UNDERUSE OF CORONARY REVASCULARIZATION PROCEDURES IN PATIENTS CONSIDERED APPROPRIATE CANDIDATES FOR REVASCULARIZATION


ABSTRACT

Background Ratings by an expert panel of the appropriateness of treatments may offer better guidance for clinical practice than the variable decisions of individual clinicians, yet there have been no prospective studies of clinical outcomes. We compared the clinical outcomes of patients treated medically after angiography with those of patients who underwent revascularization, within groups defined by ratings of the degree of appropriateness of revascularization in varying clinical circumstances.

Methods This was a prospective study of consecutive patients undergoing coronary angiography at three London hospitals. Before patients were recruited, a nine-member expert panel rated the appropriateness of percutaneous transluminal coronary angioplasty (PTCA) and coronary-artery bypass grafting (CABG) on a nine-point scale (with 1 denoting highly inappropriate and 9 denoting highly appropriate) for specific clinical indications. These ratings were then applied to a population of patients with coronary artery disease. However, the patients were treated without regard to the ratings. A total of 2552 patients were followed for a median of 30 months after angiography.

Results Of 908 patients with indications for which PTCA was rated appropriate (score, 7 to 9), 34 percent were treated medically; these patients were more likely to have angina at follow-up than those who underwent PTCA (odds ratio, 1.97; 95 percent confidence interval, 1.29 to 3.00). Of 1363 patients with indications for which CABG was considered appropriate, 26 percent were treated medically; they were more likely than those who underwent CABG to die or have a nonfatal myocardial infarction — the composite primary outcome (hazard ratio, 4.08; 95 percent confidence interval, 2.82 to 5.93) — and to have angina (odds ratio, 3.03; 95 percent confidence interval, 2.08 to 4.42). Furthermore, there was a graded relation between rating and outcome over the entire scale of appropriateness (P for linear trend = 0.002).

Conclusions On the basis of the ratings of the expert panel, we identified substantial underuse of coronary revascularization among patients who were considered appropriate candidates for these procedures. Underuse was associated with adverse clinical outcomes. (N Engl J Med 2001;344:645-54.)

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DECIDING which patients should undergo coronary revascularization remains a key challenge in the management of coronary artery disease, with individual physicians' practice patterns varying widely.1 The recommendation of revascularization is usually made by the patient's own specialist, based on an implicit judgment that the benefits of the procedure in terms of survival or decreased morbidity outweigh the risks. Expert panels' ratings of the appropriateness of revascularization in patients with a variety of typical indications, determined according to the RAND–University of California at Los Angeles (UCLA) method, make this judgment explicit, by making it possible to assign patients a score on a scale that ranges from appropriate through uncertain to inappropriate. Studies using this method have shown that overuse2-11 of invasive techniques in the management of coronary disease is uncommon, and attention has turned to the issue of underuse.12-16 Well-designed expert panels can closely reflect the views of practicing physicians,17 and methods for detecting the underuse of revascularization are highly reproducible.18

Despite reports on the ratings of a large number of expert panels2-11 on coronary revascularization, a central aspect of the validity of the appropriateness-rating method remains untested. If expert panels' judgments have clinical validity, then patients who are treated according to their ratings should have better clinical outcomes than those who are not. Furthermore, greater clinical benefits might be expected at higher levels of appropriateness. It is common for patients not to receive appropriate invasive treatment for coronary disease; 22 to 41 percent of patients for whom expert panels deem a procedure not only appropriate...
but also necessary do not undergo the procedure.¹²¹⁶

The only previous study of clinical outcomes¹² found retrospectively that, among patients for whom revascularization was deemed necessary, the rate of survival was higher and there was less chest pain among those who underwent revascularization than among those who were treated medically. However, the study was limited by insufficient statistical power to separate outcomes in patients undergoing percutaneous transluminal coronary angioplasty (PTCA) from those in patients undergoing coronary-artery bypass grafting (CABG). Previous studies of coronary revascularization have not examined clinical outcomes in relation to the entire range of ratings of appropriateness.

We undertook a prospective study of clinical outcomes, the Appropriateness of Coronary Revascularization (ACRE) study, in which prior judgments about the appropriateness of indications for revascularization, determined by an expert panel, were applied to a population-based cohort of patients with coronary artery disease. The primary hypothesis was that patients who were classified as appropriate candidates for revascularization but who did not undergo the procedure would have worse outcomes than those who did undergo it, independently of other clinical characteristics.

METHODS

Appropriateness Ratings

The ACRE appropriateness ratings for PTCA and CABG were determined in 1995, before the patients were recruited, and the internal consistency, validity, and reliability of these ratings have been reported elsewhere.¹⁹ Using the RAND–UCLA Delphi method, a nine-member expert panel rated 984 mutually exclusive indications for CABG and 995 indications for PTCA. Specific indications were grouped into broad clinical presentations (examples are shown in Table 1) and were categorized according to the severity of symptoms, the number of diseased vessels, the involvement or noninvolvement of the proximal left anterior descending artery, the ejection fraction, the results on noninvasive testing for ischemia, the degree of risk posed by surgery (defined according to the method of Parsonnet et al.²⁰), and current medications. Panelists rated the appropriateness of each procedure separately for each clinical presentation, and the median of their scores was obtained.

Median scores ranged from 1 to 9, with 1 to 3 considered to indicate that the procedure was inappropriate, 4 to 6 that its appropriateness was uncertain, and 7 to 9 that it was appropriate. Revascularization was deemed inappropriate when risks were judged to exceed benefits, of uncertain appropriateness when benefits and risks were approximately equal or when the best available evidence did not support a judgment either way, and appropriate when benefits exceeded risks by a sufficient margin to make the procedure worth performing. Each indication was defined in sufficient detail that the procedure could be considered to be equally appropriate (or inappropriate) for all patients with that indication. Examples of the panel’s ratings of frequently occurring indications are presented in Table 1.

Study Population

Before recruiting patients, we determined that 3800 patients scheduled to undergo coronary angiography would be required to allow us to detect an increase of at least 60 percent (hazard ratio, ≅1.60) in the risk of the prespecified composite primary outcome (death from any cause or nonfatal myocardial infarction) among patients who had indications for which CABG was deemed appropriate but who did not undergo CABG, as compared with those who appropriately underwent CABG (90 percent power, two-sided P=0.05). Patients were eligible for inclusion in the study if they were to undergo elective or emergency coronary angiography at any of three neighboring teaching hospitals in the City of London and

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**Table 1. Examples of Frequent Indications for PTCA and CABG.**

<table>
<thead>
<tr>
<th>CLINICAL PRESENTATION</th>
<th>SYMPTOMS, THERAPY AND ECG RESULTS</th>
<th>VARIABLES USED TO DEFINE INDICATIONS</th>
<th>APPROPRIATENESS CATEGORY (SCORE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SYMPTOMS, THERAPY AND ECG RESULTS</td>
<td>LEVEL OF OPERATIVE RISK</td>
<td>EJECTION FRACTION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Chronic stable angina,</td>
<td>Submaximal medical therapy</td>
<td>Moderate</td>
<td>&gt;35</td>
</tr>
<tr>
<td>CCS class I or II</td>
<td>very positive exercise ECG</td>
<td>Any</td>
<td>&gt;15</td>
</tr>
<tr>
<td></td>
<td>Any</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic stable angina,</td>
<td>Submaximal medical therapy</td>
<td>Moderate</td>
<td>&gt;35</td>
</tr>
<tr>
<td>CCS class III or IV</td>
<td>Maximal medical therapy</td>
<td>Low</td>
<td>&gt;35</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>Asymptomatic with maximal therapy</td>
<td>Low or moderate</td>
<td>&gt;35</td>
</tr>
<tr>
<td></td>
<td>symptoms with submaximal medical</td>
<td>Low</td>
<td>&gt;35</td>
</tr>
<tr>
<td></td>
<td>therapy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* A total of 984 indications were rated for CABG and 995 indications for PTCA, of which 312 occurred in the study sample of 2552 patients with coronary artery disease. A total of 521 patients had indications that made them appropriate candidates for both CABG and PTCA. ECG denotes electrocardiogram. CCS class refers to the Canadian Cardiovascular Society classification of symptoms, ranging from I (mild) to IV (severe). The abnormalities on the exercise ECG were defined by RAND. Operative risk was measured by the method of Parsonnet et al.²⁰.
the East End (London Chest, St. Bartholomew’s, and Royal Lon-
don hospitals) between April 15, 1996, and April 14, 1997, and
if they lived within the contiguous catchment areas of the five
health authorities covering the City of London, East London, and
Essex. There were no criteria for exclusion, and 4121 eligible pa-
tients were identified.21 The resident population of the combined
catchment area was 2,838,000, and 89 percent of the angiography
procedures performed in this population were performed at these
hospitals. Approval for the study was obtained from the five local
research-ethics committees, and written informed consent was ob-
tained from all patients.

Data from Clinical Records

Eligible patients were identified on the day of their index coro-
nary angiography through the examination of logs of admissions to
wards and catheterization laboratories. Data were abstracted from
case notes by trained nurses using standardized recording forms.
Details were obtained on clinical presentation (as defined by
RAND22), Canadian Cardiovascular Society (CCS) classification23
of the functional severity of angina (ranging from class I, denot-
ing mild angina, to class IV, denoting severe angina), current med-
ications, presence or absence of diabetes, results on exercise electro-
cardiography (ECG),24 coexisting conditions, and the physician’s
intended treatment plan.

Angiographic Data

After angiography was performed, the angiographic findings were
obtained from the written report of angiographic results found
in each patient’s case notes and were coded by a trained coder
who was unaware of the clinical details. The severity of disease in
each of the 27 coronary-artery segments defined by the Coronary
Artery Surgery Study24 was coded from 1 (no disease) to 6 (oc-
clusion), and the number of diseased vessels was calculated. In or-
der to assess the reliability of this approach, two cardiologists who
were unaware of the clinical details reviewed a random sample of
209 angiograms. There was good agreement beyond the degree
expected by chance between the cardiologists and the trained cod-
er, with weighted kappas of 0.64 and 0.63.25 Coronary artery dis-
ease, defined as stenosis of 50 percent or more of the luminal di-
ameter in the left main coronary artery or of 70 percent or more
in other arteries, was present in 2729 patients, for 2552 of whom
(94 percent) there were sufficient data for us to assign a score for
the appropriateness of CAGB; the corresponding figure for PTCA
was 2562. These patients became the study population.

Follow-up

We identified the first revascularization procedures performed
in study patients after the index coronary angiography by cross-
checking a national electronic information system (the National
Health Service–Wide Clearing System) and the hospitals’ log books
cateterization laboratories and operating rooms, using a unique iden-
tifier, the patient’s National Health Service number.

Patients were followed for the composite end point of death or
nonfatal myocardial infarction until April 14, 1999, resulting in a
median follow-up period of 30 months (range, 0 to 36). The rec-
cords of the vital status of 2537 patients (99 percent) were flagged
(with the unique identifier) at the central registry of the Office for
National Statistics so that we would be notified of the date of death
if they died. We ascertained possible cases of nonfatal myocardial
infarction by searching the data base of the National Health Serv-
vice–Wide Clearing System for discharges coded for coronary ar-
tery disease (codes 120 to 125 of the International Statistical Clas-
sification of Diseases and Related Health Problems, 10th Revision
[ICD-10])26 and by means of manual searches of admissions records
in the 13 hospitals that referred patients for angiography. Acute my-
cardial infarction was defined according to the criteria of the World
Health Organization’s Monitoring Trends and Determinants in Car-
diovascular Disease (MONICA) project.27

The presence and severity of angina were assessed according to
the CCS scale on the basis of data obtained from questionnaires
sent to patients 12 months after revascularization or 12 months af-
after angiography if no revascularization had been performed. Among
patients who had coronary artery disease at the time of angiog-
raphy and were alive 12 months later, the response rate was 76 per-
cent (1835 of 2416). Those who responded were older (P<0.001)
and more likely to be white (P<0.001) and were less likely to have
undergone a previous PTCA procedure (P=0.03), but otherwise
they did not differ significantly from those with no response in
terms of the demographic and clinical characteristics in Table 2.

Statistical Analysis

The clinical outcomes of the patients who were treated medi-
cally were compared with the outcomes of those who underwent
CABG or PTCA after angiography; comparisons were made sep-
ately for each type of procedure, within each category of appro-
priateness. Each patient’s first revascularization procedure after the
index angiography was analyzed. The independent effect of CABG
or PTCA on outcomes was estimated with the use of Cox propor-
tional-hazards models (for the composite primary outcome of death
and nonfatal myocardial infarction) and logistic regression (for
the presence or absence of angina). By design, the appropriate-
ness method classifies patients on the basis of risk. We used mul-
tivariate adjustments of hazard ratios and odds ratios to reduce the
possibility of residual confounding. Survival data were compared
by means of Kaplan–Meier curves and the log-rank test. Proportions
were compared by means of the chi-square statistic. Linear
trends in the hazard ratio across the categories of appropriateness
were assessed with the use of a likelihood-ratio test. All analyses
were performed with the use of SAS software.28

RESULTS

Of the 2552 patients analyzed, 908 had indications for which PTCA was deemed appropriate and 1353 had indications for which CABG was deemed appropriate (Table 2). There were 521 patients who were deemed appropriate candidates for both PTCA and CABG. PTCA procedures were performed in 34 (6 percent) of the 568 patients whom we rated as in-
appropriate candidates for PTCA, in 225 (22 percent) of the 1027 patients for whom we rated the appro-
priateness of PTCA as uncertain, and in 327 (36 per-
cent) of the 908 patients whom we rated as appropri-
ate candidates (P for linear trend <0.001). For CABG, the
 corresponding figures were 15 (8 percent) of 186
patients, 212 (21 percent) of 1013 patients, and 765
(57 percent) of 1353 patients (P for linear trend <0.001).
Of the 908 patients classified as appropri-
ate candidates for PTCA at the time of angiography,
327 (36 percent) underwent PTCA, 273 (30 percent)
underwent CABG, and 308 (34 percent) received
only medical treatment. Of the 1353 patients classi-
cified as appropriate candidates for CABG, 765 (57 per-
cent) underwent CABG, 234 (17 percent) underwent
PTCA, and 354 (26 percent) received only medical
treatment. Of all the PTCA procedures, 56 percent
involved stenting (55 percent, 56 percent, and 63 per-
cent in the appropriate, uncertain, and inappropriate
categories, respectively). Of the 308 patients whom
we classified as appropriate candidates for PTCA but
who received only medical treatment, the recorded
intention of the physician at the time of angiography
was to use medical treatment in 89 percent. The cor-
responding figure for CABG was 81 percent.
Among patients for whom PTCA was rated appropriate, stepwise logistic-regression analysis of all the demographic and clinical variables listed in Table 2 identified previous CABG, heart failure, and the presence of disease in two vessels as independent predictors of which patients would receive only medical treatment rather than undergo PTCA. Among patients classified as appropriate candidates for CABG, stepwise logistic-regression analysis identified previous CABG, the presence of disease in fewer than three vessels or its absence in the left main coronary artery, a lower CCS angina class, nonuse of beta-blockers, diabetes, and nonwhite race as independent predictors of which patients would receive only medical treatment.

Tables 3, 4, and 5 show the relations among the clinical outcomes, the appropriateness classifications, and whether or not patients underwent revascularization. The results have been adjusted for age, sex, and 12 characteristics for which there were significant differences.
cant differences between the treatment groups (Table 2). As compared with adjustment for age alone, the multivariate adjustment tended to have little additional effect on our estimates of hazard ratios or odds ratios. The small number of events that occurred among patients classified as inappropriate candidates for the procedures precluded multivariate adjustment in that category.

Medical Treatment versus PTCA

Among all 584 patients who underwent PTCA, 34 (6 percent) had indications rated as inappropriate for PTCA, 223 (38 percent) had indications rated as uncertain, and 327 (56 percent) had indications rated as appropriate. Patients whom we classified as appropriate candidates for PTCA but who received medical treatment were more likely to have angina at follow-up (odds ratio, 1.97; 95 percent confidence interval, 1.29 to 3.00) (Table 3) than those who received PTCA, but the two groups were equally likely to die or have a nonfatal myocardial infarction during follow-up (hazard ratio, 0.77; 95 percent confidence interval, 0.48 to 1.25) (Table 4).

Medical Treatment versus CABG

Among all 992 patients who underwent CABG, 15 (2 percent) had indications rated as inappropriate for CABG, 212 (21 percent) had indications rated as uncertain, and 765 (77 percent) had indications rated as appropriate. Patients whom we classified as appropriate candidates for CABG but who received medical treatment were more likely than those who received CABG to have angina at follow-up (odds ratio, 3.03; 95 percent confidence interval, 2.08 to 4.42) (Table 3) and to die or have a nonfatal myocardial infarction during the follow-up period (hazard ratio, 4.08; 95 percent confidence interval, 2.82 to 5.93) (Table 4). Patients whom we classified as appropriate candidates for CABG had a risk of death or nonfatal myocardial infarction within two years after angiography of 21 percent if they received medical treatment, as compared with 6 percent among those who underwent CABG (P<0.001 by the log-rank test) (Fig. 1). Patients for whom we considered CABG of uncertain appropriateness who received medical treatment were also more likely to have angina at follow-up (odds ratio, 2.23; 95 percent confidence interval,
The hazard ratios compare the likelihood of the outcomes in patients treated medically with the likelihood in patients treated with PTCA or CABG. For patients with indications rated appropriate or uncertain, the hazard ratios have been adjusted for age, sex, race, use or nonuse of beta-blockers, presence or absence of diabetes, history with respect to myocardial infarction, Canadian Cardiovascular Society angina class, number of diseased vessels, presence or absence of diffuse disease, presence or absence of impaired left ventricular function, presence or absence of heart failure, history with respect to revascularization, and Parsonnet score (which measures operative risk). For patients with indications rated inappropriate, the hazard ratios have been adjusted for age. CI denotes confidence interval, and MI myocardial infarction.

**TABLE 4. INCIDENCE OF DEATH FROM ANY CAUSE OR NONFATAL MYOCARDIAL INFARCTION AT 2.5 YEARS OF FOLLOW-UP, ACCORDING TO TREATMENT RECEIVED AND APPROPRIATENESS CATEGORY.**

<table>
<thead>
<tr>
<th>PROCEDURE AND CATEGORY</th>
<th>DEATH FROM ANY CAUSE</th>
<th>DEATH FROM ANY CAUSE OR NONFATAL MI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEDICAL TREATMENT</td>
<td>REVASCULARIZATION</td>
</tr>
<tr>
<td></td>
<td>no. who died/total no.</td>
<td>no. with event</td>
</tr>
<tr>
<td>PTCA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inappropriate</td>
<td>48/170</td>
<td>4/34</td>
</tr>
<tr>
<td>Uncertain</td>
<td>60/486</td>
<td>13/223</td>
</tr>
<tr>
<td>Appropriate</td>
<td>20/308</td>
<td>18/327</td>
</tr>
<tr>
<td>Total</td>
<td>128/964</td>
<td>35/584</td>
</tr>
<tr>
<td>CABG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inappropriate</td>
<td>13/109</td>
<td>3/15</td>
</tr>
<tr>
<td>Uncertain</td>
<td>53/514</td>
<td>19/212</td>
</tr>
<tr>
<td>Appropriate</td>
<td>68/354</td>
<td>42/765</td>
</tr>
<tr>
<td>Total</td>
<td>134/977</td>
<td>64/992</td>
</tr>
</tbody>
</table>

*The hazard ratios compare the likelihood of the outcomes in patients treated medically with the likelihood in patients treated with PTCA or CABG. For patients with indications rated appropriate or uncertain, the hazard ratios have been adjusted for age, sex, race, use or nonuse of beta-blockers, presence or absence of diabetes, history with respect to myocardial infarction, Canadian Cardiovascular Society angina class, number of diseased vessels, presence or absence of diffuse disease, presence or absence of impaired left ventricular function, presence or absence of heart failure, history with respect to revascularization, and Parsonnet score (which measures operative risk). For patients with indications rated inappropriate, the hazard ratios have been adjusted for age. CI denotes confidence interval, and MI myocardial infarction.

†Hazard ratios are indicated by the solid circles (and their 95 percent confidence intervals by horizontal lines) on a logarithmic scale. A hazard ratio of 1.0 indicates no difference in the effects of revascularization and medical treatment in terms of death or nonfatal myocardial infarction at follow-up. Values greater than 1.0 indicate a beneficial effect of revascularization over medical treatment, and values less than 1.0 indicate a beneficial effect of medical treatment over revascularization.
1.40 to 3.55) and to die or have a nonfatal myocardial infarction during the follow-up period (hazard ratio, 1.69; 95 percent confidence interval, 1.02 to 2.78) than those who underwent CABG.

In a stepwise proportional-hazards regression model of primary outcome, not undergoing CABG when the procedure was appropriate entered the model first; of the other variables, only impaired left ventricular function and age subsequently entered the model at a significance level of P<0.05.

### Dose–Response Relations

In order to investigate further the dose–response relation between the degree of appropriateness and the primary outcome, patients were categorized into five groups according to the ratings of appropriateness (Table 5). The effect on the primary outcome of not undergoing CABG, as compared with undergoing CABG, was greatest for patients whom we classified as the most appropriate candidates for CABG (those with a rating of 9), but it remained significant in the groups defined by ratings of 7 or 8 and 5 or 6 (P for linear trend across the five groups = 0.002).

### DISCUSSION

In our prospective study of patients undergoing coronary angiography, medical treatment was common among patients with indications for which revascularization had been deemed appropriate by the ACRE expert panel. Over 2.5 years of follow-up, these medically treated patients had higher mortality and a higher prevalence of angina than patients who underwent revascularization. The findings of this prospective study provide strong evidence that ratings of appropriateness have clinical validity in measuring underuse of revascularization after angiography. Our use of the appropriateness scale enabled us to identify underuse of revascularization both among appropriate candidates and among patients with indications for which revascularization was rated as of uncertain appropriateness.

The increase in the risk of adverse outcomes associated with medical treatment was greatest among the patients whom we classified as the most appropriate candidates for CABG (patients with a rating of 9). However, these effects were not confined to the patients for whom CABG was rated as appropriate. Among patients to whom we assigned a rating of 5 or 6 (usually considered “uncertain”), there were also significant effects, with a hazard ratio intermediate in magnitude between that for patients rated as appropriate and that for patients rated as inappropriate. The graded relation of revascularization with clinical outcome across the five levels of appropriateness provides evidence that the judgment of the expert panel is quantified and goes beyond the identification of the
sorts of clear-cut indications for which the evidence from randomized trials may be strongest. Previous studies have restricted the definition of underuse to the subgroup of patients for whom revascularization is judged not only appropriate but also necessary. The graded risk–benefit relation across categories of appropriateness in our study suggests that this definition is too narrow.

The better outcomes among patients for whom revascularization was deemed appropriate or uncertain were independent of a large number of clinical variables. Furthermore, they were not explained by differences in medical treatment; among the patients whom we rated as appropriate candidates for CABG, we found no difference at follow-up in the use of aspirin, beta-blockers, or statins between those who underwent CABG and those who were treated medically. The effects tended to be consistent for mortality, nonfatal myocardial infarction, and angina status.

One third of the patients whom we rated as appropriate candidates for PTCA and one quarter of those whom we rated as appropriate candidates for CABG were treated medically; these rates are in line with previous estimates that 22 to 41 percent of necessary invasive procedures are not performed.12-16 As in other studies of appropriateness, matching data abstracted from clinical records with hypothetical clinical indications creates a potential source of bias. Neither the predefined indication nor the clinical record may adequately characterize the patient. However, we found a low degree of error in the angiographic records,25 and it has previously been demonstrated that there is excellent agreement between written clinical records and the results of interviews with the physicians who perform the procedures.29 Observational studies cannot exclude as explanations other unmeasured factors, and cardiologists and surgeons may choose to perform revascularization in patients who are destined to do well for other reasons. The preference of the patient is unlikely to be a major factor, since the willingness to consider revascularization is a precondition for undergoing angiography, and other studies have found refusal by the patient to be uncommon.13

We studied the underuse of revascularization in a health care system in which access is universal and...
care is free at the point of use. Constraints on costs after angiography are less likely to influence the decision to perform a revascularization procedure in such a system than may be the case in the United States. The proportion of patients with angiographically documented coronary disease who subsequently underwent revascularization was 62 percent in our study — a proportion similar to that in a large study in the United States. However, physicians in different countries may differ in their judgments of appropriateness, suggesting that studies of clinical outcomes in relation to ratings of appropriateness are needed in countries where the rate of revascularization is higher than it is in the United Kingdom. In our study, there was good broad agreement between the categories of appropriateness defined by the expert panel and the three levels defined in the guidelines of the American Heart Association and the American College of Cardiology. However, the accumulation of new evidence regarding the effectiveness of revascularization demands an updating of the process of rating appropriateness.

Our findings raise a fundamental question about clinical decision making: Are the explicit, quantified judgments of an expert panel a better guide to the proper use of coronary revascularization than the variable decisions of individual clinicians? Reliance on an expert panel offers four potential advantages. First, as our study without exclusion criteria demonstrates, it is possible to assign an appropriateness rating in nearly all patients — not just the highly selected patients represented in trials. In making a decision together about whether to choose revascularization, the doctor and the patient can both identify the relevant clinical indications from the list used by the panel (which are specified in more detail than they are in existing guidelines) and match them to the panel’s ratings and the associated clinical outcomes. A patient with coronary disease who is not referred for revascularization by one doctor might reasonably ask, “What would the panel say?” Second, an expert panel may be better than individual clinicians at articulating the evolving results of clinical trials and applying changing technology for use in patients seen in routine clinical practice. Third, the format of the nine-member expert panel, which we used in our study, may “average out” variations in clinical decision making among individual physicians. The use of a multidisciplinary panel of surgeons, cardiologists, and general internists may reduce the practice of cardiologists “referring patients to themselves,” which may not be optimal. Fourth, an expert panel is able to make “pure” clinical decisions without the constraints of cost or expediency, on the basis of an algorithm that uses a small number of salient clinical details.

In our study, the underuse of coronary revascularization after angiography was common and, particularly in the case of CABG, was associated with adverse clinical outcomes. The integration of explicit measures of appropriateness into routine clinical decision making may improve the quality of care.

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