

Frequency of Negative Coronary Arteriographic Findings in Patients with Chest Pain Is Related to Community Practice Patterns

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Objective: To determine factors contributing to the relatively high frequency and variability (10% to 30%) of finding no significant coronary disease by coronary angiography in patients with chest pain.

Study Design: Retrospective, comparative analysis of practice patterns at 3 southeastern Michigan hospitals and a composite sample from New York State.

Patients and Methods: Medical records for 7668 patients were reviewed to determine the frequency of negative coronary arteriographic findings in patients undergoing chest pain evaluation. A private practice allopathic community hospital with interventional cardiologists and a private practice osteopathic community hospital with diagnostic facilities (DiagCommunity) were compared with a university hospital with full-time salaried interventional cardiologists and a sample of 17 New York hospitals.

Results: Of the 7668 coronary angiograms at all centers, 39.7% were performed to assess patients with stable chest pain. There was no significant obstruction found in 16.5%, and the frequency was not different between the Michigan (17.8% \pm 3.8%) and New York (14.2%) hospitals. The DiagCommunity had the highest proportion (22%; $P < .001$ vs others). On review of the negative coronary arteriographic findings, normal or near normal coronary arteriographic findings were infrequent (range, 2.4%-6.6%) but higher in the DiagCommunity (6.6% vs 2.9% \pm 1.6%; $P < .0001$).

Conclusions: The frequency of finding no significant coronary disease by arteriography in patients with chest pain is similar in southeastern Michigan hospitals and comparable to an established external database. Cardiology self-referral and personal gain does not seem to be a major factor in selection of patients for invasive studies.

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low rates of inappropriate use of coronary arteriography, but others have questioned the methods.¹⁻⁵

A consortium of major corporate employers and insurers in Michigan has argued that the frequency of nonobstructive coronary disease or negative coronary arteriographic (NCA) findings may represent a reasonable surrogate for assessing the appropriateness of coronary arteriography. In the 1970s to 1980s, the incidence of normal study results varied from 10% to 30%.⁶⁻⁸ The implicit assumption was that a high rate of "insignificant disease" or NCA findings might indicate inappropriate use of coronary arteriography, which could reflect poor clinical judgment, inaccurate noninvasive studies, or possibly financial self-interest.

We evaluated the frequency of finding nonobstructive coronary disease in patients with chest pain undergoing an elective coronary arteriogram in southeastern Michigan and compared these results with those of a previously published study to determine factors associated with this finding.

... METHODS ...

Hospital Practice Settings

Data were obtained from 3 southeastern Michigan hospitals during 12 consecutive months between 1991 and 1992: an intermediate-sized osteopathic community hospital with diagnostic coronary angiography only (DiagCommunity); a large allo-

Increasing expenditures for cardiovascular care and the frequency of coronary arteriography has brought into question how often these procedures are performed for inappropriate or uncertain indications. Several studies based on the RAND/UCLA appropriateness method have found

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pathic community hospital with high-volume diagnostic coronary arteriography, angioplasty, and cardiac surgery (RevascCommunity); and a tertiary referral university hospital (University).

The DiagCommunity and the RevascCommunity are teaching hospitals with training programs in internal medicine and cardiology. Both had private practice medical staffs in different middle-class suburbs of metropolitan Detroit. Clinical practice patterns at each were for primary care physicians to refer patients to a cardiologist for diagnostic testing and the decision for coronary arteriography. Five of the 8 cardiologists at the RevascCommunity but none of the 8 DiagCommunity cardiologists performed angioplasty. Patients at the DiagCommunity requiring revascularization were referred to nearby institutions. The University had 5 salaried interventional cardiologists whose clinical practice was more than 90% invasive with no financial incentive based on the number of coronary arteriograms.

More than 80% of patients undergoing coronary arteriography at the University were referred by other staff cardiologists.

The number of cardiology diagnosis-related groups (DRGs) (based on discharge) at each hospital was comparable (Table 1). The DiagCommunity had a significantly greater proportion of black admissions among those patients discharged with a cardiac DRG ($P < .01$). The proportions of cardiac patients older than 65 years at the RevascCommunity (59.5%) and at the DiagCommunity (58.7%) were significantly greater than at the University (38.7%; $P < .001$).

The University is located in a city of 100,000 residents that is 20 miles from the other hospitals studied; however, it has a significant referral base from the same population as the DiagCommunity and the RevascCommunity. That there was no overlap of ZIP codes for the 80th percentile of market share for cardiac DRGs between the 3 locations suggests that most patients were cared for in their local community.

Data Collection

One of the investigators in each of the 3 Michigan hospitals reviewed their catheterization laboratory log to identify patients who had undergone coronary arteriography during the study period. The observation was limited to patients undergoing diagnostic coronary arteriography for the evaluation of stable chest pain. Patients with 1 or more of the following criteria were excluded: acute coronary syndrome (unstable angina or myocardial infarction) or a single episode of chest pain; electrocardiographic or echocardiographic (echo)

Table 1. Hospital Characteristics by Institution

Characteristic	University	DiagCommunity	RevascCommunity
Beds, No.	884	338	615
Admissions, No., for			
DRG 103-118 (CVS)	2276	118	2249
DRG 121-145 (cardiac)	2098	2679	2890
Total cardiac DRGs	4374	2797	5139
Major insurance mix, %			
Medicare/Medicaid	52.5	54.9	66.4
HMO/preferred provider organization	14.1	7.4	12.6
Blue Cross	20.6	20.8	15.8
Other	12.8	16.9	5.2
Race, %			
Black	8.7	17.9	6.3
White	78.9	80.9	90.6
Other	12.4	1.2	3.1
Cardiologists performing coronary arteriography, No.	5	8	8
Cardiac catheterizations, total No.	2525	987	2821
PTCAs, No.	708	0	948
Coronary artery bypass grafts, No.	526	0	633

University = a tertiary referral university hospital; DiagCommunity = an intermediate-sized osteopathic community hospital with diagnostic coronary angiography only; RevascCommunity = a large allopathic community hospital with high-volume diagnostic coronary arteriography, angioplasty, and cardiac surgery; DRG = diagnosis-related group; CVS = cardiovascular surgery including pacemakers; PTCA = percutaneous transluminal coronary angioplasty.

evidence of a myocardial infarction or left ventricular hypertrophy; a left ventricular ejection fraction less than 50%; and valvular heart disease. Patients undergoing an assessment for reasons other than chest pain, eg, unexplained impaired ventricular function, were excluded.

The cases eligible for inclusion in the study were divided into significant vs no significant coronary obstructive disease as reported by the attending cardiologist. By convention, coronary lesions obstructing the lumen by less than 50% were considered insignificant. Examples of terms used by cardiologists in the report to characterize the absence of significant obstruction in any coronary artery are "normal," "negative," and "no significant coronary disease." To validate the conclusions and determine the frequency of "normal or near normal" studies among those with no significant occlusive disease, each of the coronary angiograms with no significant lesion were reviewed by 2 experienced cardiologists from the respective institution who were unaware of clinical information. Of those categorized as having no significant obstruction or NCA findings, a normal or near normal coronary arteriogram was defined as all vessels demonstrating a smooth coronary lumen with no reduction or indentation, loss of density, or sudden bulging greater than 30% of maximal luminal diameter.⁹

We compared the 3 Michigan hospitals with a composite of community hospitals in the state of New York (NYHosps). The latter consisted of 15 of the 56 nonfederal hospitals in New York selected to be reflective of community practice.¹ The NYHosps data set was queried by the principal investigator of that study (SJB) to identify variables required for the comparisons presented herein. The coronary angiograms of the NYHosps were not reviewed again.

The testing performed to assess the presence of ischemia before the coronary arteriogram was available on all patients. Testing was characterized as none, graded exercise electrocardiography, or pharmacologic or exercise echo or radionuclide imaging.

Statistical Analysis

Records were abstracted using standardized data forms and were entered into a computerized database. Data are presented as mean (± 1 SD). Paired *Z* and χ^2 tests were used to determine differences between 2 or more institutions, respectively. Logistic regression was performed to determine whether a specific institution differed significantly from the other institutions using nonobstructive dis-

ease or NCA findings as the dependent variable. All statistical tests were performed using Stata 5.0.

... RESULTS ...

The RevascCommunity and University hospitals, the 2 southeastern Michigan hospitals with coronary revascularization capacity, were referral centers for coronary care, and were similar in size and annual volume of invasive cardiac procedures (Table 1), and were comparable regarding the number of coronary revascularization procedures expressed as a percentage of total cardiac catheterization procedures. The DiagCommunity hospital, although considered medium sized, was smaller and served the surrounding community.

A total of 6333 and 1335 cardiac catheterizations were performed during the 12-month study at the 3 Michigan hospitals and the NYHosps, respectively; 2379 patients (37.6%) at the Michigan facilities and 668 (50.0%) at the NYHosps underwent the procedure for chest pain and fulfilled the eligibility criteria. More exclusions occurred at the DiagCommunity and the NYHosps than at the University or the RevascCommunity ($P = .026$). The NYHosps cases were more often excluded for a previous myocardial infarction ($P < .004$) and for a left ventricular ejection fraction less than 50% ($P = .0001$). A higher percentage of procedures were performed for the evaluation of chest pain at the DiagCommunity and the NYHosps than at the University and the RevascCommunity ($P < .001$ for all comparisons) (Table 2).

There was no significant coronary obstruction or NCA findings in 502 (16.5%) of the 3047 cases, with no difference between the Michigan hospitals (mean, $17.8\% \pm 3.8\%$; range, 14.7%-22.0%) and the NYHosps (14.2%). However, patients at the DiagCommunity had a higher frequency of NCA findings (22.0%), which was significantly greater than at the University (16.8%), the RevascCommunity (14.7%), and the NYHosps (14.2%; $P < .001$ for all comparisons). There were no significant differences among the other sites.

The choice of diagnostic testing for ischemia before coronary arteriography was compared. The NYHosps were more likely to perform coronary arteriography with solely an exercise electrocardiogram (56.6%, odds ratio, 34.4; 95% confidence interval [CI], 4.18-283.6; $P = .0001$) than Michigan hospitals that did not differ from each other. Michigan patients were more likely to have undergone a preangio-

graphic exercise or pharmacologic nuclear or echo imaging (average, 80% [range, 70.2%-89.0%] vs 43.3% for NYHosps).

A total of 110 patients, 3.6% of the elective studies for chest pain at the 4 sites, had angina with evidence of ischemia and normal or near normal coronary arteries on arteriograms. The mean patient age was 53.5 years, and 53% were female. The syndrome of angina with normal or near normal coronary arteries was less frequent at the University (3.4%), the RevascCommunity (3.0%), and the NYHosps (2.4%) than at the DiagCommunity (6.6%; $P < .01$ for all comparisons). There was a higher frequency of normal and near normal coronary angiograms among those with an NCA finding at the 3 Michigan hospitals than at the NYHosps (23.6% vs 16.8%; $P = .033$). This finding could be explained by a higher frequency at the DiagCommunity (29.6%) than at the other sites (eg, NYHosps, 16.8%; RevascCommunity, 20.7%; and University, 20.4%; $P = .026$).

... DISCUSSION ...

The frequency of NCA findings or no significant coronary stenosis (>49%) on arteriography in patients with chest pain in the 3 southeastern Michigan hospitals (17.8%; range, 14.7%-22.0%) is comparable to published results.^{1,4,6-8} By study

design, there were vast objective differences in professional cultures (osteopathic vs allopathic hospitals, referral mechanisms, on-site angioplasty vs no on-site angioplasty, and fee-for-service vs salaried cardiologists), yet the differences between institutions were only modest (Table 2).

Negative coronary arteriographic findings in patients with chest pain have been construed as a surrogate marker of inappropriate use, a concept akin to nonpathologic specimens in the peer review of surgeons and gynecologists. Appropriateness cannot easily be judged by this simple end point. Other factors influencing the use of diagnostic coronary arteriography for the assessment of chest pain in a given institution include patient and physician preferences, including self-referral, availability of laboratory time and outpatient facilities, historical risk as determined by morbidity and mortality, and local charge for angiography compared with nuclear or echo stress testing. The use of noninvasive testing, quality of testing, and selection of patients for coronary arteriography varies considerably among internists and cardiologists, each of which could influence the rate of finding nonobstructive coronary arteries.¹⁰⁻¹⁶ Although some HMOs do not approve the use of nuclear imaging, none of the practices studied were under contractual constraints by any payer.

We hypothesized that the University and community hospitals from the same geographic

Table 2. Frequency of Nonobstructive Coronary Arteries in Elective Coronary Arteriography for the Evaluation of Chest Pain

Hospital	Cardiac Catheterizations, Total No.	Elective Evaluation of Chest Pain, No. (%)	NCA Findings, No. (%)	Normal or Near Normal Angiography, No. (%)	Percent of Normal or Near Normal Angiography in NCA Group, No. (%)
University	2525	844 (33.4)	142 (16.8)	29 (3.4)	29 (20.4)
DiagCommunity	987	517 (52.4)*	115 (22.0) [†]	34 (6.6) [‡]	34 (29.6) [§]
RevascCommunity	2821	1018 (36.1)	150 (14.7)	31 (3.0)	31 (20.7)
NYHosps ¹	1335	668 (50.0)*	95 (14.2)	16 (2.4)	16 (16.8)
Total	7668	3047 (39.7)	502 (16.5)	110 (3.6)	110 (21.8 ± 5.44)

NCA = negative coronary angiographic; University = a tertiary referral university hospital; DiagCommunity = an intermediate-sized osteopathic community hospital with diagnostic coronary angiography only; RevascCommunity = a large allopathic community hospital with high-volume diagnostic coronary arteriography, angioplasty, and cardiac surgery; NYHosps = a composite of 15 community hospitals in the state of New York.

* $P = .001$, DiagCommunity and NYHosps vs University and RevascCommunity.

[†] $P = .001$, DiagCommunity vs other 3 sites.

[‡] $P = .01$, DiagCommunity vs other 3 sites.

[§] $P = .033$, DiagCommunity vs other 3 sites.

region and comparable patient populations by DRG, payer, and racial mix would permit characterization of the influences of cardiology practice patterns (academic vs private practice, allopathic vs osteopathic, type of testing, self-referral) on patient selection for coronary arteriography. This observation would be enhanced if the frequency in Michigan was comparable to that in another region of the United States for which a high degree of appropriateness had been established.

The rate of NCA findings in the 3 southeastern Michigan hospitals varied from a low of 14.7% in the RevasCommunity to a high of 22.0% in the DiagCommunity ($P = .0001$). There was no difference in the average between the Michigan hospitals (17.8% + 3.8%) and the NYHosp (14.2%). The degree of variation in the Michigan hospitals, which are within 25 miles of one another, is less than that described in previous comparisons of regional rates.⁸ In the Coronary Artery Surgery Study,⁷ 28% of patients enrolled had insignificant coronary disease, and subsets of women had rates greater than 50%. This highlights the degree to which the incidence of nonobstructive and normal or near normal coronary arteriograms depends on the population studied. Clearly, the rates for an entire catheterization laboratory population are not as relevant as the rate in a specific population with chest pain.

We blindly reviewed each coronary arteriogram without significant obstruction to reduce the potential for individual and institutional interpretation observer bias. The similar rate of angina with NCA and normal or near normal coronary arteriographic findings in the Michigan hospitals with different cultures supports a local community practice and argues against inappropriate use based on self-referral, clinical experience, or the quality of noninvasive studies. The NYHosp coronary angiograms were not reviewed, but the data set allowed exclusion of cases with a defined percentage reduction in cross-sectional diameter and luminal irregularities. The odds ratio of having angina with normal or near normal coronary arteries at the DiagCommunity was 2.11 (95% CI, 1.24-3.58; $P < .026$) compared with the RevasCommunity, which did not differ from the University (1.12; 95% CI, 0.66-1.90) and the NYHosp (1.46; 95% CI, 0.83-2.6).

Although the differences are small, why does the DiagCommunity have a greater incidence of NCA findings in patients with chest pain? There are no major differences in populations served (Table 1). It could be argued that busy cardiologists (interventional) at the other sites were less likely to perform

diagnostic coronary arteriography in middle-aged patients with atypical chest pain, and they overlooked patients with this syndrome. A more reasonable explanation is a referral bias to the DiagCommunity of patients for whom the primary care physician felt that the need for revascularization was unlikely. Stress echo was used infrequently but more often at the DiagCommunity than at the other sites ($P = .004$). The specificity of stress echo is reported to be at least equal to nuclear studies, but the accuracy in community practice has not been established.

Limitations

This study has several limitations: computerized and written logs were used to identify eligible cases, the data were collected retrospectively, and we did not review the angiograms of patients with significant coronary obstruction. It would have been preferable to blindly review all noninvasive studies and the coronary arteriograms of the Michigan hospitals and the NYHosp to determine whether the results were affected by the type and quality of noninvasive testing. We also did not have data on the source of patient referral, eg, generalist, internist, or other cardiologist.

It was not our intention to typify the clinical relevance of coronary disease characterized as mild on angiography. It is well accepted that most acute coronary events (myocardial infarction and unstable angina) are the result of plaque rupture, and most ruptures occur at sites that are not narrowed significantly. Similarly, coronary vasospasm resulting in angina can occur at sites that appear normal on angiograms.

... CONCLUSION ...

This study defined the rate of occurrence of NCA findings in patients with chest pain in southeastern Michigan. The average rate of 15% does not differ from that in a previously published database of New York hospitals for which appropriateness has been validated by an expert panel.¹ The results of this relatively small study seem to refute the notion that cardiologist self-referral and personal financial gain or quality of noninvasive studies has a significant influence on the decision to perform diagnostic coronary arteriography and instead suggests a common community practice pattern. A prospective study is needed to assess the optimal diagnostic algorithm for chest pain and the role of

coronary arteriography. The frequency of NCA findings is not a good surrogate for appropriateness of patient selection.

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