Physicians' Judgments of Survival After Medical Management and Mortality Risk Reduction Due to Revascularization Procedures for Patients With Coronary Artery Disease*

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Study objectives: **To assess the accuracy of physicians' judgments of survival probability for medically managed patients with coronary artery disease (CAD), and of the absolute risk reduction of mortality due to coronary artery bypass grafting (CABG) or percutaneous transluminal coronary angioplasty (PTCA) for such patients; and relationships among these judgments and the physicians' propensity to perform revascularization.**
Design: **Two surveys (for three-vessel or two-vessel CAD) for patients presenting with stable CAD, currently managed medically, and without other life-limiting problems.**
Setting: **Multiple educational conferences, 1996–1997.**
Participants: **Conference attendees.**
Measurements and results: **Main outcomes were proportions of patients for whom the physicians would recommend revascularization (CABG for three-vessel CAD, CABG or PTCA for two-vessel CAD), and judgments of the proportions of medically managed patients who would be alive after 5 years, 7 years, and 11 years, and of absolute risk reduction of mortality due to CABG (or PTCA for two-vessel CAD). At least one half of the participants judged the survival rate of medically managed patients with three-vessel or two-vessel CAD to be less than the lowest rates supported by the best available evidence. More than one fourth judged the absolute risk reduction due to CABG to be higher than the highest values based on such evidence. Physicians' propensity to perform revascularization correlated inversely with their judgments of survival given medical management, and with their judgments of absolute risk reduction due to revascularization.**
Conclusions: **Physicians may overuse revascularization because of excessive pessimism about survival of medically managed patients, and excessive optimism about the survival benefits of revascularization** ***(CHEST 2002; 122:122–133)***

Key words: coronary artery bypass; coronary artery disease; evidence-based medicine; judgment; mortality; percutaneous transluminal coronary angioplasty; physicians' practice patterns; probability

Abbreviations: BARI = Bypass Angioplasty Revascularization Investigation; CABG = coronary artery bypass grafting; CAD = coronary artery disease; CASS = Coronary Artery Surgery Study; ECSS = European Coronary Surgery Study; PTCA = percutaneous transluminal coronary angioplasty; RCT = randomized controlled trial; RITA-1 = Randomized Intervention Treatment of Angina; VACS = Veterans Administration Coronary Artery Bypass Surgery Cooperative Study

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Coronary artery disease (CAD) is an increasingly prevalent and important health problem in the United States, in other developed countries,[1] and in developing countries. CAD accounted for 5% of all US health-care spending in 1995.[2] Surgical and now angiographic revascularization procedures are increasingly popular approaches to this problem. The *per capita* rate of coronary artery bypass grafting (CABG) procedures for elderly patients increased 18% from 1987 to 1990 in the United States.[3] In 1992, 309,000 CABG and 399,000 percutaneous transluminal coronary angioplasty (PTCA) proce-

dures were performed in the United States.[4] From 1985 to 1991, the *per capita* PTCA rate increased 185% in the United States, and even faster in some European countries, *eg*, 545% in Belgium and 1960% in Denmark.[5] In the developing countries, the rate of PTCA use is also increasing, *eg*, 34% from 1993 to 1997 in Brazil.[6]

In approximately one third of patients with CAD, chronic stable angina is the first manifestation of the disease.[7] Guidelines from the American Heart Association and American College of Cardiology only suggest three subgroups of patients with stable CAD for whom CABG is supported by evidence from multiple, large, randomized controlled trials (RCTs). These subgroups are patients with left-main coronary disease; three-vessel disease; or two-vessel disease, significant proximal left anterior descending disease, and either abnormal left ventricular function or demonstrable ischemia on noninvasive testing.[8] These guidelines identified no circumstances for which the evidence supporting PTCA is this strong. Thus, something other than the evidence from clinical trials must be responsible for the growing, and some suggest excessive, use of these procedures.[4,9–15]

One explanation may be that physicians are too pessimistic about the results of medical management, and too optimistic about the results of revascularization for CAD. There is anecdotal evidence for this. For example, after Arthur Ashe acquired HIV, possibly from a blood transfusion received during four-vessel CABG, his cardiovascular surgeon said, "I think with his anatomy, the chances of living 12 years probably would have been extremely low had he not had the surgical intervention."[16] In fact, the lowest 10- to 11-year survival rates for medically managed patients reported by large trials ranged from 36% (the 11-year survival of patients in the high-risk tercile in the Veterans Administration Coronary Artery Bypass Surgery Cooperative Study [VACS])[17] to 60% (the 10-year survival of patients with left main CAD in the European Coronary Surgery Study [ECSS]).[18] Further, the absolute risk reduction of mortality at 11 years due to CABG for patients with the most severe disease in the VACS was only 13%, while neither the ECSS[17] nor the Coronary Artery Surgery Study (CASS)[19] reported significant risk reductions of mortality at 10 to 12 years for patients in any anatomic subset of CAD.

One survey has also shown that physicians may overestimate the effectiveness of revascularization, but it only assessed judgments of absolute risk reductions of mortality at 3 years due to CABG for patients with left-main CAD.[20] It showed that approximately one fourth of cardiologists judged the absolute risk reduction to be $> 45\%$, and approximately one fourth of general internists judged it to be $> 30\%$.[20] In fact, the largest absolute risk reduction for 3-year mortality reported by the three large trials[21–23] was about 20% for such patients.

Therefore, our study questions were the following: How accurate are physicians' judgments of the survival of patients with CAD of varying anatomic severity who receive medical management? How accurate are physicians' judgments of the effectiveness of CABG or PTCA in terms of reduction of the absolute risk of mortality for such patients? Are these judgments related to physicians' propensity to use revascularization for CAD?

Materials and Methods

Study Design

We surveyed two groups of physicians about their judgments of the probability of outcomes of revascularization. We asked one group of physicians about patients with stable three-vessel CAD, and the other about those with stable two-vessel CAD.

Physician Subjects

We recruited separate convenience samples of physicians for the three-vessel and two-vessel surveys. Since generalists care for many patients with stable CAD, and often make the decision to refer to cardiologists for consideration of revascularization,[24] while cardiologists usually decide what kind of revascularization, if any, is necessary, our goal was to survey both generalists and cardiologists. Therefore, we distributed surveys at venues likely to be attended by both primary care physicians and cardiologists. We distributed the three-vessel survey prior to internal medicine grand rounds at a community teaching hospital in Rhode Island in January, and then again at a university hospital in Illinois in February, 1996. From November 1996 to March 1997, we distributed the two-vessel survey at another internal medicine grand rounds and at a cardiology grand rounds at the same community teaching hospital in Rhode Island, at a cardiology conference at a second university hospital in Rhode Island, at a state-wide American College of Physicians Meeting in Rhode Island, and at a small academic primary care conference in Texas.

Survey Design

The surveys started with background questions about the respondent's current medical position (from medical student to attending physician), current or intended specialty and subspecialty, year of graduation from medical school, and experience with CAD (measured as the number of patients with CAD seen weekly.) The surveys then asked the respondents to consider a population of patients with CAD (three-vessel or two-vessel) and stable angina pectoris, currently being managed medically, and who did not have any other cardiac or noncardiac problems that might limit their life expectancies.

To assess the respondents' propensity to treat, the three-vessel survey asked for what proportion of 100 such patients would the respondent recommend CABG, as opposed to continuing medical management. Similarly, the two-vessel survey asked the respondents to estimate what proportion of 100 such patients would they recommend CABG or PTCA.

The three-vessel survey then asked the respondent to consider a population of 1,000 patients with three-vessel CAD, and estimate how many of that population would be alive after 5 years, 7 years, and 11 years, were they to receive optimal medical management. Such management could include future revascularization if symptoms were to worsen or if new acute events occurred. Then the survey asked the respondents to estimate how many patients would be alive were they to undergo CABG. Similarly, the two-vessel survey then asked the respondents to consider a population of 1,000 patients with two-vessel CAD and to estimate how many of that population would be alive after 5 years, 7 years, and 11 years were they to receive optimal medical management, and then to estimate how many patients would be alive after 5 years, 7 years, and 11 years were they to undergo CABG, and again if they were to undergo PTCA. The complete description of the population of patients with two-vessel CAD and all questions about that population appear in Appendix 1. The description of the population with three-vessel CAD and relevant questions appear in Appendix 2.

Evidence-Based Criteria for Outcome Judgments

To develop evidence-based criteria for correct judgments of these outcomes, we performed a systematic literature search for RCTs of medical management or revascularization that assessed long-term survival and stratified patients by the number of vessels affected by CAD, and whose results were reported no later than 1998. This search revealed three large RCTs that had compared long-term survival after CABG or medical management for patients with stable CAD stratified by the number of vessels involved: the CASS,[25] the ECSS,[26] and the VACS.[27] All reports were published in the 1980s and described studies that began enrolling patients in the 1970s. We found no newer RCTs that compared long-term survival after CABG or medical management of CAD. The search also identified a meta-analysis that combined evidence comparing 5-year survival after CABG and after medical management stratified by the number of vessels involved from multiple trials, including the three large trials mentioned above.[28]

Our evidence-based criteria for correct judgments of 5-year survival for patients managed medically, and of absolute risk reduction of mortality at 5 years due to CABG for patients with three-vessel and two-vessel CAD, were based on this meta-analysis. Our criteria for survival for patients with three-vessel and two-vessel CAD managed medically and absolute risk reduction due to CABG at 7 years and 11 years were based on results of the three large trials.[27,29,30]

Our systematic search revealed two large studies that compared long-term survival for patients with stable multivessel CAD after PTCA or CABG: the Bypass Angioplasty Revascularization Investigation (BARI) study,[31] and the Randomized Intervention Treatment of Angina (RITA-1) study.[32] These reports were published in the 1990s and described studies that began enrolling patients in 1989. The BARI study followed up patients for 5 years. The RITA-1 study followed up patients for 7 years (median follow-up of 6.5 years). Since no subgroup analyses of data from either study showed significant interactions between the number of involved vessels and effects of treatment on mortality, we used data from both these studies to develop our evidence-based criteria for absolute risk reduction due to PTCA (vs CABG) at 5 years and 7 years for patients with two-vessel CAD.

We used the data from these studies to derive ranges of evidence-based criteria for correct judgments using the following rules. If only a single study was available, we set the upper and lower bounds of criterion range for the correct judgment to be the upper and lower bounds of the 95% confidence interval from that study for the relevant outcome. If two studies were available, we used their point estimates to set the bounds of the criterion range. If two studies were available, but one of these studies reported a statistically nonsignificant comparison between two treatments, we chose either zero, or that point estimate from that study of the absolute risk reduction, as one bound of the criterion range for absolute risk reduction such that the width of this criterion range was maximized. Tables 1, 2 show these evidence-based criteria for correct judgments of survival for patients with three-vessel and two-vessel disease managed medically and absolute risk reduction of mortality due to CABG for them, while Table 3 shows criteria for absolute risk reduction due to PTCA for two-vessel CAD.

Analysis

We tabulated the proportion of respondents' judgments of survival rates for patients treated medically for the time periods of interest that were less than, within, or greater than the evidence-based criterion ranges for correct judgments. We calculated the respondents' judgments of the absolute risk reduction for mortality due to CABG compared to medical management during each time period for patients with either three-vessel or two-vessel disease simply by subtracting the judged rate of survival during the time period were the patients to have medical management from the judged rate of survival during the time period were the patients to undergo CABG. Thus, a positive number for absolute risk reduction of mortality indicates that the judged rate of survival after CABG was greater than the judged rate of survival after medical management, and a negative number indicates that the judged rate of survival due to CABG was less than the judged rate of survival after medical manage-

Table 1—*Evidence-Based Criteria for Correct Judgments of Survival Rates for CABG vs Medical Management for Three-Vessel CAD*

	Criterion Ranges			
Duration, yr	Survival, Medical Management, %	Risk Ratios for Mortality (CABG/Medical Management)	Absolute Risk Reductions due to CABG, %	Source of Data
5	80.3 to 84.4*	0.42 to 0.80*†	3.5 to 10.2*	Yusuf et al[28]
7	63 to 76.7	1.19 to 1.20	12 to 15.1	ECSS,[30] VACS[27]
11	50 to 75	0.99 to 1.12	− 1% to 6	CASS,[29] VACS[27]

*Range derived from 95% confidence interval from the meta-analysis.
†Range derived from odds ratio.

Table 2—*Evidence-Based Criteria for Correct Judgments of Survival Rates for CABG vs Medical Management for Two-Vessel CAD*

Duration, yr	Criterion Ranges: Survival, Medical Management, %	Criterion Ranges: Risk Ratios for Mortality (CABG/Medical Management)	Criterion Ranges: Absolute Risk Reductions due to CABG, %	Source of Data
5	85.9 to 90.3*	0.54 to 1.32*†	− 3.7 to 5.4*	Yusuf et al[28]
7	81 to 87.4	0.90 to 0.97	− 8 to 0	ECSS,[30] VACS[27]
11	69 to 79	0.80 to 1.05	− 14 to 4	CASS,[29] VACS[27]

*Range derived from 95% confidence interval from the meta-analysis.
†Range derived from odds ratio.

ment. We similarly calculated respondents' judgments of the absolute risk reduction for mortality due to PTCA compared to CABG for patients with two-vessel disease. We then similarly tabulated the proportion of these judgments that were less than, within, or greater than the relevant evidence-based criterion ranges.

Finally, we used simple linear regression to assess the relationships across physicians between their propensities to perform either CABG or PTCA and their judgments of survival for patients receiving medical management, and their relevant judgments of absolute risk reduction.

Results

Response to Surveys

We distributed 131 copies of the three-vessel survey, and 79 surveys were returned for a response rate of 60.3%. We distributed 154 copies of the two-vessel survey, and 85 surveys were returned for a response rate of 55.2%.

Participants responding to the three-vessel survey included 4 medical students (5.1%), 12 interns (15.4%), 25 residents and fellows (32%), and 37 attending physicians (47.4%). Two respondents (2.6%) were general practitioners, 7 respondents (9.0%) were family practitioners, 67 respondents (85.9%) were internists, and 2 respondents (2.6%) were other specialists; 11 respondents (14.1%) identified their intended or actual subspecialty as cardiology. Participants responding to the two-vessel survey included 5 medical students (6.0%), 9 interns (10.8%), 24 residents and fellows (28.9%), and 43 attending physicians (51.8%). Five respondents (6.0%) were general practitioners, 5 respondents (6.0%) were family practitioners, 67 respondents (80.7%) were internists, and 6 respondents (7.2%) were other specialists; 18 respondents (21.7%) identified themselves as cardiologists.

Table 3—*Evidence-Based Criteria for Correct Judgment of Survival Rates for PTCA vs CABG for Two-Vessel CAD*

Duration, yr	Criterion Ranges: Risk Ratios for Mortality (PTCA/CABG)	Criterion Ranges: Absolute Risk Reductions due to PTCA, %	Source of Data
5	0.93 to 1.50*	− 6.0 to 0.2*	BARI[31]
7	0.57 to 1.28*	− 2.1 to 4.8*	RITA-1[32]
11	Not applicable	Not applicable	

*Ninety-five percent confidence interval from the single trial.

Judgments of Mortality for Patients Treated Medically

We had complete responses to questions about judgments of survival outcomes from 70 physicians on the three-vessel survey and from 80 physicians on the two-vessel survey. A preliminary analysis of the three-vessel survey revealed no significant differences in responses made by trainees vs attending physicians, or by cardiologists vs other physicians. For the remaining analyses, we thus elected to pool responses from all respondents, regardless of seniority or subspecialty.

A majority of physicians were excessively pessimistic about the survival of patients managed medically. Figure 1 displays the distributions of the physicians' judgments of 5- through 11-year survival for patients with three-vessel CAD managed medically, vs the upper and lower bounds of the ranges of evidence-based criteria for correct judgments. The black squares indicate the median judgments. The upper and lower horizontal lines indicate the 75th and 25th percentiles of the judgments, *ie*, their interquartile range. The upper and lower bounds of the shaded box indicates the 95th and fifth percentiles of the judgments. More than half the physicians underestimated the survival of patients with three-vessel CAD managed medically at 7 years and 11 years (51.4% and 60.9%, respectively, of the physicians made judgments that were below the lower bound of the evidence-based criteria). Nearly one half of respondents (44.3%) similarly underestimated survival at 5 years. At least one fourth of the physicians

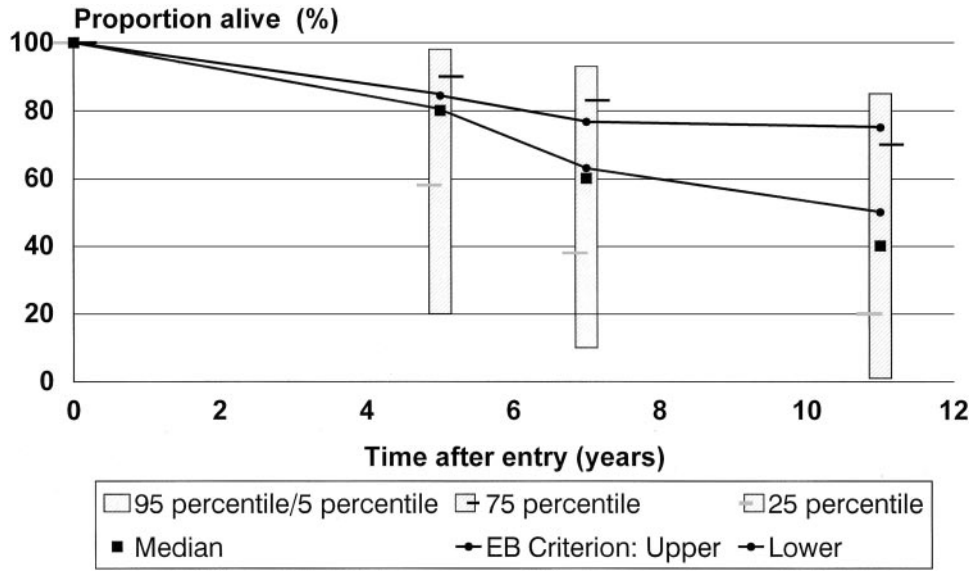

FIGURE 1. Physicians' survival judgments vs evidence-based (EB) criterion ranges for patients with three-vessel CAD managed medically. The black squares indicate the median judgments. The horizontal lines indicate the upper and lower 75th and lower 25th percentiles of the judgments. The boundaries of the shaded box indicate the upper 95th and lower fifth percentiles of the judgments. The evidence-based criteria for the correct rates of survival are indicated by the dots connected by solid lines.

judged survival for 5 years, 7 years, and 11 years to be much lower than the lower bound of the survival rate based on the best available evidence. For example, one fourth of the physicians judged 5-year survival to be $< 60\%$ for these patients, while the lower bound of our relevant evidence-based criterion was 80.3%.

A similar display of the physicians' judgments of survival for patients with two-vessel CAD appears in Figure 2. Similarly, considerably more than one half the physicians underestimated the survival of patients with two-vessel CAD managed medically at 5 years, 7 years, and 11 years (62.5%, 78.7%, and 68.8%, respectively). Again, at least one fourth of the

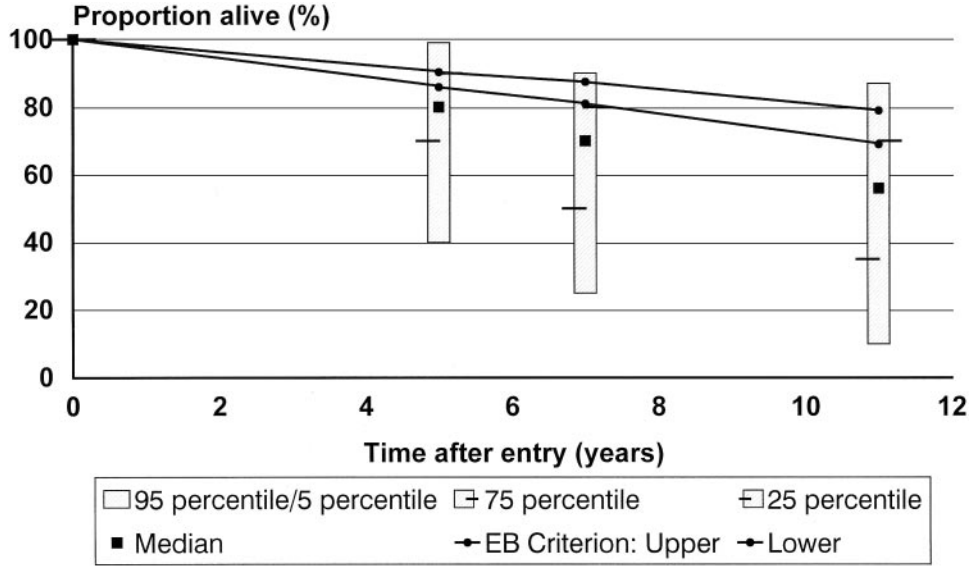

FIGURE 2. Physicians' survival judgments vs evidence-based criterion ranges for patients with two-vessel CAD managed medically. The black squares indicate the median judgment. The horizontal lines indicate the upper and lower 75th and lower 25th percentiles of the judgments. The boundaries of the shaded box indicate the upper 95th and lower fifth percentiles of the judgments. The evidence-based criteria for the correct absolute risk reduction for survival are indicated by the dots corrected by solid lines. See Figure 1 legend for expansion of abbreviation.

physicians judged survival to be much lower than the lower bound of the evidence-based survival rate. For example, one fourth of the physicians judged 5-year survival to be < 70%, while the lower bound of the relevant evidence-based criterion was 85.9%.

Judgments of Absolute Risk Reduction for Mortality Due to CABG Compared to Medical Management

The physicians varied considerably in how they judged the effectiveness of CABG, and a substantial minority of physicians overestimated the ability of CABG to prolong survival for patients with CAD. Figure 3 displays the distributions of the physicians' judgments of absolute risk reduction for mortality at 5 years through 11 years for CABG compared to medical management for patients with three-vessel CAD vs the upper and lower bounds of the ranges of the relevant evidence-based criteria. Again, the black squares indicate the median judgments, the upper and lower horizontal lines indicate the upper 75th and lower 25th percentiles of the judgments, and the upper and lower bounds of the shaded box indicates the 95th and fifth percentiles of the judgments. More than one fourth of the physicians overestimated the absolute risk reduction of survival due to CABG for three-vessel CAD at 5 years and 7 years, 34.3% and 28.6%, respectively. More than one half of the physicians (58.0%) overestimated the absolute risk reduction of survival at 11 years.

Similarly, Figure 4 displays these results for patients with two-vessel CAD. Again, at least one fourth of the physicians overestimated the survival benefits of surgery for patients with two-vessel CAD at 5 years, 7 years, and 11 years (25.0%, 47.4%, and 36.2%, respectively).

The physicians' judgments of the effectiveness of PTCA compared to CABG for patients with two-vessel disease were more accurate. Figure 5 displays the distribution of the physicians' judgments of absolute risk reduction for mortality at 5 years through 11 years for PTCA compared to CABG vs the upper and lower bounds of the relevant evidence-based criteria.

Relationship of Judgments to the Proportion of Patients for Which a Procedure Would Be Recommended

In general, physicians who were more pessimistic about survival of patients managed medically had a higher propensity to perform revascularization to treat such patients. Further, physicians who were more optimistic about the effectiveness in terms of absolute risk reduction for mortality of either CABG or PTCA had higher propensities to prescribe these treatments. Table 4 demonstrates that physicians'

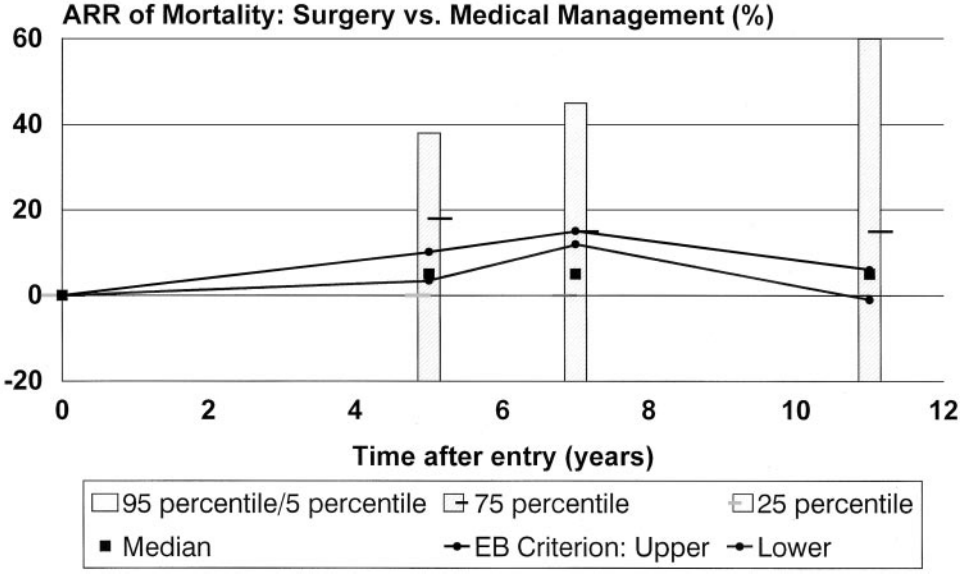

FIGURE 3. Physicians' calculated judgments of the absolute risk reduction (ARR) of mortality due to CABG compared with medical management for patients with three-vessel disease vs evidence-based criterion ranges. The black squares indicate the median judgment. The horizontal lines indicate the upper and lower 75th and lower 25th percentiles of the judgments. The boundaries of the shaded box indicate the upper 95th and lower fifth percentiles of the judgments. The evidence-based criteria for the correct absolute risk reduction for survival are indicated by the dots corrected by solid lines. See Figure 1 legend for expansion of abbreviation.

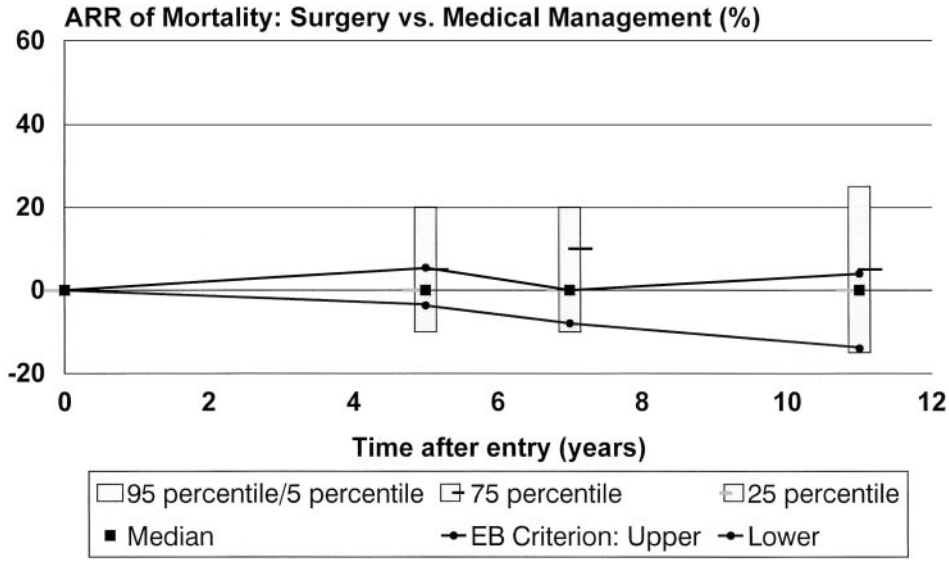

FIGURE 4. Physicians' calculated judgments of the absolute risk reduction of mortality due to CABG compared with medical management for patients with two-vessel disease vs evidence-based criterion ranges. The black squares indicate the median judgment. The horizontal lines indicate the upper and lower 75th and lower 25th percentiles of the judgments. The boundaries of the shaded box indicate the upper 95th and lower fifth percentiles of the judgments. The evidence-based criteria for the correct absolute risk reduction for survival are indicated by the dots corrected by solid lines. See Figure 1 and Figure 3 legends for expansions of abbreviations.

judgments of survival at 5 years through 11 years for patients with three-vessel disease managed medically inversely correlated with the proportion of patients for whom they recommended CABG, and that their judgments of the absolute risk reduction for mortality at 5 years through 11 years due to CABG correlated with this proportion. Table 5 shows that physicians' judgments of survival at 7 years for

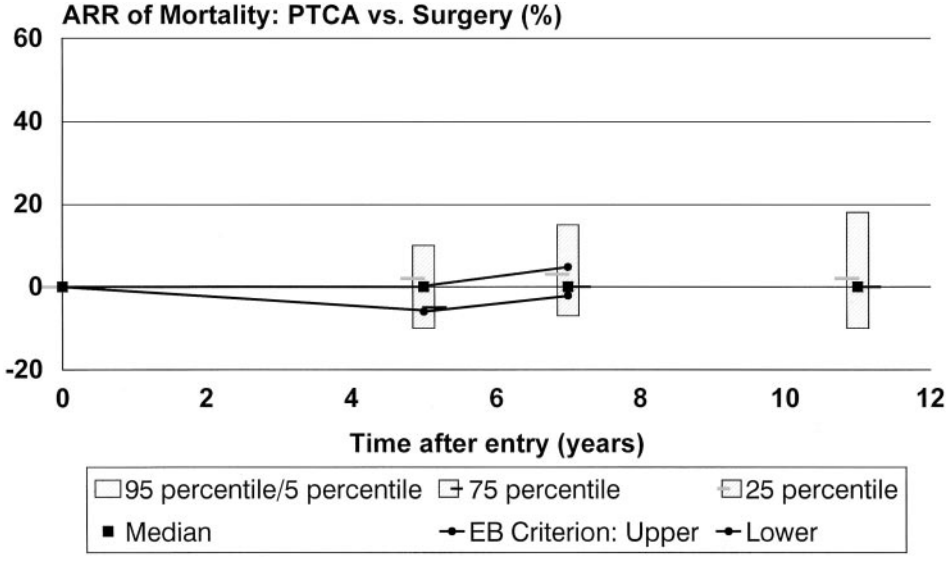

FIGURE 5. Physicians' calculated judgments of the absolute risk reduction of mortality due to CABG compared with PTCA for patients with two-vessel disease vs evidence-based criterion ranges. The black squares indicate the median judgment. The horizontal lines indicate the upper and lower 75th and lower 25th percentiles of the judgments. The boundaries of the shaded box indicate the upper 95th and lower fifth percentiles of the judgments. The evidence-based criteria for the correct absolute risk reduction for survival are indicated by the dots corrected by solid lines. See Figure 1 and Figure 3 legends for expansions of abbreviations.

Table 4—*Correlations Between Propensity To Use CABG and Judgments for Three-Vessel CAD*

Time Frame, yr	Correlation (*R*) With Propensity To Use CABG (p Value)	
	Judged Survival Given Medical Management	Judged Risk Reduction for Mortality due to CABG
5	− 0.426 (< 0.001)	0.429 (< 0.001)
7	− 0.494 (< 0.001)	0.501 (< 0.001)
11	− 0.507 (< 0.001)	0.502 (< 0.001)

patients with two-vessel disease managed medically correlated inversely with their propensity to perform CABG, while their judgments of absolute risk reduction for 7-year mortality due to CABG correlated with their propensity to perform CABG. Table 6 shows that physicians' judgments of survival at 5 years and 7 years for patients with two-vessel disease managed medically correlated inversely with their propensity to perform PTCA, while their judgments of absolute risk reduction for mortality at 5 years through 11 years correlated with their propensity to perform PTCA.

Discussion

Physicians should only undertake interventions whose benefits outweigh their harms. The degree to which health-care policy promotes access to and utilization of interventions should similarly depend on the extent their benefits outweigh their harms and costs. Several authors have suggested that American physicians overuse CABG and PTCA.[9–15] Cleland[33] warned the United Kingdom not to imitate US practice, "rational, effective health care cannot be obtained merely by throwing money at the problem. Unjustified procedures are harmful both economically and to patients."

The message that CAD is deadly but that revascularization is life-saving has often appeared in the US media, possibly increasing the public's demand for these "life-saving" therapies. For example, when Atlanta Falcons coach Dan Reeves, who had angina for 4 months, was found to have three-vessel CAD, his internist said, "If we'd played a Monday night game that weekend, he would've probably died in his hotel room." This physician apparently believed that the 1-week survival of three-vessel CAD managed medically is < 50%, but the 11-year survival for three-vessel CAD managed treated medically is actually at least 50%. Nonetheless, *USA Today* characterized Reeves' physicians as "the three doctors who helped save his life."[34]

Our data suggest that many, probably a majority, of physicians were excessively pessimistic about the survival of patients with CAD who are managed medically, and that a goodly minority of physicians overestimated the effectiveness of CABG surgery to prolong survival for these patients. Furthermore, although most physicians realized that PTCA provides no survival benefits when compared to CABG, the fact that a goodly minority of physicians overestimated the survival benefits of CABG compared to medical management suggests that the same proportion also overestimated the survival benefits of PTCA compared to medical management. Further, our data suggests that physicians who are more pessimistic about the survival of patients with CAD who are managed medically have a greater propensity to perform revascularization procedures than do physicians who are less pessimistic. Similarly, physicians who are more optimistic about the effectiveness of revascularization procedures to prolong life also have a greater propensity to perform these procedures.

There are a number of reasons why physicians may not make judgments about the outcomes of CAD in accord with the best available evidence. Simple lack of knowledge is one possible explanation. However, we suspect that most physicians are familiar with the evidence about revascularization for CAD at least in a qualitative way. They may be unfamiliar with the quantitative evidence, especially if they obtained information about therapy from review articles, textbook chapters, and other summaries. Such sources do not often emphasize quantitative results. For example, the chapters on chronic stable CAD in two major internal medicine textbooks described sub-

Table 5—*Correlations Between Propensity To Use CABG and Judgments for Two-Vessel CAD*

Time Frame, yr	Correlation (*R*) With Propensity To Use CABG (p Value)		
	Judged Survival Given Medical Management	Risk Reduction for Mortality Due to CABG Compared to Medical Management	Risk Reduction for Mortality Due to CABG Compared to PTCA
5	− 0.17 (0.14)	0.05 (0.65)	0.01 (0.96)
7	− 0.28 (0.01)	0.24 (0.04)	0.07 (0.53)
11	− 0.15 (0.18)	0.11 (0.36)	0.04 (0.72)

Table 6—*Correlations Between Propensity To Use PTCA and Judgments for Two-Vessel CAD*

Time Frame, yr	Correlation (*R*) With Propensity To Use PTCA (p Value)		
	Judged Survival Given Medical Management	Risk Reduction for Mortality Due to PTCA Compared to Medical Management	Risk Reduction for Mortality Due to CABG Compared to PTCA
5	− 0.25 (0.03)	0.31 (0.006)	− 0.05 (0.69)
7	− 0.21 (0.00)	0.31 (0.006)	− 0.001 (0.93)
11	− 0.17 (0.14)	0.24 (0.04)	0.04 (0.73)

groups of patients for whom CABG may "improve longevity,"[35] or lead to "reduced" mortality,[36] but did not mention the size of these effects.

However, why the physicians were so often pessimistic about the outcomes of medical management is unclear. Perhaps they were affected by cognitive biases. A cognitive bias can be roughly defined as a tendency to systematically overestimate or underestimate probabilities of particular outcomes due to extraneous influences. For example, "value bias" means biasing judgments of the probability of an outcome according to its importance or meaning. A relevant medical variant of value bias has been called "hanging crepe."[37] Hanging crepe is the overestimation of the probability of death for seriously ill patients. Hanging crepe may reduce the likelihood of an unpleasant surprise for the family were the patient to die, a surprise that also might make the physician look like a failure. Were such a patient to live, however, hanging crepe may make a patient's survival seem a pleasant surprise, one which might be regarded as a success by the physician.

Why physicians were too optimistic about outcomes of revascularization for patients with CAD is also unclear. Perhaps, they based their judgments on causal or pathophysiologic reasoning, *ie*, on the ease with which they could envision a pathophysiologic mechanism for the treatment. They may have found it easier to envision a pathophysiologic explanation for why revascularization should benefit patients with CAD than for why medical management should do so.

Perhaps the physicians made their judgments using judgmental "heuristics," *ie*, rules-of-thumb for making judgments, which may often produce good judgments but sometimes may be misleading. For example, the physicians may have used a heuristic that more elaborate, more invasive, or more expensive treatments have better outcomes than do less elaborate, less invasive, or less expensive ones, *ie*, a "bigger is better" heuristic. This may in part be based on what Grimes[38] called the "false idol of technology." Certainly, CABG and PTCA are more elaborate, invasive, and expensive treatments than are the drugs used to manage CAD.

Limitations

We must also acknowledge limitations of our study that affect interpretation of its results. Our physician subjects were found at three hospitals and two academic meetings in three states: Rhode Island, Illinois, and Texas. Results from this study may not generalize to physicians at other hospitals and in other locations. However, the physicians had varying amounts of training and did come from several geographic areas, so that there is no specific reason to suspect the results of this study are not widely generalizable.

Although we included both generalists and cardiologists among our physician population, we did not study enough cardiologists to have the power to find small differences between their responses and those of the generalists. It is possible that the cardiologists' judgments were more accurate than those of the generalists. In a previous study,[39] we showed that different groups of cardiologists and other internists judged the adverse effects of invasive cardiac procedures, including PTCA and CABG, differently, but that neither group was generally more accurate.

The response rates of the two surveys were 55.2% and 60.3%. Had all physicians responded, the results might have been different. However, our response rates were similar to those found in many other reports of surveys of physicians. Further, we suspect that the physicians who did respond were likely to have been more interested in or knowledgeable about the subject matter of the survey than those of did not respond. Thus, the low response rate may have biased against finding even more extreme results.

We asked physicians to make judgments about subgroups of patients, but they may be more accustomed to making judgments for individual patients. However, how physicians view the general prognosis

of subgroups of patients with CAD likely influences how they make judgments for individual patients.

We asked physicians about the management of CAD presenting as chronic stable angina. Our results may not apply to how physicians approach the management of other manifestations of CAD, *eg*, acute myocardial infarction or unstable angina.

We asked physicians to indicate the proportion of a hypothetical population for which they would recommend revascularization. Although, their answers may indicate their general propensity to treat, self-reported propensities do not always correspond to actual utilization rates.[40–42] However, treatment decisions for specific patients are probably anchored on one's general propensity to treat.

We asked physicians about the probability of only one outcome, survival. Clearly, the effects of revascularization on survival are an important consideration in the decision whether to perform revascularization. The American College of Cardiology/American Heart Association/American College of Physicians-American Society of Internal Medicine guidelines for chronic stable angina state that "the goals of coronary bypass surgery are to improve symptoms and prolong life expectancy."[8] The major trials of CABG vs medical management, and of PTCA vs either CABG or medical management, focused on survival as an outcome. Survival is obviously easy to define and extremely important. Thus we chose to ask physicians for their judgments of survival.

When making treatment decisions, however, physicians may consider other outcomes. Many authorities emphasize symptom relief as the reason to refer a patient for revascularization. For example, the revised North of England guidelines suggest referral for patients whose symptoms are not satisfactorily controlled on antianginal therapy.[43] However, there is evidence that patients referred for angiography as a prerequisite to revascularization in the United States are often not receiving maximal antianginal therapy, *eg*, $> 30\%$ are receiving only one antianginal drug at the time of referral.[44] One older study[45] also showed that patients referred for revascularization for stable CAD in the United States were not receiving very intense antianginal regimens (*eg*, 57% were receiving calcium-channel blockers, 33% were receiving β-blockers, and 43% were receiving nitrates).

Furthermore, there are many other outcomes that one might consider when deciding about revascularization. These include complications of the procedure, specific cardiac morbidity such as myocardial infarction, health status as measured by return to employment,[46] physical functioning,[47] and cognitive function.[48] In a previous study[39] done of different groups of physicians, we showed that cardiologists and other internists differed in their judgments of the rates of adverse outcomes of cardiac procedures, including CABG and PTCA, but that neither group was generally more accurate. Variability in how physicians judged the probability of such outcomes conditional on therapy may account for some of the unexplained variance in their propensity to treat.

Our evidence-based criteria for correct judgments about the outcomes of CABG were derived from data from relatively old trials. There have been innovations in anesthesia and surgical technique since these trials were performed, *eg*, use of internal mammary artery rather than saphenous vein grafts for CABG.[49] Data about the possible benefits of internal mammary grafts, however, come only from observational studies and may have been confounded by the indication for treatment.[50] There have been innovations in catheter-based revascularization techniques since the BARI and RITA-1 trials were performed, *eg*, the use of intracoronary stents. However, demonstrated advantage of stents over conventional PTCA include reduction in symptomatic angina and short-term need for repeat revascularization procedures, but not improvement in survival or reduction of serious morbid events.[51–55] One study[56] actually showed a trend toward increased early serious bleeding complications in patients receiving stents. Finally, there have also been improvements in the medical management of CAD since the CASS, ECSS, and VACS trials were performed. For example, several trials[55–59] have shown that lipid-lowering agents prevent new cardiovascular events and prolong survival in patients with hypercholesterolemia and CAD while causing few adverse effects. Thus, there is no strong reason to suspect that the mortality risk reductions due to revascularization found in the trials we used to construct evidence-based criteria were overly pessimistic.

Some may also argue that although trials are the best source of data about comparisons of one therapy vs another, they should not be used as a source of data about population survival. However, prospective observational studies[60,61] reported 5- to 10-year survival rates for their medically managed patients that were similar, or slightly better than those reported by the earlier trials, even though patients receiving medical management in observational studies are likely to have worse underlying prognoses than patients receiving revascularization.

More research is needed to ascertain how physicians judge all of the important potential benefits and harms of revascularization for CAD. Meanwhile, physicians should reread the clinical research in this

area, and reconsider how they make outcome judgments for patients with CAD in light of the available data from clinical trials.

Appendix 1

Two-Vessel CAD Population Description and Relevant Questions

Consider a population of patients with stable angina found to have two-vessel CAD, currently not being treated, and who do not have other major, life-threatening cardiac problems (*eg*, severe aortic stenosis of congestive heart failure) or major, life-threatening noncardiac problems (*eg*, metastatic cancer) that would limit their left expectancy.

Were you to see 100 such patients, estimate the number of patients (from 0 to 100) for whom you would recommend CABG _____ or PTCA _____.

Were 1,000 such patients to undergo CABG as initial therapy, estimate how many patients (from 1 to 1,000) would be alive 5 years later _____, 7 years later _____, and 11 years later _____.

Were 1,000 such patients to undergo PTCA as initial therapy, estimate how many patients (from 1 to 1,000) would be alive 5 years later _____, 7 years later _____, and 11 years later _____.

Were 1,000 such patients to receive optimal medical management as initial therapy, estimate how many patients (from 1 to 1,000) would be alive 5 years later _____, 7 years later _____, and 11 years later _____.

Appendix 2

Three-Vessel CAD Population Description and Relevant Questions

Consider a population of patients with stable angina found to have three-vessel CAD, currently treated with optimal medical management, and who do not have any other major cardiac or noncardiac problems that would limit their life expectancy.

Were you to see 100 such patients, estimate the number of patients for whom you would recommend CABG _____.

Were 1,000 such patients to undergo CABG, estimate how many patients would be alive 5 years later _____, 7 years later _____, and 11 years later _____.

Were 1,000 such patients not to undergo CABG but were to be continued on optimal medical management (and future CABG were to occur only if symptoms were to worsen or new acute events were to happen), estimate how many patients would be alive 5 years later _____, 7 years later _____, and 11 years later _____.

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Physicians' Judgments of Survival After Medical Management and Mortality Risk Reduction Due to Revascularization Procedures for Patients With Coronary Artery Disease*

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