Underuse of Cardiac Procedures: Do Women, Ethnic Minorities, and the Uninsured Fail To Receive Needed Revascularization?

Lucian L. Leape, MD; Lee H. Hilborne, MD; Robert Bell, PhD; Caren Kamberg, MPH; and Robert H. Brook, MD, ScD

Background: Women, ethnic minorities, and uninsured persons receive fewer cardiac procedures than affluent white male patients do, but rates of use are crude indicators of quality. The important question is, Do women, minorities, and the uninsured fail to receive cardiac procedures when they need them?

Objective: To measure receipt of necessary coronary artery bypass graft (CABG) surgery and percutaneous transluminal coronary angioplasty (PTCA) overall; by patient sex, ethnicity, and payer status; and by availability of on-site revascularization.

Design: Retrospective, randomized medical record review.

Setting: 13 of the 24 hospitals in New York City that provide coronary angiography.

Patients: 631 patients who had coronary angiography in 1992 and met the RAND expert panel criteria for necessary revascularization.

Measurements: The percentage of patients who had CABG surgery or PTCA was measured, as were variations in use rates by sex, ethnic group, insurance status, and availability of on-site revascularization. Clinical and laboratory data were retrieved from medical records to identify patients who met the panel criteria for necessary revascularization. Receipt of revascularization was determined from state reports, medical records, and information provided by cardiologists.

Results: Overall, 74% (95% CI, 71% to 77%) of patients who met the panel criteria for necessary revascularization had CABG surgery or PTCA (underuse rate, 26%). No differences were found in use rates by patient sex, ethnic group, or payer status, but hospitals that provided on-site revascularization had higher use rates (76% [CI, 74% to 79%]) than hospitals that did not provide it (59% [CI, 56% to 65%]) ($P < 0.01$). In hospitals that did not provide on-site revascularization, uninsured patients were less likely to have revascularization recommended to them (52% [CI, 32% to 78%]); rates of recommendation for patients with private insurance, Medicare, and Medicaid were 82%, 91%, and 75%, respectively ($P = 0.026$).

Conclusions: Although revascularization procedures are substantially underused, no variations in rate of use by sex, ethnic group, or payer status were seen among patients treated in hospitals that provide CABG surgery and PTCA. However, underuse was significantly greater in hospitals that do not provide these procedures, particularly among uninsured persons.

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Women, ethnic minorities, and the poor are less likely than non-poor white male patients to receive diagnostic and therapeutic cardiac procedures (1–14). The reported differences are substantial. For example, ratios of white to black recipients of coronary artery bypass graft (CABG) surgery of 2:1 or more have been found, even when analysis is restricted to patients who have received coronary angiography (5–8, 10–15). Such differences have been found for both discretionary and nondiscretionary procedures (16). The use of cardiac services is also lower in Hispanic patients (9), and ratios of male to female recipients ranging from 1.28 to 2.15 have been reported in population-based studies (1, 2) and studies from single institutions (4, 17). After adjustment for age and clinical severity of disease, however, these differences sometimes disappear (4).

Use rates are not indicators of quality. Discrepancies in use rates may reflect differences in need, overuse in one group, or underuse in one group. The important question is not whether women and disadvantaged groups receive fewer treatments but whether they receive them when they need them.

To evaluate the possible underuse of essential services in women and disadvantaged persons, we focused on the provision of CABG surgery and percutaneous transluminal coronary angioplasty (PTCA) in New York City because of the high percentages of ethnic minorities and low-income patients in that area. We used two standards to assess underuse of CABG surgery and PTCA: RAND expert panel necessity ratings and the presence of left main or three-vessel disease. We studied patients who received coronary angiography in public and private hospitals in New York City and asked three questions: Of the patients who need cardiac revascularization, what percentage do not receive it? Are rates of underuse higher among women, African-American patients, Hispanic patients, and uninsured persons? Finally, is underuse related to type of hospital ownership or to whether on-site CABG surgery and PTCA are available?

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Methods

Necessity Criteria

Explicit criteria for the determination of underuse were developed by the RAND expert panel in 1990 (18–20) (Appendix). After rating all of the possible indications (clinical scenarios) for CABG surgery and PTCA for appropriateness, the panel rated each "appropriate" indication for necessity. Revascularization was considered "necessary" for an indication if the panelists believed that 1) not providing revascularization for most patients with the indication would constitute improper care, 2) the likelihood of benefit from revascularization for patients with the indication would be significant, and 3) the magnitude of the benefit would not be small. A "necessary" rating implies that a physician is obligated to recommend revascularization for the given indication in the absence of contraindications or mitigating factors.

Of the indications for CABG surgery or PTCA that were previously rated as appropriate by the panel, fewer than half ($n = 249$) were rated as necessary. These indications are only 8% of all possible indications for CABG surgery and PTCA.

We conducted a separate analysis for patients with left main or three-vessel disease. These conditions are considered by many to be indications for necessary revascularization because of evidence showing that CABG surgery provides a survival benefit in patients with these conditions.

Study Sample

The sample frame included all patients who had coronary angiography for suspected atherosclerosis in 1992. To obtain comparable numbers of patients from each disadvantaged group, we used a two-stage procedure to select hospitals and patients. Using data provided by the New York Department of Health, we excluded one hospital that performed only 89 angiography procedures in 1992; we then randomly selected hospitals in each of five strata defined by the volume of angiographic procedures performed and the percentages of African-American and Hispanic patients undergoing coronary angiography in 1992. We oversampled hospitals with high proportions of minority patients. The final hospital sample consisted of 13 of the 24 hospitals in New York City that provide coronary angiography.

Nine of the 13 hospitals selected also provided revascularization. They are referred to here as *on-site hospitals*; the remaining 4 hospitals referred patients to other hospitals for revascularization and are referred to here as *off-site hospitals*. Eighty percent of patients who have angiography in New York City do so in an on-site hospital.

All of the selected hospitals agreed to participate in our study. Within each hospital, we selected a stratified random sample of patients; strata were defined by ethnic group and sex. We restricted our study to patients identified in hospital records as African American, Hispanic, or white. Although these classifications do not represent homogeneous groups in a population as diverse as that of New York City, they do capture separately identifiable groups that are known to have problems with access to health care. Because the number of Asian patients and patients of other ethnic groups in these hospitals was too small to permit adequate sampling for our study, we excluded them.

Hospitals differed markedly in terms of patient ethnicity. The proportion of nonwhite patients ranged from 3% to 87%, and most of the higher proportions were seen in hospitals that performed low volumes of revascularization procedures. To assess between-hospital variation, we oversampled patients in low-volume hospitals and oversampled minority patients in hospitals that served predominantly white populations. The analyses reported were reweighted to account for this two-step sampling strategy so that the reported results reflect the distribution of ethnic groups within the population.

The final sample comprised 3404 patients. We anticipated that 20% of these patients would have indications that met the panel criteria for necessity; thus, our study had 80% power to detect the ethnicity- and sex-based differences of 15% to 20% that we expected to find. Hospitals located 3300 (97%) angiogram reports for the patients, and these reports were then abstracted to define the extent of coronary artery disease. We excluded 303 patients who previously had CABG surgery or PTCA and 1020 patients whose angiograms showed no vessel with at least 50% narrowing. We also excluded 448 patients whose angiograms showed one or more vessels with 50% stenosis but did not satisfy the panel definition of significant coronary artery disease, which required a reduction of 70% or more in at least one major vessel (except for the left main coronary artery, where 50% stenosis was considered significant disease). This left 1529 patients who met the panel criteria for significant coronary artery disease. Hospitals located medical records for 1475 (97%) of these patients.

Record Abstraction

The clinical and laboratory data needed to determine whether patients met the panel criteria for necessity of CABG surgery or PTCA were abstracted from patients' hospital records by trained nurses. Abstractors also recorded information indicating whether revascularization was received by, offered to, or refused by the patient. If the results of

exercise stress testing were needed to determine necessity and were not in the medical record, we requested a report from the referring physician. We requested 43 stress test reports and obtained 33. The 10 patients without stress test reports were excluded from the analysis.

On the basis of abstracted data, each patient was assigned to a specific indication that had previously been classified as necessary or not necessary by the panel. Of the 1475 patients with significant coronary artery disease, 631 met the panel criteria for necessary revascularization and formed the denominator for all further analyses. These 631 patients represented 105 indications, or 43% of the 249 indications for which the panel considered revascularization necessary.

Assessing Outcomes

We used multiple sources to determine whether patients obtained necessary revascularization. We matched patients to data reported to the New York State Cardiac Surgical and Angioplasty Reporting Systems (physicians are required to report all CABG and PTCA procedures to these systems). We also checked for information about revascularization in the hospital records and matched our data to the SPARCS (Statewide Planning and Research Cooperative System) database, which contains a record of all hospitalizations in New York State. Finally, we asked cardiologists at each study hospital whether patients had received revascularization.

Hospital records rarely contained statements indicating that patients had refused CABG surgery or PTCA. Therefore, for patients who did not undergo revascularization, we asked the cardiologists whether revascularization had been recommended and, if so, whether it was refused. We were able to obtain this information for all but 33 patients (5%).

Statistical Analysis

We used multiple logistic regression to model the probability that a patient would receive a revascularization procedure (or have it recommended) as a function of hospital and several other independent variables. We calculated adjusted revascularization and recommendation rates by levels of each independent variable, except "hospital," while controlling for the other variables in the tables. The adjusted rates were produced by direct standardization (21). For example, the adjusted revascularization rate for male patients is the mean across the entire sample (male and female) of the predicted probability of revascularization under the assumption that each person is male but retains all of his or her other characteristics. Consequently, any reported difference between male and female patients is due only to sex. Except for the on-site and off-site hospital revascularization and recommendation rates calculated for all hospitals, all adjusted proportions control for hospital in addition to the other variables.

To account for the unequal sampling probabilities for hospitals and for patients within hospitals, we reweighted our results so that they are representative of the whole population having coronary angiography, unless otherwise indicated. We report 95% CIs for both unadjusted and adjusted revascularization rates. Because analyses were weighted, we computed CIs by using the bias-corrected version of the bootstrap, a resampling technique for statistical inference (22). To calculate rates of necessary revascularization and the on-site and off-site adjusted revascularization and recommendation rates, we resampled clusters of patients from the same hospitals. To calculate all other adjusted rates, we resampled individual patients (because the logistic regression model controlled for hospital). For all significance tests, we used formulas that account for the increased variance of weighted regression estimates compared with unweighted ones (23). For tests for differences among hospitals, we used Wald chi-square statistics. All statistical computations were done by using Stata software, version 5.0 (24).

Results

Sample Characteristics

The composition of our study sample reflects our stratified selection process: Of the 631 patients who met the panel criteria for necessary revascularization, 41% were women, 27% were African-American, 29% were Hispanic, and 44% were white (**Table 1**). Uninsured patients made up 25% of the patients in off-site hospitals who met the panel criteria for necessary revascularization and 16% of the patients in on-site hospitals. Patients in on-site hospitals were more likely to be in the high-risk category (7% compared with 4%) or to have an ejection fraction less than 35% (39% compared with 35%). Of the 631 patients, 443 had indications for which the panel considered CABG surgery necessary, 56 had indications for which the panel considered PTCA necessary, and 132 had indications for which the panel considered either CABG surgery or PTCA necessary.

Findings

Overall, 74% (CI, 71% to 77%) of the 631 patients whose indications met the necessity criteria had cardiac revascularization (CABG surgery or PTCA) (**Table 2**). Thus, the underuse rate was 26%. However, we found no significant differences in rates of necessary revascularization by sex, ethnic

Table 1. Characteristics of the Study Sample*

Characteristic	Patients in All Hospitals (n = 631)	Patients in On-Site Hospitals (n = 464)	Patients in Off-Site Hospitals (n = 167)
	← % →		
Sex			
Female	41	40	43
Male	59	60	57
Ethnicity			
African-American	27	25	34
Hispanic	29	30	24
White	44	45	41
Age			
75–79 years	12	14	8
65–74 years	35	33	39
18–64 years	53	53	53
Disease			
Left main	17	18	13
Three-vessel	60	59	61
Two-vessel	15	14	15
Single-vessel	9	8	11
Ejection fraction < 35%	38	39	35
High risk (Parsonnet score > 18)	6	7	4
Urgent indication†	66	63	74
Necessary procedure			
CABG surgery	70	71	66
PTCA	9	8	11
CABG surgery or PTCA	22	21	22
Payer			
Private insurance	30	35	19
Medicare	36	38	30
Medicaid	16	12	26
Uninsured	18	16	25

* CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.
† Class IV chronic stable angina, unstable angina, myocardial infarction, or near sudden death.

group, or payer status. The rate of necessary revascularization was higher in women (77% [CI, 71% to 84%]) than in men (72% [CI, 65% to 80%]), but the difference was not statistically significant (difference, 5 percentage points [CI, 2 to 11 percentage points]). Similarly, variations in rates of necessary revascularization among African-American patients (72% [CI, 65% to 80%]), Hispanic patients (67% [CI, 54% to 76%]), and white patients (75% [CI, 72% to 78%]) were small and not statistically significant. The difference between white and African-American patients was 2 percentage points (CI, −5 to 11 percentage points), the difference between white and Hispanic patients was 7 percentage points (CI, −3 to 22 percentage points), and the difference between African-American and Hispanic patients was 5 percentage points (CI, −5 to 21 percentage points). Although the rate of necessary revascularization was lower in uninsured patients than in patients with private or government insurance, the difference was not statistically significant.

Rates of necessary revascularization varied substantially among hospitals, from 21% to 87% (**Table 3**). Rates were lower in off-site hospitals (59% [CI, 56% to 65%]) than in on-site hospitals (76% [CI, 74% to 79%]) ($P < 0.01$) (difference, 17 percentage points [CI, 8 to 35 percentage points]). A sensitivity analysis of the base rate (59%) for off-site hospitals with the low outlier hospital (M) excluded yielded an average rate of necessary revascularization of 62%.

When the analyses were repeated for patients with left main or three-vessel disease (483 of the 631 patients), the results were not substantially altered (underuse rate, 25%) and no differences according to ethnicity, sex, or insurance status were found. The rate of necessary revascularization for these patients was lower for patients in off-site hospitals (61%) than for patients in on-site hospitals (79%).

Rates of necessary revascularization were lower in municipal hospitals (61%) than in private hospitals (75%) ($P = 0.02$). The study hospital with the highest rate of necessary revascularization (87%) was a municipal hospital, but this hospital was the only municipal hospital in our sample that provided on-site cardiac revascularization.

Rates of recommendation of revascularization varied substantially among hospitals and were lower in off-site hospitals (75% [CI, 69% to 77%]) than in on-site hospitals (85% [CI, 82% to 91%]) ($P < 0.001$).

Table 2. Necessary Revascularization Rates*

Variable	Patients Having Necessary Revascularization (95% CI), %
All	74 (71–77)
On-site hospital	76 (74–79)
Off-site hospital	59 (56–65)†
Sex	
Female	77 (71–84)
Male	72 (69–74)
Ethnicity	
African-American	72 (65–80)
Hispanic	67 (54–76)
White	75 (72–78)
Age	
≥75 years	75 (67–85)
65–74 years	75 (71–80)
18–64 years	71 (65–77)
Disease	
Left main	88 (76–97)
Three-vessel	70 (64–73)
Two-vessel	68 (54–88)
Single-vessel	83 (73–96)
Urgency	
Urgent indication‡	72 (68–75)
Nonurgent indication	76 (71–82)
Necessary procedure	
CABG surgery	75 (72–78)
PTCA	82 (70–95)
CABG surgery or PTCA	65 (57–75)
Payer	
Private insurance	71 (63–82)
Medicare	80 (75–85)
Medicaid	71 (64–82)
Uninsured	63 (53–73)

* All rates are weighted for sample design. CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.
† $P = 0.0006$ for off-site compared with on-site hospitals.
‡ Class IV chronic stable angina, unstable angina, myocardial infarction, or near sudden death.

Table 3. Necessary Revascularization and Recommendation Rates by Hospital*

Hospital	Type of Ownership	CABG Surgery and PTCA Available On-Site	Patients	Patients Receiving Revascularizaton	Patients Receiving a Recommendation of Revascularization
			n	%	
A	Municipal	Yes	28	87	89
B	Private	Yes	64	86	89
C	Private	Yes	57	80	81
D	Private	Yes	73	78	86
E	Private	Yes	45	78	84
F	Private	Yes	57	76	94
G	Private	Yes	51	75	85
H	Private	Yes	28	73	73
I	Private	Yes	61	67	86
J	Municipal	No	39	67	75
K	Private	No	45	61	81
L	Municipal	No	46	45	74
M	Municipal	No	37	21	54
All	–	–	631	74	84

*All rates are weighted for sample design. $P < 0.001$ for differences in revascularization rates. CABG = coronary artery bypass graft; PTCA = percutaneous transluminal coronary angioplasty.

Regression Analysis of Adjusted Rates

We used logistic regression to adjust revascularization rates and recommendation rates for hospitals (using 12 dummy variables) and for the patient characteristics shown in **Table 4**. Large, statistically significant differences among hospitals remained after we controlled for patient differences ($P < 0.001$), but most of the difference was explained by higher rates at hospitals with on-site revascularization ($P < 0.001$). After we controlled for the presence of on-site revascularization, hospital differences were marginally significant ($P = 0.03$). To compute adjusted means for on-site and off-site hospitals, we excluded "hospital" from the model.

These analyses also showed that the presence of left main or single-vessel disease ($P = 0.012$) was associated with a significantly higher likelihood that a patient would receive necessary revascularization. We detected no significant differences in rates of necessary revascularization according to ethnic group, sex, or ability to pay (**Table 4**).

Similarly, for recommendation rates, the substantial difference persisted in the adjusted analysis between on-site hospitals (85% [CI, 83% to 91%]) and off-site hospitals (78% [CI, 58% to 82%]) ($P < 0.001$). The entire group of 13 hospitals differed significantly before ($P = 0.04$) but not after ($P = 0.16$) we controlled for on-site status. We detected no statistically significant differences in recommendation rates by ethnic group, sex, or ability to pay. Again, patients with left main and single-vessel disease were significantly more likely than other patients to receive a recommendation for revascularization ($P < 0.001$) (**Table 4**).

Regression analysis of rates adjusted for hospital and patient characteristics in on-site hospitals mirrored the results for the sample as a whole: No differences were seen in rates of necessary revascularization or in recommendation rates according to sex, ethnic group, or payer status.

However, in off-site hospitals, regression analysis of adjusted rates showed that African-American patients were more likely than white or Hispanic patients to receive a recommendation for necessary revascularization (91% [CI, 81% to 96%]) ($P =$

Table 4. Adjusted Rates of Necessary Revascularization and Recommendation: All Hospitals*

Variable	Patients Receiving Revascularization (95% CI)	Patients Receiving a Recommendation of Revascularization (95% CI)
	%	
On-site hospital	76 (73–79)	85 (83–91)
Off-site hospital	59 (42–73)†	78 (58–82)†
Sex		
Female	77 (70–84)	87 (81–92)
Male	72 (65–78)	83 (77–88)
Ethnicity		
African-American	75 (66–83)	85 (77–91)
Hispanic	68 (58–77)	80 (70–87)
White	74 (68–80)	84 (79–90)
Age		
≥75 years	61 (43–78)	82 (63–95)
65–74 years	70 (60–80)	85 (77–92)
18–64 years	79 (71–85)	83 (75–89)
Disease		
Left main	88 (78–96)‡	97 (94–99)§
Three-vessel	69 (62–76)	82 (76–87)
Two-vessel	69 (56–82)	76 (62–86)
Single-vessel	85 (72–98)	87 (72–96)
Urgency		
Urgent indication‖	72 (65–79)	82 (76–88)
Nonurgent indication	76 (69–84)	86 (80–92)
Payer		
Private insurance	65 (51–76)	81 (71–88)
Medicare	82 (73–89)	89 (80–94)
Medicaid	74 (59–85)	80 (66–91)
Uninsured	64 (47–79)	82 (69–91)

* All rates are weighted for sample design.
† $P < 0.001$ for comparison of off-site and on-site hospitals.
‡ $P = 0.012$ for intragroup differences.
§ $P < 0.001$ for intragroup differences.
‖ Class IV chronic stable angina, unstable angina, myocardial infarction, or near sudden death.

Table 5. Adjusted Rates of Necessary Revascularization and Recommendation: Off-Site Hospitals*

Variable	Patients Receiving Revascularization (95% CI)	Patients Receiving a Recommendation of Revascularization (95% CI)
	%	
Sex		
Female	48 (37–64)	63 (47–79)
Male	64 (52–73)	79 (70–88)
Ethnicity		
African-American	74 (58–85)	91 (81–96)†
Hispanic	42 (21–65)	72 (53–88)
White	59 (47–72)	71 (61–82)
Age		
≥75 years	69 (32–95)	93 (61–100)
65–74 years	54 (37–74)	74 (57–87)
18–64 years	62 (45–75)	75 (62–87)
Disease		
Left main	82 (58–96)	91 (67–100)
Three-vessel	59 (46–70)	81 (72–90)
Two-vessel	51 (25–74)	61 (36–83)
Single-vessel	52 (18–84)	54 (22–85)
Urgency		
Urgent indication‡	62 (50–72)	79 (71–88)
Nonurgent indication	53 (33–73)	64 (46–81)
Payer		
Private insurance	62 (38–81)	82 (62–94)
Medicare	76 (54–89)	91 (76–97)
Medicaid	57 (39–75)	75 (57–89)
Uninsured	42 (24–66)	52 (32–78)§

* All rates are weighted for sample design.
† $P = 0.023$.
‡ Class IV chronic stable angina, unstable angina, myocardial infarction, or near sudden death.
§ $P = 0.026$.

0.023) and that uninsured patients were less likely than other patients to receive such a recommendation (52% [CI, 32% to 78%]) ($P = 0.026$) (**Table 5**). Adjusted recommendation rates were substantially lower for women (63% [CI, 47% to 79%]) than for men (79% [CI, 70% to 88%]), but the difference was not statistically significant.

Analysis of adjusted revascularization rates in off-site hospitals showed similar variations: lower rates for women (48%) than for men (64%), lower rates for uninsured persons (42%), and higher rates for African-American patients (74%); because of sample size, however, these differences did not achieve conventional levels of significance in the regression analysis.

Recommendations

Of the 45 patients in the off-site hospitals who met the panel criteria for necessary revascularization but did not receive a recommendation for revascularization, 9 (20%) had potentially mitigating conditions: Seven were addicted to cocaine or alcohol, 1 was older than 80 years of age, and 1 had an ejection fraction less than 20%. In on-site hospitals, 5 of 68 patients (7%) for whom revascularization was not recommended were in these categories.

Refusals

Documented patient refusals of revascularization were found for 10% of patients in off-site hospitals and 5% of patients in on-site hospitals. Deaths and surgeon refusals accounted for an additional small number of patients in the on-site hospital group who did not receive necessary revascularization (**Table 6**).

Unexplained Differences

Patient refusals, deaths, and other known reasons why recommended necessary revascularization was not performed in on-site hospitals accounted for all but 7 patients (2%) who did not receive revascularization. In off-site hospitals, the rate of unexplained failure to perform necessary revascularization was 21% (**Table 6**).

Discussion

In this population-based study of cardiac revascularization procedures in New York City, we found that 26% of patients who met the panel criteria for necessary revascularization failed to receive revascularization. However, the rate of underuse was not higher in women than in men, in African-American or Hispanic patients than in white patients, or in uninsured persons than in insured persons. These findings are contrary to those of previous studies that focused on rates alone or on patients with severe disease in a single institution (25).

The underuse rate was greater (41%) for patients in hospitals that did not provide CABG surgery or PTCA on site. In these hospitals, white and Hispanic patients had lower rates of necessary revascularization than African-American patients did, and uninsured patients were much less likely than patients with insurance to have CABG surgery or PTCA recommended.

Lack of precision in our study could have masked potential differences between patients of different sexes and ethnicities. However, the rate of necessary revascularization in our study was actually higher for women (77%) than for men (72%) and was slightly higher for African-American patients (75%) than for white patients (74%). Even if the true rates for these values were at the opposite extremes of our 95% CIs (**Table 4**), the differences would be small. The rate of necessary revascularization would be 70% for women, 78% for men, 66% for African-American patients, and 80% for white patients. These sex- and ethnicity-based differences are much smaller than those previously reported. With regard to payer status, however, the width of the 95% CIs makes our findings indeterminate.

The validity of the RAND expert panel criteria

for necessity was evaluated by Kravitz and colleagues (26), who found that patients who received revascularization deemed necessary according to these criteria had half the 1-year mortality rate and less chest pain than patients who met the criteria but did not have revascularization. In a study of outcomes in 6851 patients with acute myocardial infarction, Selby and coworkers (27) found that patients who met the panel criteria for necessary revascularization had a 33% lower mortality rate if they were treated at a hospital with a high volume of angiography procedures than if they were treated at a hospital with a lower rate.

Why are revascularization rates so low in off-site hospitals? Clearly, one potential explanation is the lack of availability of the service itself. Good evidence suggests that many services are less likely to be provided if they are not available at the hospital where the patient is treated. Every and associates (28) found that patients with acute myocardial infarction who were admitted to hospitals that provided on-site catheterization were three times as likely to have angiography as those admitted to hospitals that did not provide angiography. But lack of provision of CABG surgery and PTCA may be a proxy for constrained resources that lead to failure to follow up on the results of angiography to achieve needed revascularization. Indeed, three of the four off-site hospitals in our study were municipal hospitals, institutions known to be chronically underfinanced. In contrast, all of the on-site hospitals but one were private referral hospitals.

The small number of hospitals in the sample makes it impossible to disentangle the effects of municipal status from the effects of off-site status, but we investigated other possible reasons why patients in off-site hospitals who met the panel criteria for necessary revascularization did not receive it. These include lack of a recommendation of revascularization, patient refusal, and financial and cultural barriers.

Recommendation Rates

The difference in recommendation rates between on-site referral hospitals (85%) and off-site community hospitals (76%) accounted for half of the difference in revascularization rates. Several factors seemed to lead physicians in off-site hospitals to recommend necessary revascularization to fewer patients. First, 20% of patients who did not receive a recommendation of revascularization in off-site hospitals had mitigating circumstances—drug addiction, old age, or low ejection fraction—that may have led physicians not to recommend revascularization. In on-site hospitals, 7% of patients for whom revascularization was not recommended had mitigating circumstances.

Table 6. Reasons for Lack of Revascularization*

Variable	On-site Hospitals	Off-site Hospitals
	n (%)	
Total necessary cases	464 (100)	167 (100)
Patients for whom revascularization was not recommended	68 (15)	45 (27)
Patients for whom revascularization was recommended	396 (85)	122 (73)
Revascularization	364 (92)†	84 (69)†
Patient refusal	21 (5)†	12 (10)†
Death	3 (1)†	0
Surgeon refusal	1	0
No explanation	7 (2)†	26 (21)†

* These are unweighted numbers and percentages therefore differ somewhat from the weighted rates given in other tables.
† Percentage of patients for whom revascularization was recommended.

Second, physicians in off-site hospitals seemed to use stricter criteria. Patients with left main disease, for which the evidence for life-saving benefit of CABG surgery is clear, were likely (91%) to receive a recommendation, whereas patients with non–life-threatening (but disabling) single-vessel disease were not (54%) (rates for all hospitals were 97% for left main disease and 87% for single-vessel disease). Like physicians who work where resources are constrained (for example, in the United Kingdom [29]), physicians in off-site hospitals tended not to recommend care for conditions for which the need was less critical.

Third, physicians in off-site hospitals recommended revascularization less often for uninsured patients than for patients with insurance. Mort and colleagues (30) noted that physicians in general refer fewer patients for tests or services if the patients are uninsured. Of note, this was not true in on-site hospitals, where 87% of uninsured patients received a recommendation for revascularization.

Patient Refusals

Patients in off-site hospitals were twice as likely to refuse revascularization when it was recommended. Cardiologists in these hospitals indicated anecdotally that certain ethnic groups are averse to surgical treatment. Schechter and coworkers (31) showed that African-American patients were more likely than white patients to disagree with physician recommendations for cardiac catheterization. However, in the on-site hospitals, we found few refusals among Hispanic and African-American patients.

Financial and Cultural Barriers

Failure to obtain necessary revascularization was unexplained for 21% of patients in off-site hospitals for whom revascularization was recommended and for 2% of patients in on-site hospitals. Because we did not interview patients, we do not know what

accounts for the difference. We do know, however, that cultural, financial, and institutional barriers to the receipt of necessary procedures can be substantial. Many patients in the off-site hospitals in our study are poor, are members of ethnic minority groups, and are recent immigrants for whom cultural and communication barriers to care can be significant. These factors and the lack of a primary care physician who provides counseling, understanding, and follow through have been shown to result in the failure of patients to understand the need for treatments and to obtain them.

Finally, lack of ability to pay can be a barrier to revascularization even when revascularization is recommended. To receive CABG surgery or PTCA, patients in off-site hospitals must be transferred to an on-site hospital. Private referral hospitals in New York City have unofficial arrangements with off-site hospitals for the transfer of patients who need specialized care, but they are not required to accept these patients.

Although patients in off-site hospitals face many barriers in receiving needed care, we believe that the greatest barrier is the lack of on-site revascularization. The reluctance of cardiologists to recommend revascularization; problems in scheduling, transfer, and compliance; and even some patient refusals all stem from organizational and managerial barriers that would be minimized if CABG surgery and PTCA were provided on site. We do not think it is merely coincidental that the hospital with the highest rate of necessary revascularization was the one municipal hospital that provides on-site revascularization and that the private hospital with the lowest rate of necessary revascularization was the one private hospital in the sample that did not have on-site revascularization.

It is worrisome that even in on-site hospitals, 15% of the patients who met our necessity criteria failed to receive a recommendation from their physician for revascularization. This suggests inadequate dissemination of information even for indications for which it has been shown, by strong objective evidence and expert judgments, that revascularization provides benefit. Numerous factors preclude our ever achieving a rate of 100%, but it is not unreasonable to expect that cardiac revascularization will be offered to 95% of patients who need it.

Limitations

Our study has several important limitations. First, the use of self-reported ethnicity may have introduced bias. We did not use records if information on ethnicity was missing from them, and the nondifferential misclassification of those persons in the data set may have resulted in an attenuation of effects. We cannot estimate the size of this attenuation, but we believe it to be slight. Second, our findings in off-site hospitals are based on a sample of only four hospitals, most of which are municipal hospitals. Our findings may therefore not apply to all off-site hospitals, and our study should be repeated in a larger, more diverse sample of hospitals in another location. Third, although the accuracy of the record review process for recovering data is high, cardiologists may have important reasons for not referring a patient that are not documented in the medical record (32). Fourth, in the absence of patient interviews, we undoubtedly failed to identify some patients who refused recommended revascularization. Patients with doubts do not always communicate them to a physician but may rather simply fail to show up for the recommended treatment. Fifth, some patients may have undergone revascularization that went unrecorded. This is unlikely because New York State has a rigorous case-reporting system that we double-checked through inquiries to the referring cardiologists. Border crossing (having an operation in another state) was not found among the on-site patients, and it is less likely to have occurred in the off-site hospital population.

It is also important to note that our findings are not a measure of the full extent of underuse because we studied patients only after they had received angiography, which itself could be underused. In fact, in a companion study, Carlisle and associates (33) found that 22% of patients who were treated in an emergency department for chest pain and who met the criteria for necessary stress tests and angiographic studies failed to receive them.

Conclusion

In conclusion, our results are both encouraging and disturbing. The encouraging finding is that physicians in New York City provide cardiac revascularization services to those who need them without regard to sex, ethnicity, or ability to pay. The disturbing result is that many patients who need these procedures fail to get them, particularly if they are cared for at hospitals that perform coronary angiography but do not provide CABG surgery and PTCA on site. In these hospitals, uninsured patients were especially likely not to receive a recommendation for necessary revascularization, and even when patients received such a recommendation, almost one third did not receive CABG surgery or PTCA.

Clearly, extensive efforts are needed to remove barriers to referral and to ensure that all patients receive revascularization when they need it. Our findings also indicate an urgent need for a complete policy analysis that examines the wisdom of dissociating the provision of diagnostic angiography from that of therapeutic PTCA and CABG surgery.

Appendix: The RAND Appropriateness Method: Development of Indications and Appropriateness Criteria

The method for measuring appropriateness has been described by Park and coworkers (34) and Chassin and colleagues (35). Briefly, after a comprehensive literature review, a set of clinical scenarios (*indications*) was derived that encompassed all possible reasons (both appropriate and inappropriate) that might arise in clinical practice for performing CABG surgery or PTCA. There were 996 indications. These indications were then rated for appropriateness by a panel of nine expert clinicians selected from a group of physicians nominated by relevant specialty societies.

Each panelist received a copy of the literature review and, after reading it, was asked to rate each indication for the appropriateness of CABG surgery or PTCA by 1) using their best clinical judgment and 2) considering an average patient presenting to an average surgeon or cardiologist performing CABG surgery or PTCA in 1990. "Appropriate" was defined to mean that the expected health benefit (in terms of quality of life or longevity) exceeded the expected negative consequences (pain, disability, and risk for death) by a margin sufficient to make the procedure worth doing. The cost of the procedure was not considered in the appropriateness rating. Extremely appropriate indications were rated as 9, extremely inappropriate indications were rated as 1, and indications that were considered neither appropriate nor inappropriate were rated as 5.

Because CABG surgery and PTCA are often alternative treatments, each indication was rated in three ways: for the appropriateness of CABG surgery in a patient who is not also a candidate for PTCA, for the appropriateness of CABG surgery in a patient who is a candidate for both PTCA and CABG surgery, and for the appropriateness of PTCA compared with medical therapy. This required each panelist to provide nearly 3000 appropriateness ratings.

The final appropriateness rating was the median of the nine panelists' ratings after the second round of ratings. An indication was considered appropriate if the median rating was 7 to 9, inappropriate if the median rating was 1 to 3, and uncertain if the median rating was 4 to 6. An indication was also considered uncertain if there was disagreement about it, regardless of the median rating. Disagreement was defined as having occurred if more than two panelists assigned a rating in the inappropriate range (1 to 3) and more than two panelists assigned a rating in the appropriate range (7 to 9). Overall, 4% of ratings had disagreement.

After rating indications for appropriateness, the panelists rated all appropriate indications for necessity. Panelists were asked to rate an indication as necessary if they believed that 1) not providing revascularization for most patients with this indication would constitute improper care, 2) the likelihood of benefit from revascularization would be significant, and 3) the magnitude of the benefit would not be small. The implication of a necessary rating is that a physician is obligated to recommend revascularization for a patient with the given indication in the absence of contraindications or mitigating factors. For example, a patient with chronic stable angina (class IV) who is receiving maximal medical therapy, has two-vessel disease with proximal left anterior descending involvement, has a very positive result on exercise electrocardiography, has an ejection fraction of 15% to 35%, and is at low risk from surgery has a necessary indication.

An indication was most likely to be rated by the panel as necessary if outcome data confirmed the effectiveness of revascularization in increasing survival or relieving pain in patients with that indication. Particularly for CABG surgery, extensive outcome data are available from randomized trials. We classified an indication as necessary if the median rating of the nine experts was 7, 8, or 9 on a scale of 1 to 9 in the second round of necessity ratings. Of the indications for CABG surgery or PTCA previously rated as appropriate by the panel, fewer than half (n = 249) were rated as necessary. These indications represent only 8% of all possible indications for CABG surgery and PTCA.

Ratings tended to cluster around the median. For example, of the 49 indications with a necessary rating and a median rating of 9, only 5 (10%) were rated less than 7 by any panelist. Similarly, of the 114 indications with a median necessity rating of 7, 79 had no rating less than 4 and only 2 had more than 1 rating less than 4. Median ratings of 7 were found exclusively for indications in high-risk patients.

The 631 patients in our study represented 105 indications with a necessary rating, but 14 indications accounted for 50% of patients. Of these 14 indications, 5 were rated 9, 5 were rated 8, and 4 were rated 7. The distribution of median necessity ratings for the 631 patients was 9 for 179 indications, 8 for 276 indications, and 7 for 176 indications.

The reproducibility of the panel process was recently reported (36). Among three independent panels, agreement was more than 90% for judgments of appropriateness and necessity. Most important, none of the indications rated as necessary by one panel were rated as inappropriate by either of the other two.

The literature review, the listing of all 2990 appropriateness ratings, the definitions of terms, and the final panel ratings of appropriateness and necessity have been published as monographs (37, 38) and are available from RAND, 1700 Main Street, Santa Monica, CA 90407-2138.

From RAND, Santa Monica, California; Harvard School of Public Health, Boston, Massachusetts; and University of California, Los Angeles, School of Medicine and School of Public Health, Los Angeles, California.

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Requests for Reprints: Lucian L. Leape, MD, Department of Health Policy and Management, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02115.

Current Author Addresses: Dr. Leape: Department of Health Policy and Management, Harvard School of Public Health, 677 Huntington Avenue, Boston, MA 02115.
Dr. Hilborne: University of California, Los Angeles, School of Medicine, 10833 LeConte Avenue, Los Angeles, CA 90024.

Drs. Bell and Brook: RAND, 1700 Main Street, Santa Monica, CA 90407.
Ms. Kamberg: RAND, 1333 H Street NW, Washington, DC 20005.

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