or down-sloping ST-segment depression, or the occurrence of typical angina at any time during the test after the first three minutes. A very positive exercise treadmill test result was defined as a positive test result occurring during the first three minutes of exercise, or a drop in systolic blood pressure of 20 mm Hg or more occurring during the first three minutes of exercise, or more than 2.5 mm of horizontal or down-sloping ST-segment depression at any time.

Data collection took place in hospitals, physicians' offices, and clinics as necessary to obtain complete clinical data on each case. Data collection methods are described in the preceding article in this series.[12] Of the 1810 procedures of participating physicians sampled from the claims data, we determined that 75 (4.1%) represented errors in the claims data: the procedure performed was not a coronary angiography (1.9%), the procedure was not performed in 1981 (0.4%), the procedure was not performed within the geographic area (1.8%), or the physician had no record at all of having seen the patient (1.7%).

We were able to obtain complete information in 1677 cases, or 97% of all cases eligible for inclusion in the study after excluding the claims errors. Data were incomplete in 58 cases (3%) and were excluded either because medical records known to exist could not be found (56 cases) or because available medical records from all sources could not provide data complete enough for us to determine the indication for the procedure (two cases).

Based on data elements recorded in the abstraction forms, one or more indications was assigned to each case. For cases with more than one indication, the one with the highest appropriateness rating was designated the primary indication and was used throughout the subsequent analysis. In the preceding article in this series, we reported studies of the validity of the complete process of medical records abstraction and indications assignment.[12]

We sampled roughly equal numbers of cases in each site to maximize our ability to detect differences among sites. With 500 cases in each site, we could expect to detect a true difference of eight percentage points in appropriate or inappropriate use in at least 80% of repeated trials. We tested for differences in the distributions among sites of patient characteristics and indications using χ^2 tests.[13]

RESULTS

Demographic and clinical characteristics of the patient populations in each site are listed in Table 1. The sites differ on several of these factors. Patients in the high-use site were significantly older than in either of the low-use sites; 21% of patients in site 1 were older than 74 years, compared with 15% in site 2, and 9% in site 3. Patients in the high-use site were also more likely to have had a previous coronary angiogram or previous coronary artery bypass surgery (CABS) than in either of the low-use sites.

Significant differences among sites were observed in the proportion of patients with previous myocardial infarction and those with congestive heart failure. These differences were not, however, consistently related to the rate of use of coronary angiography. No significant differences among sites were observed in race or sex or the proportion of patients with angina.

We divided the 300 indications for coronary angiography into 12 major clinical groups according to the patient's major presenting complaint. The distribution of cases whose primary indications fell in each major clinical group in each site is shown in Table 2. In general, patients received coronary angiography for the same reasons in all sites. In site 1, chronic stable angina, unstable angina, and valvular disease accounted for 64% of patients; in site 2, for 66%; and in site 3, for 65%.

Only minor differences among sites are apparent in the distributions of patients by major clinical group. Somewhat fewer patients in the high-use site received their coronary angiograms during or after hospital admission for unstable angina than in the low-use sites: 22% in site 1 compared with 29% in site 2, and 28% in site 3. As suggested by data in Table 1, more patients in site 1 had their coronary angiograms following CABS than in either of the low-use sites. Other differences were minor and inconsistently related to overall rates of use.

Table 3 shows how the cases in each site were distributed by groupings of indications for each appropriateness category and gives more detail about severity of symptoms, results of noninvasive tests, and level of medical therapy. The high-use site (site 1) demonstrated significantly fewer appropriate cases than either of the low-use sites. The high-use site showed more equivocal cases than either of the low-use sites, but there were no significant differences in the distribution of inappropriate cases by site.

Table 1.—Demographic and Clinical Characteristics of Patients Undergoing Coronary Angiography in Three Geographic Areas in 1981

Characteristic*	Site No. 1 (n=628)	2 (n=514)	3 (n=535)
Coronary angiography rate/10 000 elderly†	50	23	22
Age, y, %‡			
64-69	47	55	63
70-74	31	31	27
75-79	15	13	8
≥80	6	2	1
Sex, %§			
M	60	58	58
Nonwhite, %§	6	9	7
Congestive heart failure, %‖	21	27	20
Angina, %§	37	36	37
Previous MI, %¶			
0	55	47	63
1	35	37	28
>1	10	16	9
Previous CABS, %‡	9	4	3
Previous coronary angiography, %‡	15	9	8

*MI indicates myocardial infarction; and CABS, coronary artery bypass surgery.
†The rates for persons aged 65 years or older in 1981 are adjusted for differences in age and sex among sites.[7]
‡$P<.01$ for differences in age distribution among sites.
§$P>.05$ for differences among sites in sex and race distributions and in percent of patients with angina.
‖$P<.05$ for differences among sites in percent of patients with congestive heart failure.
¶$P<.01$ for differences among sites in percent of patients with none, one, or more than one previous MI.

Table 2.—Distribution of Patients Who Underwent Coronary Angiography by Major Clinical Group and Site

Major Clinical Group, %*	Site No.† 1 (n=628)	2 (n=514)	3 (n=535)
Chronic stable angina	28	25	28
Unstable angina‡	17	22	20
Valve disease	19	19	17
Following MI§	10	12	9
Nonspecific chest pain	8	4	11
Following unstable angina‖	5	7	8
Following CABS	5	2	1
Asymptomatic	3	1	2
During an acute MI¶	2	2	1
Congestive heart failure	2	3	2
Following survival from sudden cardiac arrest	<1	<1	<1
Other	1	1	2

*MI indicates myocardial infarction; and CABS, coronary artery bypass surgery.
†Column percentages may not add up to 100% due to rounding.
‡Coronary angiography was performed during the hospital admission occasioned by unstable angina.
§This is defined as within six months of an MI (but more than six days after its onset).
‖This is defined as within three months of hospital discharge following an episode of unstable angina.
¶This is defined as within six days of the onset of MI.

To understand better the differences among sites in distribution of cases by appropriateness category, we examined the severity of patients' angina and degree of medical therapy in each site. Data in Table 4 show that for patients with clinical manifestations of coronary artery disease, those in site 1 had significantly less severe angina than patients in either low-use site. Patients in site 1 were also less frequently treated with long-acting nitrates and β-blockers, a regimen our panel defined as maximal medical therapy for 1981. In site 1, of the patients with angina, 52% received maximal therapy compared with 70% in site 2, and 63% in site 3 ($P<.01$, χ^2).

We looked further at intensity of medical management by measuring the daily dose of propranolol hydrochloride received by each patient with angina receiving this drug. In our sample of 1981 patients, this drug was by far the most frequently used β-blocker. Among all sites, 81% of patients receiving β-blockers were taking propranolol (81%, site 1; 83%, site 2; and 78%, site 3; $P>.05$, χ^2). Data in Table 4 show the distribution of patients according to their daily dose of propranolol in each site. More patients with angina receiving propranolol received low daily doses in site 1 than in either low-use site.

Finally, data in Table 4 also show the results of angiography by site for those patients with angina (stable or unstable) or other clinical manifestations of coronary artery disease (myocardial infarction or previous CABS). There were no significant differences among sites in the severity of coronary artery disease discovered at the time of angiography. The results were the same whether we used a criterion of 50% reduction in luminal diameter or the 70% criterion used in the data presented in Table 4.

COMMENT

We studied how appropriately physicians used coronary angiography in 1981 in the elderly Medicare population. We examined cases from three large geographic areas, one with a high rate of use and two with low rates of use for this procedure. The fact that patients in the high-use site were more likely to have had a previous coronary angiogram or CABS suggests that these patterns of high- and low-use were present for some time before 1981.

We found that physicians used coronary angiography differently in the high-use site compared with their counterparts in the two low-use sites. Patients in site 1 were older, had less severe angina, and were less often treated with maximal medical therapy than patients in the low-use sites. These findings help explain our finding of fewer appropriate and more equivocal procedures in site 1 than sites 2 or 3. Over all sites, about three fourths of the cases were classified appropriate.

There were no significant differences among sites in the frequency of cases classified as inappropriate. There were, however, a substantial proportion of inappropriate procedures in all three sites, averaging 17% of all cases. Patients who had no angina and no functional evaluation by means of exercise testing constituted the most frequent group, accounting for about half of all inappropriate cases over all three sites. Among these patients, about two thirds had previously sustained a myocardial infarction, undergone CABS, had stable angina, or been hospitalized for unstable angina. The remaining one third were entirely asymptomatic or had nonspecific chest pain.

The results of coronary angiography in our patients showed no differences in severity of coronary artery disease among sites. We expected to find somewhat less severe disease in site 1, because patients there had less severe symptoms and less intensive medical treatment than patients in the other sites. The most likely explanation for this finding is that patients in site 1 were significantly older than their counterparts in the other sites. Probably the effect of increased age cancelled out the effects of decreased levels of symptoms and treatment.

The principal factor that might limit the generalizability of our results is that we studied the use of coronary angiography in 1981. Our expert panel rated the appropriateness of performing this procedure based on information known to have been available and known standards of practice in 1981. What has changed since 1981? The most important changes have been the addition of new data on the efficacy of CABS and the emergence of several new treatments: calcium-channel blocking agents for the medical treatment of angina, intracoronary thrombolytic treatment of acute myocardial infarction, and transluminal angioplasty as an alternative to CABS.

Table 3.—Indications for Coronary Angiography by Site for Each Appropriateness Category

Indications, %*	Site No. 1 (n=628)	2 (n=514)	3 (n=535)
Appropriate			
During evaluation of valve disease	19	19	17
Unstable angina			
Pain controlled	12	13	12
Pain persists	4	8	7
Stable angina			
Class III or IV, maximal therapy	8	12	12
Class III or IV, less than maximal therapy, positive or very positive treadmill test result	3	1	3
Class I or II, maximal therapy, positive or very positive treadmill test result	3	2	2
Class I or II, less than maximal therapy, positive or very positive treadmill test result	4	2	5
Stable angina following MI, unstable angina, or CABS			
Class III or IV	7	14	10
Class I or II	3	2	2
Nonspecific chest pain with positive or very positive treadmill test result	4	1	3
Following MI, unstable angina, or CABS, no angina, with positive or very positive treadmill test result	2	1	4
Other appropriate	3	2	4
Total % appropriate†	72	77	81
Equivocal			
Stable angina			
Class III or IV; less than maximal therapy; no or negative treadmill test result	4	3	2
Class I or II, maximal therapy; no or negative treadmill test result	1	2	1
No angina (asymptomatic, post MI, or previous stable angina), positive treadmill test result; negative or absent exercise thallium scan test result	4	1	1
Other equivocal	2	1	1
Total % equivocal‡	10	7	4
Inappropriate			
No angina, no exercise tests performed, post MI, post CABS, following unstable angina, or previous stable angina	6	5	1
Asymptomatic or nonspecific chest pain	3	3	5
No angina, negative treadmill test result, post MI, post CABS, following unstable angina, or previous stable angina	2	<1	1
Nonspecific chest pain	2	<1	3
Stable angina, class I or II, less than maximal therapy, absent or negative treadmill test result	2	2	1
Congestive heart failure	2	3	2
During acute, uncomplicated MI§	1	1	<1
Other inappropriate	1	1	1
Total % inappropriate‖	18	17	15

*MI indicates myocardial infarction; and CABS, coronary artery bypass surgery.

†$P<.01$ for differences in frequency of appropriate indications among all sites and for site 1 vs sites 2 and 3 combined.

‡$P<.01$ for differences in frequency of equivocal indications among all sites and for site 1 vs sites 2 and 3 combined. Column percentages may not add up to total percentages due to rounding.

§These cases represent the use of coronary angiography solely for diagnostic purposes and do not include instances where intracoronary streptokinase was administered; seven such cases were excluded from the analysis.

‖$P>.05$ for differences in frequency of inappropriate indications among all sites and for site 1 vs sites 2 and 3 combined. Column percentages may not add up to total percentages due to rounding.

In 1981, the available data suggested that many, if not all, patients with angina who had three-vessel disease and reasonable ventricular function benefited from CABS, with improved survival.[6,14-16] Recent studies have documented that in patients with mild angina this benefit is probably limited to those patients with three-vessel disease who have modest reductions in ejection fraction.[17-19] Medical treatment of angina has improved significantly since 1981, with the addition of calcium-channel blocking agents and a wider spectrum of β-blockers. The increased efficacy of medical treatment,[20-22] and our improved understanding of the role of CABS might lead experts today to view the use of coronary angiography in patients with mild angina or who have received less than maximal medical therapy as less appropriate than our panel did for 1981.

The use of intracoronary thrombolytic therapy today is limited to a few institutions and not often used in the elderly because of the prevalence of complicating comorbid conditions. Furthermore, it may be supplanted by the intravenous use of tissue plasminogen activator.[23] Because research has yet to document the efficacy of transluminal angioplasty in enhancing survival, its principal appropriate use today is to treat anginal pain. As just discussed, the increased spectrum of medical treatment for angina may have reduced the appropriateness of proceeding to invasive treatment before medical therapy has been exhausted.

In summary, it seems unlikely that any of the major uses of coronary angiography we classified as inappropriate in 1981 would today be considered appropriate. Possibly some of the uses we described as appropriate for 1981—particularly for patients with mild angina and those with less than maximal medical therapy—might be considered as less than appropriate today.

We believe our method of rating the appropriateness of indications for coronary angiography has validity; it separates clinically important differences in appropriateness among different indications for the procedure. While we have not demonstrated predictive validity (eg, that patients who received coronary angiography for indications rated appropriate by our panel have better health outcomes than if they had not received it), we believe the ratings demonstrate face validity and content validity.

Examining the data in Table 3, we believe most physicians will agree that the appropriate indications in the first section of the table represent circumstances under which coronary angiography is clearly indicated, many of which have been well documented in the clinical literature. The appropriateness of coronary angiography for the equivocal indications is far less clear. For the inappropriate indications, we believe few physicians would advocate the routine use of coronary angiography. There is much less, if any, solid research data documenting the efficacy of coronary angiography in these circumstances.

Table 4.—Angina Class, Propranolol Hydrochloride Dose, and Angiography Results By Site

	Site No.		
	1	2	3
Angina class, %*			
None	26	17	16
I	3	1	4
II	26	20	21
III	34	40	44
IV	11	22	16
Sample size, No.	303	242	243
Daily propranolol dose, mg, %†			
20-40	34	16	15
60-80	35	31	31
120-240	25	46	49
>240	6	8	5
Sample size, No.	71	101	84
No. of major coronary vessels with ≥ 70% reduction in luminal diameter, %‡			
0	17	19	18
1	24	21	27
2	29	31	30
3	23	22	20
Left main	6	7	6
Sample size, No.	420	365	353

*This includes those patients who received coronary angiography for chronic stable angina, following a myocardial infarction, an episode of unstable angina, or coronary artery bypass surgery. $P<.01$ for differences among all sites, and for site 1 vs sites 2 and 3 combined.

†This includes only patients with angina classes I through IV receiving propranolol therapy. $P<.05$ for differences among sites; $P<.01$ for differences between site 1 vs sites 2 and 3 combined.

‡This excludes patients with no symptoms, nonspecific chest pain, congestive heart failure, and valvular disease. $P>.05$ for differences among all sites and for site 1 vs sites 2 and 3 combined.

These results can be viewed from several different perspectives. Physicians may argue that preservation of clinical independence and the full exercise of clinical judgment dictate that an indication be considered appropriate if a single physician believes it to be so. Payers might be less willing to provide reimbursement automatically for indications rated clearly inappropriate; they might, for example, see these as circumstances warranting second opinions. Before undergoing a procedure, a patient might want to know the relative appropriateness of the indication for it. Such information would allow the patient to add his or her preferences toward risk and benefit into the decision-making process. Some patients may prefer to undergo a procedure if the benefits only slightly outweigh the risks (eg, a 6 on a scale like the one we used); others may demand a wider margin.

We believe our findings on the differences among sites in the approaches physicians take toward coronary angiography can stimulate a productive educational dialogue. Data like these can help generate better agreement among physicians on when coronary angiography should and should not be performed. Our data on the level of appropriateness with which coronary angiography was performed in 1981 require confirmation for more recent years and younger populations and need further validation by different methods. If confirmed, our finding that one of six coronary angiograms is performed inappropriately would suggest the need for an increased professional effort to improve the appropriateness with which this procedure is used.

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