Impact of Completeness of Percutaneous Coronary Intervention Revascularization on Long-Term Outcomes in the Stent Era

Edward L. Hannan, PhD; Michael Racz, PhD; David R. Holmes, MD; Spencer B. King III, MD; Gary Walford, MD; John A. Ambrose, MD; Samin Sharma, MD; Stanley Katz, MD; Luther T. Clark, MD; Robert H. Jones, MD

Background—The importance of completeness of revascularization by percutaneous coronary intervention in patients with multivessel disease is unclear in that there is little information on the impact of incomplete revascularization outside of randomized trials. The objective of this study is to compare long-term mortality and subsequent revascularization for percutaneous coronary intervention patients receiving stents who were completely revascularized (CR) with those who were incompletely revascularized (IR).

Methods and Results—Patients from New York State's Percutaneous Coronary Interventions Reporting System were subdivided into patients who were CR and IR. Then subsets of IR patients were contrasted with CR patients. Differences in long-term survival and subsequent revascularization for CR and IR patients were compared after adjustment for differences in preprocedural risk. A total of 68.9% of all stent patients with multivessel disease who were studied were IR, and 30.1% of all patients had total occlusions and/or ≥2 IR vessels. At baseline, the following patients were at higher risk: those who were older and those with more comorbid conditions, worse ejection fraction, and more renal disease and stroke. After adjustment for these baseline differences, IR patients were significantly more likely to die at any time (adjusted hazard ratio=1.15; 95% confidence interval, 1.01 to 1.30) than CR patients. IR patients with total occlusions and a total of ≥2 IR vessels were at the highest risk compared with CR patients (hazard ratio=1.36; 95% confidence interval, 1.12 to 1.66).

Conclusions—IR with stenting is associated with an adverse impact on long-term mortality, and consideration should be given to either achieving CR, opting for surgery, or monitoring percutaneous coronary intervention patients with IR more closely after discharge. **(*Circulation*. 2006;113:2406-2412.)**

Key Words: angioplasty ■ mortality ■ percutaneous coronary intervention ■ revascularization ■ stents

Unlike the case in coronary artery bypass graft (CABG) surgery, in which most patients are completely revascularized (CR) and in which CR has been demonstrated to be associated with better long-term outcomes,[1–5] the strategy for patients with multivessel disease undergoing percutaneous coronary intervention (PCI) frequently involves incomplete revascularization (IR). In IR, balloon angioplasty and stent placement are performed on only some of the patient's diseased vessels. Reasons for not attempting to treat all diseased vessels may include the presence of 1 or more chronic total occlusions, the presence of serious medical conditions such as severe left ventricular dysfunction, or the decision to treat only the "culprit lesion" that is thought to be responsible for the patient's symptoms.

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Several studies have compared long-term outcomes of CR and IR patients with the use of PCI.[6–16] Most of these studies were conducted before the introduction of coronary stenting, however, and many were conducted in the context of randomized trials in which IR patients were monitored more closely than they would be under normal circumstances.

The purpose of the present study was to compare long-term outcomes (3-year mortality and 3-year subsequent revascularization) for patients with multivessel disease who were CR and IR with coronary stenting. When significant differences were found, we then focused on groups of IR patients for whom the

Received January 6, 2006; revision received January 6, 2006; accepted February 24, 2006.

From the State University of New York, University at Albany (E.L.H.); New York State Department of Health, Albany (M.R.); Mayo Clinic, Rochester, Minn (D.R.H.); Fuqua Heart Center/Piedmont Hospital, Atlanta, Ga (S.B.K.); St Joseph's Hospital, Syracuse, NY (G.W.); University of California at San Francisco School of Medicine, Fresno (J.A.A.); Mt Sinai Medical Center, New York, NY (S.S.); North Shore–Long Island Jewish Health System, Manhasset, NY (S.K.); University Hospital of Brooklyn, Brooklyn, NY (L.T.C.); and Duke University Medical Center, Durham, NC (R.H.J.).

Correspondence to Edward L. Hannan, PhD, School of Public Health, State University of New York, University at Albany, One University Place, Rensselaer, NY 12144-3456. E-mail elh03@health.state.ny.us

Circulation is available at http://www.circulationaha.org DOI: 10.1161/CIRCULATIONAHA.106.612267

outcomes were the worst, namely, patients with total occlusions and/or patients with ≥2 IR vessels after revascularization.

Methods

Data and Patients

The primary database used in the study is New York State's Percutaneous Coronary Interventions Reporting System (PCIRS), which contains patient demographics, risk factors, complications, and discharge disposition along with patient, operator, and hospital identifiers. PCIRS also includes information on the number of coronary vessels diseased (by noting whether each vessel has ≥70% stenosis) and the specific vessels for which PCI was attempted. An attempt is defined as an attempt to cross a lesion with a guidewire regardless of the success of this effort.

In-hospital deaths reported in PCIRS were matched against New York's administrative acute care hospital discharge data set (Statewide Planning and Research Cooperative System) to ensure accuracy, and hospitals were asked to resolve any discrepancies. In addition, the accuracy of risk factor reporting was ascertained by having the New York State Department of Health's utilization review agent audit hospitals' medical records. To obtain deaths after discharge from a hospital, New York's Vital Statistics Death File was linked to PCIRS by patient Social Security numbers. Subsequent revascularizations were obtained by using patient Social Security numbers to match against future PCI procedures in PCIRS and future CABG procedures in New York's CABG surgery registry, the Cardiac Surgery Reporting System.

Patients in the study included all patients with multivessel disease (defined as stenosis ≥70% in at least 2 of the 3 main coronary arteries) who underwent stenting in nonfederal New York State hospitals between January 1, 1997, and December 31, 2000, except patients with previous revascularization, left main disease (defined as stenosis >50%), or an acute myocardial infarction during the 24-hour period before undergoing PCI; patients who had CABG surgery after PCI in the index admission; and non–New York patients. The study was limited to New York residents because the New York Vital Statistics Death File applies only to residents of the state.

Complete revascularization was defined as attempting all lesions with ≥50% stenosis in major epicardial coronary vessels (proximal, mid, and distal right coronary artery, left anterior descending, and left circumflex) either during the index hospitalization or any time within 30 days after discharge from the index hospitalization but before suffering a new myocardial infarction. Patients not meeting these criteria were regarded as IR patients. The subset of IR patients defined as having total occlusions included patients with 100% stenosis before and after undergoing stenting.

The decision to perform CR or to perform targeted revascularization or IR on a given patient was made at the discretion of the consulting cardiologist and interventional cardiologist. The factors involved in this decision were multiple and included, among others, risk-benefit ratio, the complexity of the lesions, identification of a culprit lesion, the amount of contrast used or anticipated to be required, comorbid conditions, and clinical presentation.

Data Analysis

The primary purpose of the present study was to determine whether long-term mortality was significantly different for stent patients with multivessel disease who were CR and IR, as well as to determine whether long-term mortality differed according to the specific characterization of the IR.

A secondary purpose was to determine whether there were differences in rates of subsequent revascularization for the aforementioned groups of patients. Another purpose was to compare long-term mortality for high-risk subgroups of patients (diabetics, patients with compromised left ventricular function, and patients aged ≥80 years).

Differences between IR patients and CR patients with respect to potential risk factors for long-term outcomes were examined with the use of χ^2 and Fisher exact (for binary risk factors) tests with a 0.05 level of significance. Factors included the number of vessels diseased, patient age and sex, a variety of comorbidities, and measures of the patient's hemodynamic state and ventricular function.

After we verified that the proportional hazards assumption was reasonable,[17] we tested for differences in long-term mortality between IR patients and CR patients while controlling for differences in the 2 groups with respect to various patient risk factors. A backward stepwise Cox model with $P<0.05$ was first used to identify patient risk factors that were significantly related to long-term mortality. Type of revascularization was then added to the group of significant patient risk factors as an independent binary variable with "1" denoting the IR subgroup. The point estimate and its confidence interval (CI) were calculated for the hazard ratio (HR) for IR. Initially, each patient was classified into 1 of 5 anatomic groups on the basis of whether 2 or 3 vessels were diseased (with ≥70% stenosis), whether there was significant disease in the left anterior descending artery, and, if there was, whether it was in the proximal region. The intent was to use 5 separate multivariable analyses to investigate differences between the IR subgroups and CR patients for each anatomic group. However, a single multivariable analysis that included 4 of the 5 groups as indicator variables and the other as a reference category revealed that the groups did not have significantly different long-term survival, and therefore subsequent analyses included all anatomic groups in a single statistical model.

The aforementioned analyses were then repeated after 3 high-risk subgroups of IR patients were identified (total occlusion and another IR vessel, no residual total occlusion but ≥2 IR vessels, total residual occlusion but no other IR vessel) to determine the difference in survival for each of these groups relative to CR patients. Adjusted survival curves were generated with the Cox model in conjunction with methods described by Ghali et al.[18]

To test survival differences between CR patients and IR patients for 3 subsets of patients with increased risk (patients with diabetes, compromised ventricular function [defined as left ventricular ejection fraction <40%], and patients aged ≥80 years), we repeated the Cox survival analyses after restricting the data set to each of these groups.

We then investigated differences in subsequent CABG surgery and subsequent PCI for CR patients and each of the high-risk subgroups of IR patients. A curve describing the percentage of patients in each group who underwent subsequent CABG surgery was generated with Kaplan-Meier estimates with censoring for deaths that occurred before subsequent CABG surgery.

Selection bias was examined with a propensity model.[19,20] The significant predictors of high-risk IR groups were identified by fitting a logistic regression model with a binary dependent variable representing IR. For each anatomic group, the propensity score was subdivided into quintiles, and HRs were compared across quintiles. All statistical analyses were conducted with SAS (version 8.2; SAS Institute, Cary, NC).

The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

Results

A total of 21 945 stent patients participated in the study; a total of 15 128 (68.9%) of these patients were IR. The range of IR patients by hospital was from 52% to 88%. Table 1 presents percentages of IR for various demographics and patient risk factors. Patient characteristics associated with IR were older age (76.8% IR for patients aged ≥80 years compared with 68.9% for all stent patients in the study), lower ejection fractions (>81% IR for patients with ejection fractions <30%), myocardial infarction that occurred >1 week before admission, 3-vessel disease (89.0% IR), and a variety of comorbidities.

When significant patient risk factors for long-term mortality were identified and adjusted for, the adjusted HR for IR patients relative to CR patients was 1.15 (95% CI, 1.01 to

TABLE 1. Percentage of IR Patients for Various Patient Characteristics in Patients Undergoing Stent Implantation for the First Time in New York, 1997-2000

	IRs		
Risk Factor	n	%	*P*
All patients	15 128	68.9	
Age, y			<0.001
<50	1633	63.7	
50–59	3261	66.9	
60–69	4207	68.4	
70–79	4214	70.3	
≥80	1813	76.8	
Gender			0.441
Male	10 354	68.8	
Female	4774	69.3	
Hispanic ethnicity	1006	73.3	<0.001
Race			<0.001
White	13 069	68.5	
Black	1043	74.2	
Other	1016	69.5	
Ejection fraction			<0.001
<20%	118	80.8	
20% to 29%	553	81.9	
30% to 39%	1376	79.0	
≥40%	12 182	68.0	
Missing	899	60.7	
Previous myocardial infarction			0.02
1–7 d	3441	69.1	
≥8 d	711	72.9	
None	10 976	68.6	
Stroke	754	77.5	<0.001
Carotid/cerebrovascular disease	587	76.6	<0.001
Aortoiliac disease	514	80.6	<0.001
Femoral/popliteal disease	634	79.8	<0.001
Hemodynamically unstable	79	85.0	<0.001
Shock	21	95.5	0.005
Cardiopulmonary resuscitation	15	100.0	0.005
ECG evidence of LV hypertrophy	1206	74.0	<0.001
Congestive heart failure			<0.001
This admission	1182	78.2	
Before this admission	756	78.1	
None	13 190	67.8	
Malignant ventricular arrhythmia	201	73.1	0.15
Chronic obstructive pulmonary disease	958	75.5	<0.001
Diabetes	3987	71.9	<0.001
Renal failure			<0.001
Dialysis	160	74.1	
Creatinine >2.5 mg/dL	211	82.8	
No renal failure	14 757	68.7	
No. of diseased vessels (≥70%)			<0.001
2	11 335	64.1	
3	3793	89.0	

LV indicates left ventricular.

1.30). The next portion of the study concentrated on identifying the various subgroups of the IR patients (patients with 1 IR vessel and no total occlusions, ≥2 IR vessels and no total occlusions, 1 total occlusion and no other IR vessels, and ≥2 IR vessels and at least 1 total occlusion). Table 2 presents the unadjusted and adjusted HRs for mortality for each of these groups of IR patients relative to CR patients. As indicated, when the data were not adjusted for severity of illness, patients in the IR subgroups were significantly more likely to die at any time than other patients. The HRs for these IR patients relative to other patients were 1.20 for patients with 1 IR vessel and no total occlusion, 2.77 for patients with ≥2 IR vessels and ≥1 total occlusions, 1.81 for patients with 1 total occlusion and no other IR vessels, and 1.88 for patients with ≥2 IR vessels and no total occlusions. All of these HRs were statistically significant (with $P=0.01$ for the first group and $P<0.001$ for the other 3 groups).

When the data were adjusted for patient severity of illness before the revascularization, survival differences between the IR and CR groups were more similar but still statistically different for all but 1 comparison. The HR for the IR patients with 1 IR vessel and no total occlusion was not significant (HR=1.00; 95% CI, 0.87 to 1.15; $P=0.99$). However, the respective adjusted HRs for the other 3 groups of IR patients were 1.36, 1.35, and 1.25. All of these HRs were statistically significant (with $P=0.002$, $P<0.001$, and $P=0.02$, respectively).

Figure 1 presents adjusted survival curves for the CR group and the 3 subgroups of IR patients with significantly lower survival. The adjusted survival percentage at 3 years for CR patients was 91.4%, and the adjusted survival percentages for the respective IR groups were 89.5%, 88.8%, and 88.7%.

Figure 2 demonstrates that the need for subsequent CABG surgery after stenting ranged from 6.5% within 3 years for CR patients and 10.3% for patients with 2 IR vessels and no total occlusions. This difference was statistically significant ($P<0.001$), whereas no other IR groups were statistically different from CR patients.

The need for subsequent PCI within 3 years was higher for patients with 2 IR vessels and no total occlusions (28.1%) and for patients with 1 IR vessel and no total occlusions (26.2%) than it was for CR patients (23.5%). However, the IR group with a single total occlusion had a significantly lower ($P<0.001$) rate of subsequent PCI (17.4%) than the group of CR patients. Of the 17.77% of patients requiring subsequent PCI, 8.74% (slightly less than half) were referred for target lesion revascularization. In addition, the percentage of patients undergoing subsequent revascularization for an acute myocardial infarction was 11.05%. This percentage was 10.09% for CR patients and 11.46% for IR patients ($P=0.16$ for difference).

The survival advantage for patients not in the 3 IR subgroups with lower survival was less pronounced for diabetics, patients with ejection fraction <40%, and patients aged ≥80 years and was not significant after adjustment for risk for any of the subgroups (Table 3). The respective HRs for mortality and their 95% CIs for these groups were 1.24 (1.00 to 1.55), 1.13 (0.86 to 1.48), and 1.28 (0.97 to 1.70).

When patients with a previous myocardial infarction at any time before the index procedure were removed from the data set, the mortality HRs for the 3 groups of IR patients with

TABLE 2. HRs (IR/CR) for Mortality for Various Subgroups of IR

	No. of Patients	Unadjusted HR Compared With CR (95% CI)	Adjusted HR Compared With CR (95% CI)
CR	6817		
1 IR vessel with no total occlusion	8518	1.20 (1.04–1.38)	1.00 (0.87–1.15)
≥2 IR vessels and at least 1 total occlusion	1321	2.77 (2.29–3.35)	1.36 (1.12–1.66)
1 IR vessel is totally occluded	3232	1.81 (1.53–2.13)	1.35 (1.14–1.59)
≥2 IR vessels with no total occlusions	2057	1.88 (1.57–2.27)	1.25 (1.03–1.50)

Adjusted by age, ejection fraction, stroke, carotid artery disease, aortoiliac disease, femoral/popliteal disease, shock, hemodynamic instability, cardiopulmonary resuscitation, congestive heart failure, chronic obstructive pulmonary disease, diabetes, renal failure, and left ventricular hypertrophy.

lower long-term survival increased from 1.36, 1.35, and 1.25 to 1.44, 1.55, and 1.34 (with respective probability values of 0.03, $<$0.001, and 0.03).

In the propensity analysis, significant covariates included worst lesion type attempted, age, sex, ejection fraction, previous myocardial infarction, stroke, carotid/cerebrovascular disease, aortoiliac disease, femoral/popliteal disease, congestive heart failure, diabetes, number of diseased vessels/left anterior descending artery involvement, and hospital IR percentage. The C statistic for the model was 0.78, which is indicative of good discrimination. Distributions of IR cases ranged from 20% to 88% across quintiles. HRs all favored CR patients and were relatively consistent, ranging from 1.19 for the quintile with the second highest percentage of IR patients to 2.02 for the quintile with the lowest percentage of IR patients. The quintile with the highest percentage of IR patients had a 1.93 HR. Thus, in addition to the HRs being similar across quintiles, there was not a monotonic decrease in hazards as the percentage of IR cases decreased across quintiles.

Discussion

Multiple surgical series have identified better long-term outcomes for CABG patients who are CR.[1–5] However, studies that compare outcomes for IR versus CR for PCI have yielded results that are not as definitive.[6–16] Most of these studies are relatively old and may not be reflective of current practice because of the numerous advances that have been made in PCI during the course of the last decade, particularly with respect to the introduction of and improvement in the technology of stent placement.

There are a few relatively recent studies that compare IR and CR. In the Arterial Revascularization Therapies Study (ARTS) trial, van den Brand et al[8] found that among stented angioplasty patients with multivessel disease who underwent either CR or IR, the IR patients had a significantly lower 1-year event-free survival rate than CR patients (69.4% versus 76.6%; $P<0.05$) and that the difference was attributable to a higher incidence of subsequent CABG procedures (10.2% versus 2.0%; $P<0.05$). Using data from the National

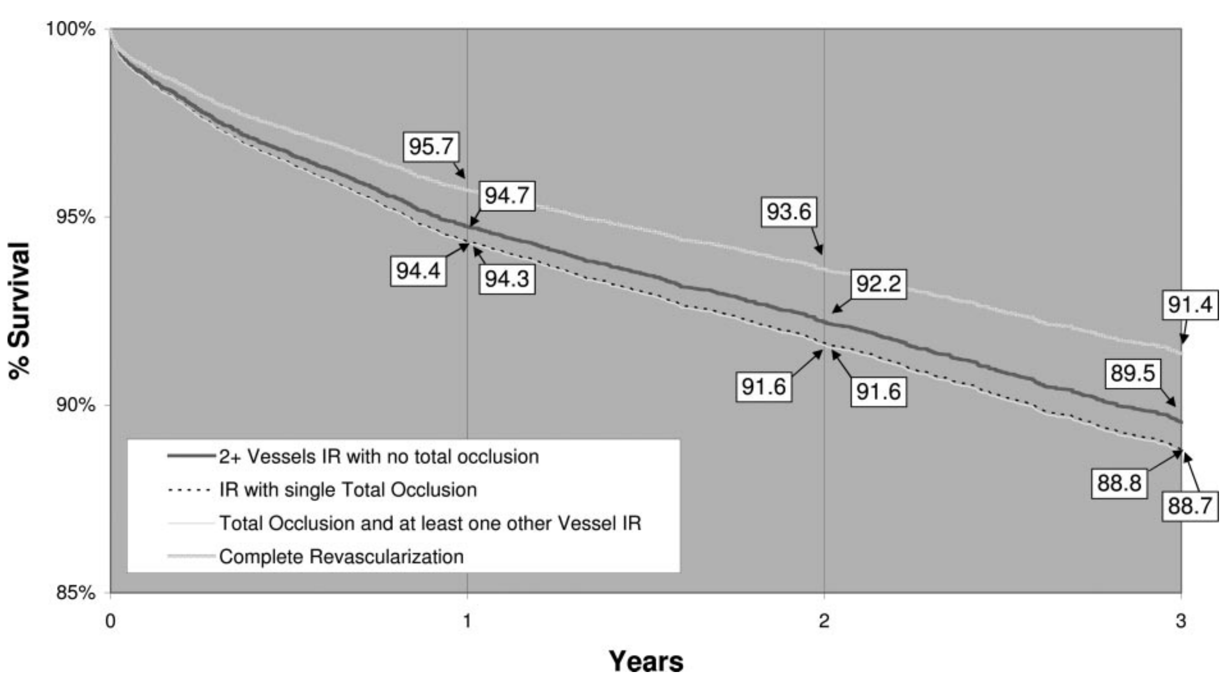

Figure 1. Adjusted survival curves for stenting: 3 IR subgroups versus CR group.

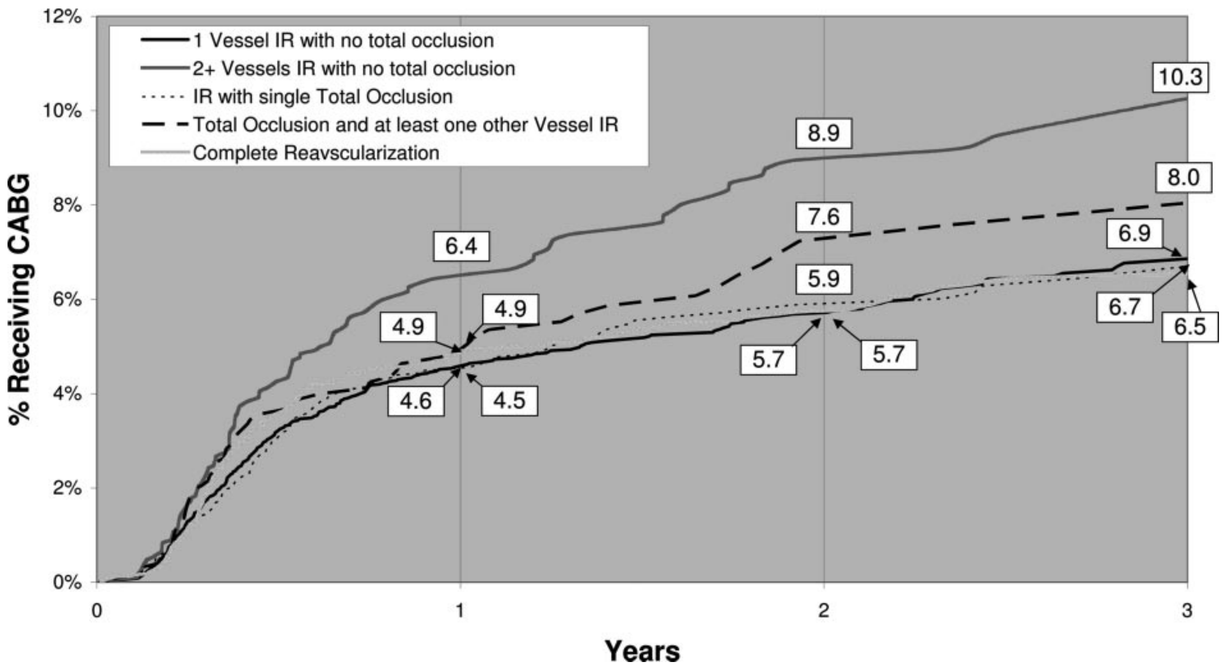

Figure 2. Percentage of stent patients undergoing a CABG procedure within 3 years: 4 IR subgroups versus CR group.

Heart, Lung, and Blood Institute Percutaneous Transluminal Coronary Angioplasty Registry containing outcomes for CR and IR patients with multivessel disease, Bourassa et al[9] concluded that the adjusted risk of mortality, having a Q-wave myocardial infarction, recurrent angina, or a repeated PCI was not different at 9-year follow-up for IR and CR patients but that IR patients were more likely to undergo CABG (32% versus 14%; $P<0.001$) and were more likely to experience recurrent angina at 9 years (19% versus 10%; $P<0.05$). Mariani et al[6] found no differences in 1-year mortality (1.4% versus 0%) or in 1-year adverse events (11.3% versus 11.2%) between IR and CR patients with multivessel disease with unstable angina. However, the study had low statistical power, with only 44 CR patients and 147 IR patients.[6] In a study of diabetic patients with multivessel disease who underwent PCI, Nikolsky et al[10] found that IR patients had a significantly lower 5-year survival rate (83.0% versus 94.5%; $P<0.001$) and a significantly lower myocardial infarction–free survival rate (79.9% versus 92.9%). In addition, after adjustment for patient risk, IR was significantly related to higher mortality (95% CI for HR=1.54 to 7.69; $P=0.003$).

The results of our present study demonstrate that subsets of stent patients with multivessel disease who were IR had significantly worse long-term survival than CR patients, even after adjustment for patient risk. The groups that had at least 1 total occlusion and at least 2 IR vessels had the worst rate of survival relative to CR patients (adjusted HR=1.36; 95% CI, 1.12 to 1.66; $P\leq0.001$). For patients with 1 vessel totally occluded and no other IR vessels, the adjusted HR was 1.35 (95% CI, 1.14 to 1.59; $P=0.002$), and for patients with ≥2 IR vessels with no total occlusions, the adjusted HR was 1.25 (95% CI, 1.03 to 1.50; $P=0.02$).

With respect to subsequent revascularization, all groups of IR patients experienced higher rates of subsequent CABG surgery than CR patients, but the IR patients with total occlusions, particularly those with no other IR, experienced lower rates of subsequent PCI than other patients. Although this appears on the surface to be somewhat good news for IR patients, the fact that they had higher long-term mortality than non-IR patients suggests that they may have benefitted from more subsequent revascularization.

Although diabetics and patients aged ≥80 years who were IR did not have significantly higher mortality than their counterparts who were CR, there was a trend in that direction (HR=1.24 and HR=1.28, respectively), and the lack of significance would appear to be due in part to lower statistical power for the subgroup analyses.

There are a few reasons why our results may be different than those of earlier studies on the comparison of IR and CR for PCI patients. First, we examined subsets of IR patients that could be expected to have higher long-term mortality risks (patients with total occlusions and patients with ≥2 IR major epicardial vessels after stenting).

Second, with the introduction of stents and other innovations in PCI, short- and long-term outcomes for patients who undergo PCI have improved substantially over the course of the last few years. Thus, diseased vessels that have undergone

TABLE 3. HRs (IR Groups*/CR) for Mortality for Various Subgroups of Patients

	No. of Patients	Unadjusted HR (95% CI)	Adjusted HR* (95% CI)
Diabetics	5549	1.76 (1.42, 2.18)	1.24 (1.00, 1.55)
Ejection fraction <40%	2562	1.31 (1.00, 1.72)	1.13 (0.86, 1.48)
Age ≥80 y	2362	1.62 (1.23, 2.14)	1.28 (0.97, 1.70)

*At least 1 totally occluded vessel or at least 2 IR vessels with no total occlusions.

stent placement can be expected to fare better than diseased vessels that are not treated percutaneously, and this margin may be increasing over time with the reduction in restenosis rates associated with improvements in stent technology.

In addition, most earlier studies were randomized controlled trails (RCTs) whereby patients were carefully monitored periodically for symptoms and the need for subsequent revascularization, whereas our study was an observational study that mirrored real practice. To the extent that the monitoring activities of RCTs identify potential problems earlier than they would otherwise be noted, they may shield patients from the dangers of IR. When patients are not enrolled in RCTs, they are less likely to be monitored as closely and may be more likely to experience restenosis and mortality before seeking or obtaining treatment. For example, comparisons of the results from clinical trials with our study suggest that in clinical trials the tendency for patients to undergo subsequent CABG surgery is much higher among IR patients than among CR patients (10.2% to 2% in 1 year and 32% to 14% in 9 years, respectively, for van den Brand et al[8] and Bourassa et al[9]) compared with observational studies (7.4% for IR patients compared with 6.6% for CR patients in 3 years in our study).

Another reason for differences in conclusions between our study and earlier studies is more limited statistical power in detecting differences in relatively rare events such as mortality in the RCTs.[21] For example, the largest of the aforementioned trials concluded that there was no difference in 5-year mortality rates of 12.5% for CR patients versus 16.0% for IR patients ($P=0.13$, power 43%),[9] yet our study found a significant 3-year risk-adjusted mortality difference between IR and CR patients when the 3-year risk-adjusted mortality rates were much closer (9.7% for IR patients versus 8.7% for CR patients).

There are some caveats associated with the study. Because it is an observational study, patients were not randomized to IR and CR, and we therefore had to risk-adjust the data to take into account the fact that IR patients tended to be older and sicker than their CR counterparts. In addition, we attempted to reduce selection bias as much as possible by using propensity analyses, which demonstrated that the survival advantage of CR over IR was relatively consistent across various quintiles of predicted tendency of using IR.

Nevertheless, there may be selection biases that could not be controlled and that contribute to the findings of the study. For example, we did not have access to angiographic variables such as occlusion length, calcium, occluded distal vessel size, and territory that might have had an impact on short-term and long-term outcomes.

We do not know the reasons why more vessels were not attempted for the IR cases; in particular, we do not know whether a vessel could have been attempted or if it was impossible because of the nature of the lesion. It is also possible that total occlusions may not have been attempted because they were in previously infarcted regions that would not benefit from revascularization or they are not attempted because they have a low success rate. To test the impact of this possibility on our findings, we expanded the group of exclusions from patients suffering an acute myocardial infarction in the previous 24 hours to patients suffering an acute myocardial infarction at any time before the index admission. With this exclusion, there were a total of 12 146 patients in the study, 7927 (65.4%) of whom were IR. The mortality HRs for the 3 groups of IR patients with lower long-term survival increased from 1.36, 1.35, and 1.25 to 1.47, 1.52, and 1.35 (with respective probability values of 0.02, <0.001, and 0.03). Thus, the existence of infarcted regions that would not benefit from CR does not seem to explain the inferior outcomes for subgroups of IR patients.

It is also notable that the range by hospital in percentage of patients who were IR was 52% to 88%, which suggests that there may be differences among hospitals in the willingness to attempt CR in addition to angiographic differences among patients. We believe that the patients who had IR probably had more lesions of a complex nature and that this is one reason why they were IR and therefore had a higher long-term risk. However, this may mean that they would have been better served by CABG surgery, by attempts at CR, or at least by closer monitoring subsequent to IR.

We looked at differences in all-cause deaths because we did not have reliable data on cardiac deaths, although that would have been preferable. In addition, we do not know whether medical therapy after the procedure differed for IR and CR patients, although it seems reasonable to assume that it would have been essentially the same given that the same time frame was used to observe CR and IR outcomes.

Another caveat is that the time interval used to account for staged revascularizations was 30 days after discharge from the hospital, and this may be too short. However, we changed the interval to 60 days, and the results remained essentially unchanged with respect to odds ratios and entirely unchanged with respect to statistical significance.

The results of this study raise the question of the appropriate treatment for IR patients. Two other possible options are complete PCI revascularization and CABG surgery. It should be noted that when CABG surgery was compared with PCI with the use of the same PCI data from New York, CABG surgery was found to yield superior long-term survival and freedom from subsequent revascularization.[22] In addition, similar findings have been reported in other recent observational studies[23,24] and in a meta-analysis of PCI/CABG long-term mortality trials.[25] However, all of these studies predate the use of drug-eluting stents. We look forward to continued efforts to identify the appropriate and optimal treatment for patients with multivessel disease.

Acknowledgments

The authors thank Kenneth Shine, MD, the Chair of New York State's Cardiac Advisory Committee, and the remainder of the Cardiac Advisory Committee for their encouragement and support of this study; and Paula Wauselauskas, Donna Doran, Casey Joseph, Kimberly S. Cozzens, Rosemary Lombardo, and the cardiac surgery departments and cardiac catheterization laboratories of the 35 participating hospitals for their tireless efforts to ensure the timeliness, completeness, and accuracy of the registry data.

Disclosures

Dr Sharma has received research grant support from Johnson&Johnson, Lilly, and Boston Scientific Corp and has served on speaker's bureaus for Boston Scientific Corp–Scimed. The other authors report no conflicts of interest.

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CLINICAL PERSPECTIVE

The objective of this study was to compare long-term mortality and subsequent revascularization for percutaneous coronary intervention (PCI) patients receiving stents who were completely revascularized (CR) with those who were incompletely revascularized (IR). Complete revascularization was defined as attempting all lesions with $\geq$50% stenosis in major epicardial coronary vessels either during the index hospitalization or any time within 30 days after discharge from the index hospitalization but before suffering a new myocardial infarction. (An "attempt" is defined as an attempt to cross a lesion with a guidewire regardless of the success of this effort.) A total of 68.9% of all stent patients with multivessel disease who were studied were IR, and 30.1% of all patients had total occlusions and/or $\geq$2 IR vessels. At baseline, the following patients were at higher risk: those who were older and those with more comorbid conditions, worse ejection fraction, and more renal disease and stroke. After adjustment for these baseline differences, IR patients were significantly more likely to die at any time (adjusted hazard ratio=1.15; 95% confidence interval, 1.01 to 1.30) than CR patients. IR patients with total occlusions and a total of $\geq$2 IR vessels were at the highest risk in comparison to CR patients (hazard ratio=1.36; 95% confidence interval, 1.12 to 1.66). We conclude that IR with stenting is associated with an adverse impact on long-term mortality, and consideration should be given to either achieving CR with PCI, opting for coronary artery bypass graft surgery for patients who cannot be CR with PCI, or at the very least monitoring PCI patients with IR more closely after discharge.