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The Association between the On-Site Availability of Cardiac Procedures and the Utilization of Those Services for Acute Myocardial Infarction by Payer Group

JOHN G. CANTO, M.D., MSPH, WILLIAM J. ROGERS, M.D., YUAN ZHANG, PH.D.,* JEFFREY M. ROSEMAN, M.D., PH.D., WILLIAM J. FRENCH, M.D.,† JOEL M. GORE, M.D.,‡ NISHA C. CHANDRA, M.D.,§ FOR THE NATIONAL REGISTRY OF MYOCARDIAL INFARCTION 2 INVESTIGATORS

University of Alabama Medical Center, Birmingham, Alabama; *ClinTrials Research, Inc, Lexington, Kentucky; †Harbor UCLA Medical Center, Torrance, California; ‡University of Massachusetts Medical Center, Worcester, Massachusetts; §Johns Hopkins Bayview, Baltimore, Maryland

A list of participants in the National Registry of Myocardial Infarction 2 can be obtained from ClinTrials Research, Inc, Lexington, Kentucky, USA

Summary

Background: Prior studies have suggested that in-hospital availability may be an important determinant for the use of invasive cardiac services; however, whether this association is influenced by payer status remains unclear.

Hypothesis: The interaction of payer status and the on-site availability of coronary arteriography is associated with increased utilization of this procedure.

Methods: In-hospital availability and utilization of coronary arteriography was ascertained in 275,046 patients with acute myocardial infarction (AMI) enrolled in the National Registry of Myocardial Infarction 2 from June 1994 to April 1996. Logistic regression analyses were performed to determine the association between the on-site availability of cardiac catheterization at the initial hospital and subsequent utilization of coronary arteriography. Similar analyses were performed within Medicare, Medicaid, Commercial, Health Maintenance Organization (HMO), and Uninsured payer groups.

Results: Patients initially admitted to hospitals having on-site cardiac catheterization facilities were almost twice as likely to receive coronary arteriography as patients admitted to hospitals without such facilities and later transferred out [unadjusted odds ratio (OR) = 1.69, 95% confidence interval (CI) 1.66–1.73, $p < 0.0001$; adjusted OR = 2.08, 95% CI 2.01–2.15, $p < 0.0001$]. Furthermore, this relationship of increased utilization with greater availability was evident within each payer group, but was highest among those with Commercial insurance and lowest among Medicaid recipients: [Commercial insurance (OR = 2.19, 95% CI 2.07–2.31, $p < 0.0001$); Uninsured (OR = 1.74, 95% CI 1.57–1.92, $p < 0.0001$); HMO (OR = 1.67, 95% CI 1.54–1.82, $p < 0.0001$); Medicare 1.60, 95% CI 1.55–1.64, $p < 0.0001$); Medicaid (1.46, 95% CI 1.29–1.65, $p < 0.0001$)].

Conclusions: Our results show a strong association between in-hospital availability and subsequent utilization of invasive cardiac procedures following AMI among all patients, but the strength of these associations varied among payer status.

Key words: acute myocardial infarction, coronary arteriography, health insurance, payer status

Introduction

The increased utilization of expensive high-technology procedures is of concern to health policy makers and has contributed significantly to U.S. health care costs.[1] In an era that has seen a dramatic rise in the utilization of such resources, more than 952,000 coronary angiography procedures, 398,000 angioplasties, and 485,000 coronary artery bypass surgeries (CABG) are being performed in the U.S. each year.[2] Prior studies have shown that in-hospital availability[3–6] may be an important determinant of invasive cardiac services use in the management of acute myocardial infarction (AMI), and only through better understanding of the factors that impact the utilization of such resources may it be possible to attenuate the escalation of their costs.

Today, a minority of hospitals in the U.S. provide high-technology cardiac services. Recent figures report that 42% of

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Address for reprints:

John G. Canto, M.D., MSPH
328 THT Bldg.
UAB Medical Center
Birmingham, AL 35294, USA

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U.S. hospitals offer coronary angiography and 28% offer CABG.[7] Although many patients with AMI may present to hospitals that do not have a full complement of cardiac services, prior studies have suggested that patients may not necessarily be referred to another hospital to be considered for an invasive procedure.[3,4] The utilization of invasive cardiac procedures is being ascertained in the ongoing National Registry of Myocardial Infarction 2 (NRMI 2), a voluntary database that has enrolled over one-quarter million patients with AMI. The purpose of this analysis is to ascertain from NRMI 2 whether there is a relationship between the utilization of cardiac procedures and the on-site availability of those services for patients with AMI. An additional aim of this study is to determine the interaction of payer status and the hospital availability of cardiac catheterization on the usage of this procedure.

Methods

Patient Population and Hospital Information

The National Registry of Myocardial Infarction is a multicenter, voluntary database designed to collect, analyze, and report cross-sectional data on patients admitted with myocardial infarction (MI) at participating hospitals.[8] Data from each enrolled patient are entered onto a two-page case report form by trained chart abstractors and forwarded to ClinTrials Research, Inc. (Lexington, Ky.). Double key data entry and 87 electronic data checks are routinely performed by the data collection center to help ensure the accuracy, consistency, and completeness of the data. Inaccurate and internally inconsistent case report forms are excluded from analysis and are returned to the principal hospital site for additional review and correction. Hospitals are strongly encouraged to enroll all patients diagnosed with AMI consecutively. Confirmation of AMI is based on at least one of the following criteria: (1) a total creatine kinase (CK) or CK-MB greater than or equal to twice the upper limits of normal; (2) electrocardiographic (ECG) evidence indicative of AMI; (3) alternative enzymatic, scintigraphic, or autopsy evidence indicative of AMI; (4) implantable cardioverter-defibrillator (ICD)-9 CM diagnosis code of 410.X1. This study reports the findings from 1,388 hospitals that enrolled 275,046 patients with AMI into the NRMI 2 during the period of June 1994 to April 1996.

Analysis

The primary objective in this analysis was to study the association between the utilization of an invasive cardiac procedure and its availability. The best statistical design to answer this question is to perform a stratified or logistic regression analysis by patients who presented to hospitals with and without on-site coronary arteriography laboratories. However, these types of statistical analyses were not directly possible due to the fact that the NRMI 2 did not track patients after hospital transfer. Thus, the true post-MI usage of coronary arteriography in these patients cannot be stated with certainty because transferred-out patients may have received these procedures on arrival at a second hospital. Though follow-up data were not available after the transferred-out period, comprehensive data were available among transferred-in patients during both the initial and latter hospitalization periods. Furthermore, transfer status for each subject was known. Therefore, by making certain assumptions regarding the likelihood that a transferred-out subject was to receive an invasive procedure, we can evaluate the impact of these assumptions on our results.

A conservative imputation method that assumed that all transferred-out patients received coronary arteriography was utilized for transferred-out patients to determine the likelihood of receiving coronary arteriography based upon the capability of the presenting hospital type (those with on-site coronary arteriography versus no on-site coronary arteriography facility). For this imputation, a logistic regression analysis was then performed to determine whether associations existed between the usage of coronary arteriography and its availability among all patients and each payer group.

Five Payer Groups

The primary payers were the following: Commercial/Preferred Provider Organizations, Health Maintenance Organizations (HMO), Medicare, Medicaid, and Uninsured. Excluded from this analysis were patients whose payer status was classified as VA/Champus (< 1% of total) and those whose payer status was unknown (8% of total).

Statistical Methods

Logistic regression analyses were performed on the imputation method (described above) to determine whether the availability of coronary arteriography was associated with an increased likelihood of receiving this procedure for (1) the overall study sample; (2) each payer group; and (3) among higher-risk patients with recurrent ischemia, recurrent infarction, Killip class III and IV, ejection fraction < 40%, sustained ventricular tachycardia or ventricular fibrillation [which are American College of Cardiology/American Heart Association (ACC/AHA) Class I and IIa recommendations for proceeding with an invasive cardiac evaluation]. Finally, a multivariate logistic regression analysis was performed on the imputation method (described above) to ascertain whether the presence of an on-site catheterization laboratory at the initial hospital was an independent predictor of receiving coronary arteriography. Variables included in the adjusted model were as follows: demographic and baseline characteristics (age as a continuous variable, race, gender, payer status, U.S. region), past medical history (MI, angina, congestive heart failure, coronary angioplasty, CABG, stroke), cardiac risk factors (diabetes, hypertension, hypercholesterolemia, smoking, and family history of coronary artery disease), presenting characteristics (initial ECG, chest pain on presentation, Killip class, blood pressure, pulse, infarct type and location), and the on-site availability of coronary catheterization laboratory. All statistical analyses were performed with SAS 6.10 statistical package programs

(SAS Institute, Inc., Cary, N.C., USA). This report is based on information processed by the central data collection center as of April 30, 1996.

Results

Imputations for Patients Transferred Out

A conservative estimate, which assumed that all transferred-out patients received coronary arteriography, showed that the likelihood of undergoing coronary arteriography was almost two times higher when patients were initially admitted to hospitals having on-site facilities than to hospitals without such facilities and later transferred out (OR = 1.69, 95% CI 1.66–1.73, p < 0.0001).

Furthermore, when this more conservative imputation was applied to each payer group (Table I), this relationship of increased utilization with greater availability was evident and was highest among those with Commercial insurance and lowest among Medicaid recipients: [Commercial insurance (OR = 2.19, 95% CI 2.07–2.31, p < 0.0001); Uninsured (OR = 1.74, 95% CI 1.57–1.92, p < 0.0001); HMO (OR = 1.67, 95% CI 1.54–1.82, p < 0.0001); Medicare 1.60, 95% CI 1.55–1.64, p < 0.0001); Medicaid (1.46, 95% CI 1.29–1.65, p < 0.0001)].

When the imputation method was restricted to patients with recurrent ischemia, recurrent infarction, Killip class III and IV, ejection fraction < 40%, sustained ventricular tachycardia, or ventricular fibrillation (which are ACC/AHA Class I and IIa recommendations for proceeding with an invasive cardiac evaluation), patients initially admitted to hospitals having on-site facilities were still almost 1.6 times more likely to undergo coronary arteriography than when initially admitted to hospitals without such facilities and later transferred out (OR = 1.65, 95% CI 1.60–1.70, p < 0.0001). Conversely, patients initially admitted to hospitals without on-site facilities were 39% less likely to be transferred to a secondary hospital to receive coronary arteriography (despite ACC/AHA guidelines that recommend proceeding with an invasive cardiac evaluation) than when initially admitted to hospitals with such facilities (OR = 0.61, 95% CI 0.59–0.63, p < 0.0001).

When this imputation was stratified by payer status and restricted to these same high-risk patients, those initially admitted to hospitals having on-site facilities were more likely to receive coronary arteriography for each payer group (Table II), and this was highest among those with Commercial insurance (OR = 2.01, 95% CI 1.85–2.18, p < 0.0001), and lowest among Medicaid (OR = 1.31, 95% CI 1.10–1.57, p = 0.003) and HMO (OR = 1.49, 95% CI 1.31–1.69, p < 0.0001) patients.

Finally, a multivariate logistic regression analysis was performed using a conservative estimate (which again assumed

TABLE I Likelihood to receive coronary arteriography by initial presenting hospital capability: Imputation by payer status [a]

Payer group	Cath lab available +	Cath lab available −	p Value	OR	95% CI
All					
Cath, n	112,133	21,443	0.0001	1.69	1.66, 1.73
No Cath, n	64,711	20,955			
Commercial					
Cath, n	32,819	6,122	0.0001	2.19	2.07, 2.31
No Cath, n	5,841	2,387			
Medicare					
Cath, n	44,983	8,633	0.0001	1.60	1.55, 1.64
No Cath, n	45,010	13,788			
Uninsured					
Cath, n	6,714	1,392	0.0001	1.74	1.57, 1.92
No Cath, n	2,136	769			
HMO					
Cath, n	11,533	1,920	0.0001	1.67	1.54, 1.82
No Cath, n	3,867	1,078			
Medicaid					
Cath, n	3,216	658	0.0001	1.46	1.29, 1.65
No Cath, n	2,027	604			

[a] This imputation assumed that all transferred-out patients received coronary arteriography. For example, among all payer groups (row 1) who presented to hospitals with no cath lab on site (column 3), 21,443 were transferred-out patients, and all these patients were assumed to have received coronary arteriography; and another 20,955 were not transferred out and did not receive coronary arteriography.
Abbreviations: n = number of patients, OR = odds ratio, CI = confidence interval.

TABLE II Likelihood to receive coronary arteriography by initial presenting hospital capability: Imputation by payer status/high risk [a]

Payer group	Cath lab available +	Cath lab available −	p Value	OR	95% CI
All					
Cath, n	55,510	9,719	0.0001	1.65	1.60, 1.70
No Cath, n	37,485	10,808			
Commercial					
Cath, n	14,398	2,546	0.0001	2.01	1.85, 2.18
No Cath, n	2,821	1,001			
Medicare					
Cath, n	25,012	4,318	0.0001	1.64	1.58, 1.71
No Cath, n	27,418	7,688			
Uninsured					
Cath, n	3,156	570	0.0001	1.67	1.43, 1.95
No Cath, n	1,029	310			
HMO					
Cath, n	5,250	832	0.0001	1.49	1.31, 1.69
No Cath, n	1,866	441			
Medicaid					
Cath, n	1,654	304	0.003	1.31	1.10, 1.57
No Cath, n	1,126	272			

[a] This imputation assumed that all transferred-out patients received coronary arteriography. For example, among all payer groups (row 1) who presented to hospitals with no cath lab on site (column 3), 9,719 were transferred-out patients, and all these patients were assumed to have received coronary arteriography; and another 10,808 were not transferred out and did not receive coronary arteriography.
Abbreviations as in Table I.

that all transferred-out patients received coronary arteriography) to ascertain whether the presence of an on-site catheterization laboratory at the initial hospital was an independent predictor of receiving coronary arteriography. Results are depicted in Table III, and after adjusting for age, comorbidities, and other potential confounders, patients who were initially admitted to hospitals having on-site facilities were over two times as likely to undergo coronary arteriography than when initially admitted to hospitals without such facilities and later transferred out (OR = 2.08, 95% CI 2.01–2.15, $p<0.0001$). The presence of an on-site catheterization facility was among the strongest predictors of receiving coronary arteriography.

Discussion

General Comments

This analysis is enhanced by the large number of patients treated with AMI. Also, given the observational nature of our study, our results are more likely to reflect true practice patterns seen in the community. Coronary arteriography is a valuable technology for identifying high-risk patients with AMI who may benefit from further revascularization procedures (coronary angioplasty and CABG). However, nondiscriminate use may contribute to significant economic costs. Our results show a very strong association between in-hospital availability and subsequent utilization of coronary arteriography, but the strength of these associations varied among payer status.

Cause and Effect: Why May There be a Correlation between Procedure Utilization and On-Site Availability of High-Technology Facilities?

Such associations seem plausible for several reasons. First, resource utilization of a technology may be influenced by financial incentives. Physicians may increase case volume to

TABLE III Multiple logistic regression model for likelihood to receive cardiac CATH

Variable	OR	95% CI		p Value
		Lower limit	Upper limit	
History of heart failure	0.51	0.49	0.53	<0.001
Medicaid vs. Commercial	0.53	0.49	0.57	<0.001
History of stroke	0.59	0.56	0.62	<0.001
Killip class IV vs. I	0.61	0.55	0.67	<0.001
Black	0.68	0.65	0.72	<0.001
Killip class II vs. I	0.69	0.67	0.72	<0.001
Killip class III vs. I	0.71	0.67	0.74	<0.001
Previous myocardial infarction	0.76	0.74	0.78	<0.001
HMO vs. Commercial	0.82	0.77	0.86	<0.001
Hispanic	0.83	0.77	0.90	<0.001
Q wave	0.83	0.81	0.86	<0.001
Medicare vs. Commercial	0.89	0.86	0.93	<0.001
Smoker	0.90	0.88	0.93	<0.001
Native American	0.91	0.75	1.12	<0.001
History of CABG	0.92	0.89	0.96	<0.001
Diabetes	0.92	0.90	0.94	<0.001
Age (continuous variable)	0.94	0.93	0.94	<0.001
Asian-Pacific Islander	0.96	0.84	1.10	0.59
Uninsured vs. Commcercial	0.98	0.84	1.13	0.77
Pulse	0.99	0.99	0.99	<0.001
Blood pressure	1.00	1.00	1.00	<0.001
History of angina	1.00	0.97	1.03	0.95
Hypertension	1.06	1.03	1.09	<0.001
ST elevation	1.16	1.12	1.19	<0.001
Male	1.27	1.23	1.30	<0.001
Hypercholesterolemia	1.37	1.33	1.41	<0.001
Chest pain	1.90	1.84	1.96	<0.001
History of coronary angioplasty	1.64	0.56	1.73	<0.001
On-site availability CATH lab	2.08	2.02	2.15	<0.001

Region, MI location were also included into multivariable model.

Abbreviations: CI = confidence interval, OR = odds ratio, CABG = coronary artery bypass graft, CATH = catheterization, MI = myocardial infarction.

justify and support overhead expenses. Some have suggested[9] that hospitals may have an economic incentive to build more cardiac catheterization facilities because they may be profitable. Second, a technology that is easily accessible is more likely to be utilized. Although there are widely accepted indications for coronary arteriography in the post-MI period, there are still many conditions for which there is conflicting evidence and/or divergence of opinions about the usefulness of coronary arteriography after MI, such as performing coronary arteriography in all patients after MI, in all non-Q wave MIs, or in those with prior revascularization.[10] It is conceivable, where no consensus agreement exists, that the favored method of initial reperfusion therapy or risk stratification may be influenced by the capabilities of the presenting hospitals. A more conservative approach with noninvasive work-up may be pursued, especially if no on-site cardiac catheterization facility is available. Likewise, a more invasive style of management may be performed if the invasive technology is easily accessible. Third, some have argued that a more aggressive style of risk stratification may shorten hospital stay by promoting discharge of low-risk patients earlier or by identifying high-risk patients sooner.[11] If this proves to be the case, greater usage of coronary arteriography in the postinfarct period may be advocated by some care providers, especially if that service is readily available.

A direct comparison among hospitals with and without cardiac procedure availability was limited by the fact that NRMI 2 did not collect continuous, follow-up data on those patients who were transferred to other hospitals. However, if we assumed that all transferred-out patients received coronary arteriography, those initially admitted to hospitals with on-site cardiac catheterization facility were still almost two times more likely ultimately to receive coronary arteriography as those without on-site capability. Similarly, this association was even stronger after controlling for potentially important confounding factors such as region, age and other demographics factors, co-morbidities, cardiac risk factors, and clinical presenting characteristics. This imputation represented a very conservative estimate, and the true point estimate (odds ratio) will be likely higher as it would be unlikely that every transferred-out patient will have received coronary arteriography.

Although higher utilization of coronary arteriography among hospitals with on-site cardiac catheterization facilities appears evident, lower utilization of this technology among hospitals without on-site cardiac catheterization facilities was also seen. For example, among patients who met Class I or IIa ACC/AHA recommendations for proceeding with an invasive strategy of post-MI risk stratification, those who were initially admitted to hospitals without cardiac catheterization facilities were almost 50% less likely to be transferred to a secondary hospital to receive an invasive cardiac procedure (compared with those who initially presented to hospitals with state-of-the art technologies). The Myocardial Infarction Triage Intervention (MITI) registry, which can track patients transferred from one institution to another, has also reported that, among those who presented to hospitals without an on-site catheterization laboratory, generally lower-risk patients rather than higher-risk patients were being transferred out.[12] However, their (MITI) data suggested that a conservative, less invasive treatment approach was not necessarily associated with any increase in long-term mortality, although this was not a randomized study.

Although payer status has been previously shown to be an important determinant of the use of coronary angiography post-MI (limited to patients < 65 years old and to those who presented to large, tertiary care hospitals),[13] the NRMI 2 data suggest that on-site availability of a high technology procedure is associated with increased use, regardless of payer status. A consistent relationship between service availability and subsequent in-hospital utilization was evident among each of the five payer groups studied, although the strength of these associations varied among the payer groups. For example, this association was highest in the Commercial group, whose physicians may have a strong economic incentive to perform a more expensive strategy of risk stratification, and this group was also the more likely than other groups to utilize this more costly procedure when it was available. Conversely, this association was generally lower in Medicaid, and Medicaid reimbursement for many medical procedures is frequently lower compared with other payer groups. Although speculative, these analyses by payer group suggest that economic considerations among Medicaid and Commercial groups may contribute to the degree of differences observed among payer groups.

Prior Studies

Three prior analyses have shown a strong relationship between availability and usage of invasive cardiac procedures for patients with AMI. Blustein[4] reviewed the 1986 administrative data from New York State and concluded that the availability of cardiac services in the hospital to which a patient initially presented significantly influenced the likelihood of receiving coronary arteriography, coronary angioplasty, and CABG. Likewise, Every *et al.*[3] found that MITI registry patients admitted to hospitals with on-site cardiac catheterization facilities were far more likely to undergo angiography than patients admitted to hospitals where transfer to another institution would be required to perform cardiac catheterization. Furthermore, they found that admission to a hospital with on-site facilities was more strongly associated with the use of coronary arteriography than any other characteristic of the patient. Finally, Pilote *et al.*[5, 6] in the GUSTO I trial found that the regional use of cardiac procedures was closely correlated with their availability among the U.S. census regions, except in New England. Though each of the above three studies are in accord with our results, the NRMI 2 database is unique because it is much larger (seven times the number of enrollees of all three prior studies combined), more inclusive (thrombolytic- and nonthrombolytic-treated patients, non-Q-wave and Q-wave infarctions), and broader-based to reflect contemporary, real-world practice patterns among all 50 states.

Other analogous situations have shown correlations between medical availability and service use. Higher patient-

referrals for x-rays[14] are seen if radiographic capabilities are present in the doctor's office. Physician visit rates reflect the local concentration of physicians,[15,16] surgery rates reflect the density of surgeons,[17] and CABG rates parallel the regional availability of cardiologists.[18,19] Increased numbers of physicians and hospital beds have led to greater use of medical services.[20] Thus, our results are consistent with prior studies of AMI management and other similar cases, which have shown a correlation between availability and use of different medical technologies.

Limitations

As already mentioned, the major limitation of this analysis was that the NRMI 2 did not provide longitudinal follow-up once patients were transferred out to another institution. However, given the conservative nature of our imputations, which support a relationship between service availability and service usage of invasive cardiac procedures, the validity of our analysis is not likely compromised. Though some patients who presented to noninvasive hospitals received an outpatient cardiac catheterization and may have been initially discharged home, this practice probably occurs to a smaller extent in some areas of the U.S. and is unlikely to diminish the strength of our associations significantly (statistically). Other limitations may include a selection bias whereby patients who preferred the latest in state-of-the-art care may have presented to hospitals with a wider complement of cardiac services and greater concentration of cardiologists. Also, critically ill patients may have been directly referred to cardiac centers with on-site cardiac facilities.

Furthermore, NRMI 2 tends to represent the larger hospitals compared with nonregistry hospitals.[8] Although collectively the NRMI 2 represents almost one quarter of all acute care hospitals in the U.S., the smaller hospitals without catheterization facilities in the NRMI 2 may not be necessarily representative of all such hospitals, and therefore our findings may not be generally applicable to all hospital types.

Conclusion

A potential causal relationship between service availability and service usage of invasive cardiac procedures may be implied from this analysis of over one-quarter of a million patients in the National Registry of Myocardial Infarction 2. The data (1) demonstrate a significant association between availability and usage among all patients regardless of payer group, although the strength of these associations varied among payer status; and (2) are consistent with prior studies from smaller reports. However, the proper rate for service utilization remains largely unknown. Further studies may need to determine whether the cost/benefit ratio of greater utilization of high technological procedures improves long-term survival and quality of life.

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