Predictors and Outcomes of Ad Hoc Versus Non-Ad Hoc Percutaneous Coronary Interventions

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Predictors and Outcomes of Ad Hoc Versus Non-Ad Hoc Percutaneous Coronary Interventions

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Objectives Our aim was to compare longer-term outcomes for ad hoc percutaneous coronary intervention (PCI) and non-ad hoc PCI.

Background Ad hoc PCIs, whereby PCI is performed immediately after cardiac catheterization, has become the most common way of performing PCI. However, no studies have compared longer-term outcomes for ad hoc and non-ad hoc PCIs.

Methods A total of 46,565 New York State patients who underwent PCI in nonfederal New York State hospitals between January 1, 2003 and June 30, 2005 were followed through December 31, 2005, and in-hospital and longer-term outcomes were compared for ad hoc and non-ad hoc PCI patients after adjusting for differences in pre-procedural risk factors.

Results There was no difference in risk-adjusted in-hospital mortality (adjusted ad hoc/non-ad hoc odds ratio: 0.82, 95% confidence interval [CI]: 0.55 to 1.22). Ad hoc PCI patients had significantly lower 36-month mortality (adjusted hazard ratio [HR]: 0.76, 95% CI: 0.69 to 0.85, $p < 0.0001$). Ad hoc PCI patients had significantly higher 36-month subsequent revascularization (adjusted HR: 1.11, 95% CI: 1.01 to 1.21, $p = 0.03$), but after excluding subsequent PCIs that occurred within 30 days of the index PCI in another vessel, the difference was no longer significant (adjusted HR: 1.03, 95% CI: 0.95 to 1.12, $p = 0.43$).

Conclusions On average, lower-risk patients undergo ad hoc PCI, and after risk-adjustment for differences in patient mix, ad hoc PCI patients have lower 3-year mortality rates. (J Am Coll Cardiol Intv 2009;2:350–6) © 2009 by the American College of Cardiology Foundation

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In recent years, there has been an enormous increase in the number of percutaneous coronary interventions (PCIs) performed in the U.S. For example, the number has risen from slightly more than 400,000 procedures in 2000 to 1,265,000 in 2005 (1).

In conjunction with this increase, there has been a tendency to improve efficiency by performing PCIs immediately after cardiac catheterization (ad hoc PCIs). Potential advantages of such an approach are a reduction in resources due to a single catheterization laboratory visit and a potentially shorter length of stay, greater patient satisfaction because performing both procedures together is simpler and creates less anxiety, a lower risk of contrast nephropathy (especially in patients with baseline renal insufficiency), and easier access site management (2,3). Potential disadvantages include an abbreviated informed consent process (particularly for interventions for which there is an alternative intervention), the need for immediate decision making regarding the appropriateness of the procedure, and difficulties obtaining surgical backup (particularly on nights and weekends) (3).

Several studies have examined the frequency with which ad hoc PCI is performed (3–9). However, many of these studies are relatively old, and the outcomes investigated were short-term outcomes. This study reports on the use of ad hoc procedures for PCI in all of New York State in a recent time period, and compares short- and medium-term outcomes for ad hoc versus non-ad hoc PCIs.

Methods

Data. The database used in the study is New York's Percutaneous Coronary Interventions Reporting System (PCIRS), a mandatory registry in New York that was initially developed in 1992 that contains detailed information for each patient undergoing PCI in the state on demographics; pre-procedural risk factors; peri-procedural complications; types of devices used; lesions diseased; dates of admission, discharge, and procedure; discharge disposition and destination; and hospital and operator identifiers. The PCIRS contains information on diseased and attempted lesions, including regions of the heart, whether or not a lesion was attempted, and pre- and post-procedural stenosis. The data are collected by hospital catheterization laboratories, entered on paper forms, and then submitted to the New York State Department of Health on diskettes or through a web-based submission process. The data are checked for accuracy and completeness by matching to administrative data and by extensive auditing of medical records by the New York State Department of Health's utilization review agent.

The PCIRS data were matched to New York's vital statistics data so that patients could be followed after discharge for evidence of subsequent death. Data from New York's Cardiac Surgery Reporting System were used along with PCIRS data to identify repeat revascularizations after discharge through December 31, 2005.

Patients. Patients in the study were derived from the 105,390 patients who underwent PCI in nonfederal New York State hospitals between January 1, 2003 and June 30, 2005. Exclusions were 3,617 patients with left main disease; 15,293 with acute myocardial infarction within 24 h, shock, hemodynamic instability, or coded as an emergency priority patient; 34,779 with a previous PCI or coronary artery bypass graft (CABG) surgery; 4,049 who were not New York residents; 10,599 whose catheterization hospital was not known or different from their PCI hospital; and 7,340 with a missing ejection fraction. The remaining 46,565 patients were included in the study.

Patients with a diagnostic catheterization performed in a non-PCI hospital were excluded because the fact that they were not candidates for ad hoc PCI introduces a selection bias. Patients with previous revascularization were excluded because their adverse outcomes could have been related to the earlier revascularization. The study was limited to New York residents because the New York Vital Statistics Death File only applies to residents of the state. All patients in the study were followed through December 31, 2005 for evidence of death or subsequent revascularization in New York.

Abbreviations and Acronyms

CABG = coronary artery bypass graft
CCS = Canadian Cardiovascular Society
CI = confidence interval
HR = hazards ratio
LAD = left anterior descending coronary artery
OR = odds ratio
PCI = percutaneous coronary intervention
PCIRS = Percutaneous Coronary Interventions Reporting System

End points. End points in the study were 36-month mortality, subsequent revascularization with and without the exclusion of staged PCIs occurring within 30 days of the index procedure, subsequent target vessel revascularization with PCI or CABG surgery, and repeat target vessel PCI. These adverse outcomes were risk-adjusted to account for differences in baseline risk of ad hoc and non-ad hoc PCI patients as described in the following text.

Statistical analysis. Differences in baseline characteristics between ad hoc and non-ad hoc PCI patients (e.g., demographics, comorbidities, left ventricular function, vessels diseased, symptoms) were examined using Fisher exact and chi-square tests. To test for risk-adjusted differences in the adverse outcomes between ad hoc and non-ad hoc patients, proportional hazards models with a robust covariance matrix that accounts for correlation of survival times for individuals within a hospital or operator cluster (10) were developed for each adverse outcome measure after having confirmed that the proportional hazards assumption was justified (11). Candidate independent variables included the patient risk

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factors available in PCIRS (demographics, left ventricular function, myocardial infarction more than 1 day before the procedure, and numerous comorbidities). Variables that were statistically significant in a stepwise analysis were retained in each model.

Type of delivery (ad hoc, non-ad hoc) was used in each model as the study independent variable with ad hoc treated as the indicator variable, and the ad hoc/non-ad hoc adjusted hazards ratios (HRs) were obtained by exponentiating the coefficient of that variable. To test for selection bias, a propensity model was developed (12,13). The risk factors in Table 1 were used as independent variables in a logistic regression model with a binary dependent variable representing ad hoc/non-ad hoc PCI. The propensity score was subdivided into quintiles, and 36-month HRs for ad hoc/non-ad hoc PCI were examined across quintiles for mortality, subsequent revascularization, and repeat target vessel PCI to determine if there was any trend or major difference based on whether the PCI was staged or ad hoc. All tests were 2-sided and conducted at the 0.05 level, and all analyses were conducted in SAS 9.1 (SAS Inc., Cary, North Carolina).

Results

A total of 38,431 patients (82.5%) received ad hoc PCIs and 8,134 patients (17.5%) received non-ad hoc PCIs. The percentage of PCI patients undergoing ad hoc PCI increased in every 6-month period from a low of 78.8% to a high of 85.4%. The variation across hospitals in the percentage of patients who underwent ad hoc PCIs was from 35% to 97%. The median follow-up time was 19.45 months, and 17.2% of the patients had a follow-up time of at least 30 months.

Table 1 presents the prevalences of patient characteristics for ad hoc and non-ad hoc procedures. As indicated, patients receiving ad hoc procedures were younger, more likely to be men and Hispanic, had higher ejection fractions, were less likely to have suffered a previous myocardial infarction, more likely to have Canadian Cardiovascular Society (CCS) class IV, more likely to undergo stenting with drug-eluting stents, and less likely to have any of numerous comorbidities.

With regard to in-hospital mortality, ad hoc patients had significantly lower unadjusted mortality (0.25% vs. 0.45%, unadjusted ad hoc/non-ad hoc odds ratio [OR]: 0.52, 95% confidence interval [CI]: 0.37 to 0.73). However, after adjustment the difference was not significant (adjusted OR: 0.82, 95% CI: 0.55 to 1.22, data not shown). Ad hoc PCI patients experienced lower rates of renal failure (0.07% vs. 0.14%) and myocardial infarction (0.85% vs. 0.95%) than non-ad hoc PCI patients. There was no difference in mortality between centers with high and low rates of PCI after adjustment for other factors.

Table 2 presents risk-adjusted HRs (ad hoc/non-ad hoc) for 5 adverse events (mortality, subsequent revascularization, subsequent revascularization excluding staged PCIs occurring within 1 month of the index procedure, subsequent revascularization of the target vessel with PCI or CABG, and repeat target vessel PCI) at 36 months. As indicated, ad hoc PCI patients had significantly lower mortality (adjusted HR: 0.76, 95% CI: 0.69 to 0.85, $p < 0.0001$). This difference remained significant after adjusting for hospital volume. Ad hoc patients had a significantly higher subsequent revascularization rate (adjusted HR: 1.11, 95% CI: 1.01 to 1.21, $p = 0.03$). After excluding subsequent PCIs that occurred within 30 days of the index PCI in another vessel, there was no longer a significant difference in subsequent revascularization (adjusted HR: 1.03, 95% CI: 0.95 to 1.12, $p = 0.43$) (Table 2). There were no significant differences in subsequent target vessel revascularization (adjusted HR: 0.95, 95% CI: 0.88 to 1.03, $p = 0.23$) or in repeat target vessel PCI (adjusted HR: 0.97, 95% CI: 0.89 to 1.07, $p = 0.52$).

As indicated in Table 3, the mortality advantage with ad hoc PCI for women (adjusted HR: 0.78, 95% CI: 0.66 to 0.91, $p = 0.002$) and patients with multivessel disease (adjusted HR: 0.77, 95% CI: 0.68 to 0.87, $p \leq 0.0001$) were all about the same and nearly identical to the adjusted HR of 0.76 for all patients presented in Table 2. The adjusted HRs for patients with congestive heart failure (adjusted HR: 0.82, 95% CI: 0.69 to 0.97, $p = 0.02$), CCS class IV (adjusted HR: 0.80, 95% CI: 0.66 to 0.97, $p = 0.02$), and patients of age 75 and older (adjusted HR: 0.80, 95% CI: 0.70 to 0.92, $p = 0.002$) were somewhat higher but still significant.

Significant predictors of ad hoc versus non-ad hoc procedure in the propensity analysis were age, sex, race, ethnicity, body surface area, number of vessels diseased with or without proximal LAD, ejection fraction, angina class IV, history of myocardial infarction before procedure, cerebrovascular disease, peripheral arterial disease, congestive heart failure, diabetes, renal failure with no dialysis, organ transplant, and type of stent inserted. The results of the propensity analyses demonstrated that adjusted HRs for quintiles for each of the outcome measures were quite close to the HRs for all patients for that outcome measure. For the measures with significant differences (mortality and subsequent revascularization), only 2 of 10 quintile HRs were in the opposite direction of the HR for all patients, and those favored ad hoc PCI when it was used the least. In general, there was no trend toward more favorable HRs for ad hoc PCI when it was predicted to be used the most. The C statistic for the propensity model was 0.61, a relatively low value that indicates that, despite the number of significant variables in the model, there was a low ability to identify factors that predicted the use of ad hoc PCI.

Table 1. Risk Factors for Ad Hoc and Non-Ad Hoc PCIs in New York: January 1, 2003 to June 30, 2005

Risk Factor	% in Population (n = 46,565)	% With Ad Hoc PCI (n = 38,431)	% With Non-Ad Hoc PCI (n = 8,134)	p Value
Total	100	82.5	17.5	
Demographic characteristics				
Age (yrs)				<0.0001
59 or less	35.43	36.60	29.89	
60 to 69	28.35	28.63	27.01	
70 to 79	25.16	24.41	28.72	
80 or more	11.06	10.36	14.38	
Female gender	36.00	35.38	38.94	<0.0001
Race				<0.0001
White	83.41	83.00	85.35	
Black	9.82	9.73	10.24	
Other	6.78	7.28	4.41	
Hispanic ethnicity	8.50	8.76	7.27	<0.0001
Body surface area (mean ± SD)	—	2.01	2.02	0.15
Priority of intervention				0.49
Elective	51.48	51.55	51.13	
Urgent	48.52	48.45	48.87	
Cardiac risk factors				
Number of vessels diseased				<0.0001
1 without proximal LAD	45.06	46.22	39.55	
1 with proximal LAD	11.48	11.73	10.29	
2 without proximal LAD	23.96	23.64	25.47	
2 with proximal LAD	7.95	7.73	8.99	
3	11.56	10.68	15.70	
Lesion type				
Chronic total occlusion	3.12	3.03	3.59	0.008
Ejection fraction (%)				<0.0001
19 or less	0.63	0.50	1.27	
20 to 29	2.59	2.27	4.14	
30 to 39	5.62	5.33	6.96	
40 to 49	13.48	13.50	13.34	
50 or more	77.68	78.40	74.29	
Previous MI (days)				<0.0001
1 to 7	18.81	19.51	15.47	
8 to 14	1.53	1.04	3.84	
15 to 20	0.33	0.22	0.87	
21 and older	9.51	9.16	11.18	
None	69.82	70.07	68.65	
CCS class				<0.0001
I to III	73.41	72.65	76.97	
IV	24.30	25.03	20.81	
None of above category	2.30	2.32	2.21	
Type of PCI				
Stent placement				0.002
Yes	96.43	96.55	95.86	
Type of device used				<0.0001
DES	74.65	75.59	70.22	
BMS without DES	19.57	18.85	23.01	
Other	5.77	5.57	6.76	
Comorbidities				
Cerebrovascular disease	6.65	6.20	8.78	<0.0001
Peripheral vascular disease	5.62	5.14	7.88	<0.0001
CHF history				<0.0001
None	91.96	92.81	87.96	
Before this admission	5.83	5.17	8.93	
This admission	2.21	2.02	3.11	
Malignant ventricular arrhythmia	0.39	0.35	0.58	0.003
COPD	6.81	6.67	7.44	0.01
Diabetes	27.89	27.17	31.26	<0.0001
Renal dialysis	1.66	1.49	2.50	<0.0001
Creatinine >2.5 mg	2.24	1.94	3.69	<0.0001
Organ transplant	0.23	0.19	0.38	0.001

BMS = bare-metal stent(s); CCS = Canadian Cardiovascular Society; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; DES = drug-eluting stent(s); LAD = left anterior descending coronary artery; MI = myocardial infarction; PCI = percutaneous coronary intervention.

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Table 2. Adjusted HRs (Ad Hoc vs. Non-Ad Hoc) and 95% CIs for Mortality, Subsequent Revascularization, Subsequent Revascularization Excluding Non-TVR Within 30 Days of Index PCI, and TVR: New York, January 1, 2003 to June 30, 2005

	Non-Ad Hoc PCI (n = 8,134)		Ad Hoc PCI (n = 38,431)			
Outcomes	Mean Time of Follow-Up (Months)	Number of Events	Mean Time of Follow-Up (Months)	Number of Events	Adjusted HR for Ad Hoc Relative to Non-Ad Hoc PCI	p Value
Mortality	20.7	630	19.6	1,630	0.76 (0.69–0.85)	<0.0001
Subsequent revascularization	17.3	1,678	16.3	7,975	1.11 (1.01–1.21)	0.03
Subsequent revascularization (excludes staged PCIs)	18.6	1,395	17.3	6,404	1.03 (0.95–1.12)	0.43
Subsequent TVR (PCI or CABG)	18.7	978	17.9	4,158	0.95 (0.88–1.03)	0.23
Repeat target vessel PCI	19.2	728	18.3	3,301	0.97 (0.89–1.07)	0.52

Adjusted for age, sex, race, ethnicity, body surface area, number of vessels diseased with or without proximal left anterior descending coronary artery, ejection fraction, history of myocardial infarction before procedure, cerebrovascular disease, peripheral arterial disease, malignant ventricular arrhythmia, chronic obstructive pulmonary disease, diabetes, renal failure with dialysis, renal failure with no dialysis, organ transplant, and type of stent inserted.

CABG = coronary artery bypass grafting; CI = confidence interval; HR = hazard ratio; PCI = percutaneous coronary intervention; TVR = target vessel revascularization.

Discussion

Ad hoc PCIs (PCIs performed in the same catheterization laboratory visit as the diagnostic catheterization) have become commonplace in recent years. A few earlier studies have examined predictors and outcomes of ad hoc PCI. In a study using data from the American College of Cardiology's National Cardiovascular Data Registry from 2001 to 2003, Krone et al. (3) found that 60.6% of patients underwent ad hoc PCI, and there was no difference between ad hoc and non-ad hoc PCI with respect to in-hospital mortality, renal failure, and vascular complications. Fewer ad hoc patients (58.6% vs. 63.0%) tended to be high risk (3).

In a study using 1995 to 1998 data from New York's angioplasty registry, Goldstein et al. (5) found that ad hoc patients were less likely to have each of several different comorbidities and that there was no difference in in-hospital mortality (ad hoc/non-ad hoc OR: 1.14, p = 0.38), but that ad hoc patients had higher mortality if they had congestive heart failure (OR: 1.59, p = 0.04) and CCS class IV (OR: 1.64, p = 0.04) (5). Feldman et al. (6) used 2000 to 2001 data from the same registry to demonstrate that there were no differences between ad hoc and staged PCI patients with respect to in-hospital mortality, major adverse cardiac events, or renal failure, but that staged patients trended toward a higher rate of site access site injury (adjusted OR: 1.34, 95% CI: 0.99 to 1.81). High-risk patients did not have different in-hospital outcomes (6).

Our study is an extension of earlier studies in 2 major respects. First, it spans a time period that is entirely in the era of drug-eluting stents. Second, and more importantly,

Table 3. Adjusted HRs (Ad Hoc vs. Non-Ad Hoc) and 95% CIs for 36 Month Mortality in Selected Patient Subgroups, New York: January 1, 2003 to June 30, 2005

			Mortality		
Patient Group	Timing of PCI	Number of Cases	Number of Events	Adjusted HR	p Value
Female gender	Non-ad hoc	3,167	286	Reference	
	Ad hoc	13,595	734	0.78 (0.66–0.91)	0.002
Age ≥75 yrs	Non-ad hoc	2,366	326	Reference	
	Ad hoc	8,348	757	0.80 (0.70–0.92)	0.002
Multivessel disease	Non-ad hoc	4,080	383	Reference	
	Ad hoc	16,158	845	0.77 (0.68–0.87)	<0.0001
Congestive heart failure	Non-ad hoc	979	212	Reference	
	Ad hoc	3,355	443	0.82 (0.69–0.97)	0.02
CCS class IV	Non-ad hoc	1,693	163	Reference	
	Ad hoc	9,620	509	0.80 (0.66–0.97)	0.02

Adjusted for age, sex, race, ethnicity, body surface area, number of vessels diseased with or without proximal left anterior descending coronary artery, ejection fraction, history of myocardial infarction before procedure, cerebrovascular disease, peripheral arterial disease, malignant ventricular arrhythmia, chronic obstructive pulmonary disease, diabetes, renal failure with dialysis, renal failure with no dialysis, organ transplant, and type of stent inserted.

Abbreviations as in Table 2.

this study compares longer-term out-of-hospital outcomes for ad hoc and non-ad hoc PCI patients.

Our study demonstrates that of all patients undergoing catheterization in hospitals approved to perform PCI in New York between 2003 and 2005 who underwent elective PCIs without having had previous revascularization, a total of 83% received ad hoc PCIs. Consequently, it is important to compare these patients' relative risk-adjusted outcomes with those of other PCI patients who receive PCI at a later time than their catheterization visit (non-ad hoc patients). Furthermore, since in-hospital adverse event rates are so low for elective patients in particular, it is also important to compare longer-term outcomes of ad hoc and non-ad hoc PCI patients. In particular, it is of interest to determine whether certain patient characteristics are associated with significantly better or significantly worse outcomes for ad hoc PCI patients compared with non-ad hoc patients.

Since ad hoc PCI patients undergo PCI after a short decision-making period without the aid of a multidisciplinary clinical team, it is of interest to contrast the patient characteristics of ad hoc and non-ad hoc patients and to examine the indications for PCI among ad hoc patients.

Findings of our study were that there was a large variation across hospitals in New York with respect to the use of ad hoc PCI (35% to 97% among patients receiving their cardiac catheterization in the same hospital). This variation was smaller than the variation found in an earlier study in New York (which was between 7% and 86%), and the overall percentage of ad hoc procedures rose from 62% in the earlier 1995 to 1998 study to 83% in this 2003 to 2005 study (5).

Patients receiving ad hoc procedures were of lower risk on average (younger, with higher ejection fractions, less likely to have suffered a previous myocardial infarction, and less likely to have important comorbidities). Other findings were that there was no difference in risk-adjusted in-hospital mortality (adjusted ad hoc/non-ad hoc OR: 0.82, 95% CI: 0.55 to 1.22). Ad hoc PCI patients had significantly lower 36-month mortality (adjusted HR: 0.76, 95% CI: 0.69 to 0.85, $p < 0.0001$). Ad hoc PCI patients had significantly higher 36-month subsequent revascularization (adjusted HR: 1.11, 95% CI: 1.01 to 1.21, $p = 0.03$). After excluding subsequent PCIs that occurred within 30 days of the index PCI in another vessel, the difference was no longer significant (adjusted HR: 1.03, 95% CI: 0.95 to 1.12, $p = 0.43$). There were no significant differences in subsequent target vessel revascularization (adjusted HR: 0.95, 95% CI: 0.88 to 1.03, $p = 0.22$) or in repeat target vessel PCI (adjusted HR: 0.99, 95% CI: 0.91 to 1.08, $p = 0.88$).

It is also notable that 2 subsets of patients (congestive heart failure and CCS class IV) that had worse outcomes for ad hoc PCI in an earlier New York study (5) experienced significantly better longer-term mortality in this study.

The lower mortality rate for ad hoc PCI could be a result of any combination of decrease in vascular complications, variations in anticoagulation regimens, the risk associated with a second catheterization procedure, or differences in baseline risk not accounted for in our risk-adjustment process because of selection bias caused by variables not available in our database.

However, there are some concerns about the use of ad hoc PCI. As indicated in Table 1, 10.7% of the ad hoc PCI patients had 3-vessel disease, and 7.7% and 11.7% had 2-vessel left anterior descending coronary artery (LAD) disease and 1-vessel LAD disease, respectively. Thus, a total of 30.1% of ad hoc PCI patients were in categories that are regarded as candidates for CABG surgery. Although a higher percentage (35.0%) of non-ad hoc PCI patient were in 1 of these 3 categories, and there are various reasons why CABG surgery may have been contraindicated for these patients, this is nevertheless a high percentage of patients for whom either type of revascularization was seemingly an option given the most recent guidelines for CABG surgery (14).

There are a few limitations to the study. First, it is an observational study and is, therefore, subject to selection bias of various types, which could bias the study in favor of either ad hoc or not ad hoc PCI. This includes variables not present in the databases, such as whether a patient was contraindicated for CABG surgery. Nevertheless, we risk-adjusted the outcomes to the extent possible and used propensity analyses to subdivide patients into groups based on their tendency to undergo ad hoc PCI, and found no large difference in relative outcomes among the different groups. However, in general, decisions to perform ad hoc PCI were made by individual operators, and their reasons were not contained in our database. Also, the C statistic for the propensity analysis was low (0.61), and this may be indicative of missing predictors of ad hoc PCI in our database.

Although our databases contained detailed information on patient risk factors for short-term outcomes, we did not have access to all factors related to guidelines for the use of PCI and CABG surgery. Consequently we were unable to precisely identify all patients indicated for each procedure. Thus, we were unable to identify all patients who were candidates for CABG surgery although some were identified based on vessels diseased and LAD involvement. Furthermore, we were unable to identify patients who were not indicated for PCI because of limited coronary artery disease, and to the extent that there was a higher percentage of these patients in 1 of the 2 groups, this could have biased the results because these patients should experience better longer-term outcomes.

Conclusions

We believe that this is the first study to explore differences in longer-term outcomes based on whether patients under-

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went ad hoc PCI. We look forward to similar studies in other settings.

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