Is Coronary Angiography Underused in an Inner-City Population?

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Purpose: We sought to determine, prospectively, if any race or sex disparities in coronary angiography use was explained by standardized criteria for the procedure.

Methods: We prospectively identified 153 patients ≥40 years of age who underwent evaluation for coronary disease from December 1998 to November 1999 at a municipal hospital. Patients requiring angiography were referred to a nearby academic facility. Information abstracted from medical records was used to assess appropriateness of management and clinical outcomes. Physician reviewers used RAND criteria to rate the appropriateness and necessity for angiography. Multivariate logistic regression models determined predictors of angiography.

Results: Blacks and Hispanics made up 78% of patients, and proportions of men and women were similar. The patients' mean age was 58.4 years (± 10.4). The most frequent indication for angiography was atypical chest pain (32.7%). Approximately two thirds of the population had two or more coronary risk factors (such as diabetes and hypertension). Angiography was rated necessary for 75% (*n*=77) of patients; of these, 66.2% had the procedure. Among those undergoing angiography, two thirds had clinical disease (≥50% stenosis of a major vessel). In multivariate logistic regression models, urgent indications, such as post-myocardial infarction angina or exacerbation of angina, were the strongest predictors for angiography (odds ratio 3.9, 95% confidence interval 1.7–9.1]). During the 18 months of follow-up, no deaths were seen among the medically treated patients for whom angiography was rated necessary (*n*=26).

Conclusion: Angiography was underused in this publicly insured population. Improved access to coronary angiography among minority populations with multiple coronary risk factors is still needed. (*Ethn Dis.* 2006;16:659–665)

Key Words: Coronary Angiography, Disparities, Race, Sex

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BACKGROUND

Racial, ethnic, and sex disparities in the use of invasive cardiac procedures, such as coronary angiography and revascularization, have been well documented.[1–5] However, most reports are based on retrospective chart reviews or secondary analyses of large administrative databases, which often contain limited clinical information. Few studies have examined whether differences exist in the appropriateness of such procedures by race or sex based on standardized clinical criteria or prospectively followed patients to determine clinical outcomes among those who did not receive an indicated procedure.[6–8] The purpose of this study was to determine if referral to coronary angiography differed by either race/ethnicity or sex among patients with symptoms suggestive of coronary ischemia and, if so, whether differences were explained by standard clinical criteria for the procedure. We also wanted to determine if any adverse outcomes occurred among persons for whom angiography was judged necessary but who did not undergo the procedure within 18 months of presentation.

METHODS

Patient Population and Data Collection

Individuals undergoing evaluation in the general medical inpatient or outpatient services (eg, the outpatient clinic or stress testing laboratory) for

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coronary symptoms were prospectively identified by using computer records at a municipal hospital center in the Bronx, New York. Patients were recruited weekly over 12 months starting in December 1998 and followed for 18 months. Patients were eligible for the study if they were ≥40 years of age and undergoing evaluation for chest pain/pressure or angina equivalents. Patients were excluded if they had limited life expectancy (eg, AIDS, metastatic cancer, leukemia, lymphoma, severe refractory heart failure) at the time of enrollment; significant mental/cognitive disorders (eg, dementia, Alzheimer's disease) that would preclude their ability to give consent for interviews; or a history of severe valvular heart disease, congenital heart disease, or previous coronary artery bypass graft. Patients were also excluded if they underwent stress testing solely to establish an exercise regimen or as part of a preoperative evaluation. We initially screened 513 patient records by using information contained in the computer system. Of these, 357 records appeared to meet inclusion criteria and were retrieved for full abstraction. Fewer than half (*n*=165) of the patient records that were abstracted met all eligibility criteria, and 153 agreed to participate

(92.7%). The study was approved by the institutional review board of the academic affiliate institution of the hospital center and all patients who participated completed an informed consent form by telephone per study protocol.

Trained medical record abstractors used standardized forms to collect patient demographic data (age, sex, race/ethnicity, and insurance carrier status) and detailed information on medical history, clinical presentation, angina severity as classified by the Canadian Cardiovascular Society, current medications, cardiac risk factors, and angiography results.[9]

Insurance providers overlapped; therefore, categories were created based on the primary payer. For example, those with Medicare and private insurance were coded as private ($n=34$); Medicare and Medicaid as Medicare ($n=38$); and Medicaid and self-pay as Medicaid ($n=75$). Information on insurance could not be determined for six subjects.

Appropriateness and Necessity Measures

The RAND criteria for coronary angiography were used by trained physician reviewers to assess the appropriateness and necessity of coronary angiography for each study case.[10–12] These comprehensive criteria were developed by a national multispecialty expert physician panel and applied to patients undergoing coronary angiography in New York State. The criteria include detailed information on the patient's medical history and clinical data. Angiography was considered inappropriate if the panel deemed that the risks associated with the procedure exceeded the procedure's potential benefits and were reflected in a median rating of 1 to 3 (on a 9-point scale) without disagreement among the panelists. A case was considered uncertain in appropriateness if the median score was 4–6 (ie, the risks and benefits were similar) or the panel members dis-

Table 1. Examples of indications for angiography

Clinical Indications	Appropriateness Category
*Atypical chest pain, positive EST, two or more coronary heart disease risk factors, normal ejection fraction, age <75 (males) or 50–75 years (females)	Appropriate
†Chronic stable angina (class III/IV), on less than maximal medicine, indeterminate EST, normal ejection fraction, age <75 years	Uncertain
‡Chronic stable angina (class I/II), on less than maximal medicine, no EST, normal ejection fraction, age <75 years	Inappropriate
New-onset or crescendo angina requiring hospitalization to rule out myocardial infarction (MI)	Appropriate
≤21 days after acute MI with recurrent angina or asymptomatic with a very positive exercise stress test	Appropriate

* Coronary risk factors include smoking, diabetes, hypertension, hypercholesterolemia, and family history of premature coronary heart disease.
† Angina class based on the Canadian Cardiovascular Society classification of symptoms, which ranges from I (mild) to IV (severe).
‡ Maximal medical therapy implies receiving two or more anti-anginal medications.
EST=exercise stress test.

agreed. Cases were considered appropriate if the median rating was 7–9 without disagreement. Cases were considered necessary if they were appropriate without panel disagreement and the panel's median necessity score was 7–9, which indicated that the panel believed withholding the procedure would be improper, that the patient may benefit, and that the benefit is likely to be large. Underuse occurs when angiography is rated necessary but the procedure is not performed.[8] All abstracted records were reviewed by physicians for accuracy and re-abstracted to assess inter-rater agreement (89%). Then 10% ($n=15$) of all case records were randomly selected for review by an outside expert to assess completeness and accuracy in the application of the RAND criteria. Agreement was 93% (14/15). Examples of the most common indications for angiography are in Table 1.

Data Analysis

We generated descriptive statistics to characterize the study population (such as percentage female, Hispanic, etc). Univariate analyses were used to calculate the crude rates for coronary angiography according to sex, race/ethnicity,

clinical diagnosis, coronary risk factors, insurance status, and appropriateness ratings. Significance for these associations were determined by using chi-square tests for the categorical variables and Student t tests for differences in continuous variables.[13] Similar analyses were also done for those subjects for whom the procedure was rated necessary.

In multiple logistic regression equations, independent variables were collapsed if they had more than two categories. For example, Blacks were coded as the referent group and compared to all others; Hispanics were also a referent group and compared to all others. Insurance status was dichotomized into insured (private or Medicare) vs underinsured (Medicaid or self-pay). Indications for angiography were dichotomized into urgent (ie, unstable angina, exacerbation of class III/IV angina, post-myocardial infarction [MI] angina, or recent MI) vs nonurgent (atypical chest pain or class I/II angina). Other independent variables included in the regression models were age, which remained a continuous variable, and sex (male vs female). Separate regression models were constructed for patients that met RAND criteria for necessity ($n=77$).

Table 2. Patient characteristics

Total *N*=153	*n (%)*
Female	79 (51.6)
Race/ethnicity	
Hispanic	71 (46.4)
Non-Hispanic Black	48 (31.3)
White	18 (11.8)
Others*	16 (10.5)
Coronary risk factors	
Smoking (within previous 6 months)	45 (29.4)
Diabetes	66 (43.1)
Hypertension	111 (72.5)
Hypercholesterolemia	94 (61.4)
2 or more coronary risk factors	95 (65.5)
Payer status	
Medicaid and self-pay	75 (49.0)
Medicare	38 (24.8)
Private	34 (22.2)
Unknown	6 (3.9)
Clinical diagnosis	
Atypical chest pain	50 (32.7)
Chronic stable angina class I/II	26 (17.0)
Chronic stable angina class III/IV	39 (25.5)
Unstable angina	18 (11.8)
Recent myocardial infarction (MI)†	20 (13.1)
Stress test results	
Strongly positive	27 (19.9)
Positive	78 (57.4)
Indeterminate	18 (13.4)
Negative	12 (8.8)
Angiography rating	
Appropriate and necessary	77 (75.5)
Appropriate but not necessary	28 (26.4)
Uncertain	35 (22.8)
Inappropriate	13 (8.5)

* Others include 3 Asians, 6 Guyanese, 4 of unknown ethnicity or race, and 3 ''Other.''
† MI within 30 days of enrollment into the study.
N=135 for patients that had stress testing.

Outcomes of Interest

All the independent variables were entered into multiple logistic regression equations to determine predictors of the main outcome or dependent variable (ie, angiography within 90 days of study enrollment). Secondary outcomes data were collected through 18 months of follow-up on all medically treated patients (ie, not referred to angiography) but for whom the procedure was deemed necessary. These patients were telephoned semi-annually to determine the following: recurrent chest pain or unstable angina, acute MI, congestive heart failure, or death. Patients who indicated an outcome of interest had occurred were also asked if they had any further diagnostic testing or a heart procedure, such as angiography or open heart surgery. Information on these secondary outcomes was adjudicated by medical record abstractions.

RESULTS

The patients' mean age was 58.4 years (standard deviation [SD]=10.4). Patient sex, ethnicity, and Medicaid status can be found in Table 2. Almost three quarters of the patients were diagnosed with hypertension, and 43% had diabetes. Although two thirds of the patients had two or more risk factors for coronary disease, atypical chest pain (32.7%) was the most frequent diagnosis or indication for angiography. One quarter of patients presented with or after an episode of unstable angina or MI.

The most frequent indications for coronary angiography are shown in Table 1. Cases were classified into four groups: inappropriate, uncertain, appropriate but not necessary, and appropriate and necessary. Of the 153 study cases, <10% (*n*=13) were inappropriate, and ≈ 20% (*n*=35) were uncertain. Of the 105 patients for whom angiography was rated appropriate, all RAND panel ratings agreed completely for 102 (97.1%) cases. Of the 105 patients, angiography was rated as appropriate but not necessary for 28 (26.7%) cases, and 77 (75.5%) met necessity criteria (ie, appropriate and necessary).

Overall no demographic differences were seen among patients who underwent angiography (*n*=78) compared to those who did not. However, differences were found according to clinical indications for the procedure. Patients who had a recent myocardial infarction or a positive stress test were more likely to undergo angiography than patients with chest pain or negative stress test, respectively (see Table 3). Among the 78 patients who had angiography, two thirds (*n*=51) had clinically significant coronary artery disease, defined as ≥50% stenosis of a major coronary vessel. No significant differences were seen in coronary disease status based on the appropriateness ratings. While cases rated appropriate were most likely to undergo coronary angiography, little difference was seen between cases rated uncertain or inappropriate (57.1%, 40%, and 30.8%, respectively; overall *P*=.07) (Table 4). Of the 28 cases that were rated appropriate but not

Table 3. Angiography rates

Characteristic	Percentage of Patients Who Had Angiography	
Sex		
Female (*n*=79)	48.1	
Male (*n*=74)	54.1	*P*=.46
Race/ethnicity		
Non-Hispanic Black (*n*=48)	44.7	
Hispanic (*n*=71)	53.5	*P*=.72
White (*n*=18)	50.0	
Other (*n*=16)	58.8	
Payer status*		
Medicaid/self-pay (*n*=75)	53.3	
Medicare (*n*=38)	42.1	*P*=.24
Private (*n*=34)	61.8	
Clinical diagnosis		
Atypical chest pain (*n*=50)	30.0	
Mild angina (*n*=26)	38.5	
Moderate-severe angina (*n*=57)	61.4	*P*<.001
Recent myocardial infarction (*n*=20)	90.0	
Stress test results		
Positive (*n*=105)	55.2	
Negative or indeterminate (*n*=30)	30.0	*P*=.01
Appropriateness ratings		
Appropriate (*n*=105)	57.1	
Uncertain (*n*=35)	40.0	*P*=.07
Inappropriate (*n*=13)	30.8	
Necessity ratings		
Necessary (*n*=77)	66.2	
Not necessary (*n*=10)	40.0	*P*=.10

* No data on insurance for six subjects, *n*=147.
N=135 for patients that had stress testing.
Necessity rating given only if angiography rated appropriate (7, 8, or 9) and no disagreement in panel rating.

necessary, nine (32%) had the procedure. When necessity criteria were applied, cases rated appropriate and necessary more often had angiography compared to those that were not necessary (66.2% vs 40.0%; *P*=.10).

After controlling for age, sex, race/ethnicity, and insurance status, patients with an urgent indication (ie, unstable angina, exacerbation of class III/IV, acute MI, or post-MI angina) were almost four times more likely to undergo angiography, compared to those with non-urgent indications (ie, atypical chest pain or class I/II angina), OR=3.9, 95% CI=1.7–9.1. Results were similar when stratified by appropriateness and necessity criteria. Outcomes data collected over an 18-month follow-up showed no deaths and one subsequent revascularization procedure (coronary artery bypass graft) among 26 of 77 (33.8%) patients for whom the procedure was rated necessary but who were managed medically.

DISCUSSION

The main findings from this study are that clinical diagnosis or indication for angiography was the most important predictor for its use and that one third of patients for whom the procedure was rated necessary did not undergo coronary angiography. Despite this underuse, no adverse clinical events were seen over an 18-month follow-up period.

This study extends earlier reports that found evidence of underuse of coronary angiography ranging from 20% to 60% of eligible patients by prospectively applying standardized clinical criteria to assess the appropriateness of angiography and measuring outcomes in a predominately minority, inner-city population.[8,14–17] This study confirms that coronary angiography is still underused in minority populations. We also found that angiography was used for uncertain or equivocal indications, but few were done inappropriately.[11] Ongoing initiatives to lessen disparities in cardiovascular care need more innovative strategies to improve access to coronary angiography when clinically indicated and lower use of the procedure when indications are inappropriate and possibly of uncertain appropriateness.

We found that clinical diagnosis or indication for angiography predicted its use. Several reasons might account for our findings. First, our study was conducted prospectively for patients being evaluated for symptoms suggestive of coronary ischemia and had detailed clinical information on cardiac history, prescribed medications, and results of noninvasive testing. Many of the larger scale studies examining for disparities in cardiac care have done so retrospectively or focused on revascularization procedures or hospitalized patients.[18–22] Second, most patients recruited for our study had already undergone stress testing. Noninvasive testing correlates with invasive cardiac procedure rates.[23,24] Third, the study population was somewhat homogenous in that most were Hispanic or Black and Medicaid recipients.

Other studies have found underuse of angiography.[8,14,25] A study examining rates of coronary angiography in the Veterans Administration hospital found significant underuse of the procedure, compared to fee-for-service systems.[14] Similar results have also been reported in public compared to private hospitals.[8,26,27] A researcher examining the

Table 4. Angiography rates among those for whom angiography was rated necessary*

Total *N*=77	Percentage of Patients Who Had Necessary Angiography	
	66.2	
Sex		
Female (*n*=40)	65.0	
Male (*n*=37)	67.6	*P*=.81
Race/ethnicity		
Non-Hispanic Black (*n*=23)	78.3	
Hispanic (*n*=34)	64.7	*P*=.30
White (*n*=11)	45.5	
Other (*n*=9)	66.7	
Payer status		
Medicaid/self-pay (*n*=39)	66.7	
Medicare (*n*=19)	63.2	*P*=.83
Private (*n*=18)	72.2	
Clinical indication		
Atypical chest pain (*n*=17)	58.8	
Mild angina (*n*=14)	35.7	
Moderate-severe angina (*n*=32)	71.9	*P*=.01
Acute myocardial infarction (*n*=14)	92.9	

* Necessity rating given only if angiography rated appropriate (7, 8, or 9) and no disagreement in panel rating; 51 (66.2%) patients had a necessary angiography, 26 did not (33.8%).

[One of] the main findings from this study is that one third of patients for whom the procedure was rated necessary did not undergo coronary angiography.

impact of social factors on the delivery of cardiac care found that patients who received care at the voluntary hospital where the invasive procedures were provided were more likely to undergo coronary angiography than patients who received care from an affiliate public hospital without such services.[27] Patients in our study also received care from a public hospital that did not provide coronary angiography; instead, they must be referred to a nearby academic medical center. Perhaps this off-site referral process might have led to difficulties arranging inpatient transfers or coordinating outpatient procedures. One plausible way to minimize problems with transferring patients to other facilities for specialty care is to equip more public hospitals with invasive cardiac services in communities such as the Bronx that have high rates of coronary disease.[3,28,29] The strategy of regionalizing specialized invasive procedures to high-volume medical centers has been previously proposed in an effort to reduce variation in cardiac care, duplication of services, as well as

improve clinical outcomes.[14,17,30–32] However, patients in our study did not experience adverse clinical outcomes, as other studies have found.[31,33] The current study site has begun plans to expand cardiac services offered to their patients. Future research should determine if angiography use increases appropriately. This research is of particular importance since almost one third of patients had angiography for uncertain or equivocal indications. Thus, improving access may lead to both increased use of angiography in patients judged as appropriate or necessary candidates for the procedure as well as among those for whom the procedure was rated inappropriate or equivocal in appropriateness.[11]

Our study has several limitations. We only used appropriateness criteria from RAND, and our results might be different if other criteria were used.[21,32] RAND criteria for angiography are exhaustive and sufficiently detailed to allow all possible clinical presentations and indications for the procedure to be rated accordingly.[10,11] These criteria

have also been used by many researchers, have good inter-panel agreement between the appropriateness classifications, and have scientific data supporting their reproducibility and validity.[8,34–36] The absence of race or sex disparities in angiography use might be due to limited power, since our sample size was small. On the other hand, our study population was homogenous with respect to socioeconomic status, and Caucasians represented only 12% of the sample. We examined angiography rates from one institution, and referral to angiography varies by geographic regions.[15,31,37] Our results might be different if several sites were studied with larger samples. Nonetheless, we found, as did others, that angiography was underused, and interview data did not reveal that refusal was a reason for the underuse.[14,38]

In conclusion, clinical indication for angiography was the strongest predictor for the procedure and not the patients' race/ethnicity or sex. Innovative strategies are warranted to lessen barriers to angiography to ensure that all who need the procedure can have it. While improving access to the procedure, healthcare providers need to further weigh the risk and benefits among patients for whom indications for angiography are considered uncertain or equivocal in appropriateness and to avoid referring patients for this procedure for inappropriate indications. Future research should examine not only outcomes among patients who do not have angiography when indicated

but also among those who have the procedure under equivocal circumstances.

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