JACC: CARDIOVASCULAR INTERVENTIONS
VOL. 4, NO. 12, 2011

ISSN 1936-8798/$36.00
PUBLISHED BY ELSEVIER INC.
DOI: 10.1016/j.jcin.2011.08.013

CLINICAL RESEARCH

30-Day Readmission for Patients Undergoing Percutaneous Coronary Interventions in New York State

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Objectives This study sought to report percutaneous coronary intervention (PCI) 30-day readmission rates, identify the impact of staged (planned) readmissions on overall readmission rates, determine the significant predictors of unstaged readmissions after PCI, and specify the reasons for readmissions.

Background Hospital readmissions occur frequently and incur substantial costs. PCI are among the most common and costly procedures, and little is known about the nature and extent of readmissions for PCI.

Methods We retrospectively analyzed 30-day readmissions after PCI using the nation's largest statewide PCI registry to identify 40,093 New York State patients who underwent PCI between January 1, 2007, and November 30, 2007. Demographic variables, pre-procedural risk factors, complications of PCI, and length of stay were considered as potential predictors of readmission, and reasons for readmission were identified from New York's administrative database using principal diagnoses.

Results A total of 15.6% of all PCI patients were readmitted within 30 days, and 20.6% of these readmissions were staged. Among unstaged readmissions, the most common reasons for readmission were chronic ischemic heart disease (22.5%), chest pain (10.8%), and heart failure (8.2%). A total of 2,015 patients (32.2% of readmissions) underwent a repeat PCI. Thirteen demographic and diagnostic risk factors, as well as longer lengths of stay, were all associated with higher readmission rates.

Conclusions Future efforts to reduce readmissions should be directed toward the recognition of patients most at risk, and the reasons they are readmitted. Staging also should be examined from a cost-effectiveness standpoint as a function of patients' unique risk factors. (J Am Coll Cardiol Intv 2011;4:1335–42) © 2011 by the American College of Cardiology Foundation

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Manuscript received April 29, 2011; revised manuscript received August 4, 2011, accepted August 5, 2011.

JACC: CARDIOVASCULAR INTERVENTIONS, VOL. 4, NO. 12, 2011
DECEMBER 2011:1335–42

Short-term hospital readmissions account for a substantial portion of our country's healthcare budget. For example, Jencks et al. (1) found that 1 in every 5 Medicare fee-for-service beneficiaries hospitalized between 2003 and 2004 was readmitted within 30 days. In 2004, the estimated cost of these unplanned 30-day hospital readmissions was $17.4 billion, which comprised nearly 17% of all the hospital payments made by Medicare in that year. A study that reviewed recent literature on readmissions found that between 9% and 48% of all readmissions were judged to be preventable because "they were associated with indicators of substandard care during the index hospitalization such as poor resolution of the main problem, unstable therapy at discharge, and inadequate post-discharge care" (2).

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One of the challenges in reducing short-term readmissions is that large studies of representative populations have generally lacked detailed information about the index population and the subsequent admission. However, the New York Percutaneous Coronary Interventions Reporting System (PCIRS) does contain this detailed information, including the ability to determine which PCI patients were staged to undergo another PCI on a diseased vessel not attempted during the index admission. PCIRS also has the ability to link patients across admissions so that detailed clinical data are available about the patient if a repeat PCI is performed. If the patient is readmitted without a subsequent PCI, New York's administrative data are available to determine the primary reason for readmission.

Abbreviations and Acronyms

AMI = acute myocardial infarction

CABG = coronary artery bypass graft

PCI = percutaneous coronary intervention

PCIRS = Percutaneous Coronary Interventions Reporting System

SPARCS = Statewide Planning and Research Cooperative System

The purposes of this study are to report PCI readmission rates, identify the impact of staged (planned) readmissions on overall readmission rates, determine the significant predictors of unstaged 30-day readmissions after PCI, and specify the reasons for readmissions. It is expected that with better information about which patients are at higher risk for readmission following PCI and why they are readmitted, effective efforts can be undertaken to reduce readmission rates. Furthermore, information never reported in earlier studies about the extent of staging for PCI can aid in efforts to examine the advisability of staging and to reduce overall readmission rates.

Methods

Data. The main database used in this study was the New York State PCIRS registry, which was developed in 1991 for the purpose of collecting information on all patients undergoing PCI in New York's nonfederal hospitals. PCIRS contains detailed information for each patient undergoing PCI in the state regarding demographics; pre-procedural risk factors; peri-procedural complications; types of devices used; extent of disease and lesions treated; dates of admission, discharge, and procedure; discharge disposition and destination; and hospital and operator identifiers. 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. Between one-quarter and one-third of the hospitals are audited each year on the basis of the accuracy of previous reporting, the time elapsed since the previous audit, and reported risk factor prevalence rates.

New York's Statewide Planning and Research Cooperative System (SPARCS) is New York's administrative discharge database. It includes information on demographics, diagnoses, procedures, admission and discharge dates, and discharge destination. SPARCS was used to identify readmissions to a hospital within 30 days after discharge from an index admission, and then these readmissions were matched to PCIRS to identify PCI patients who were readmitted within 30 days. For patients who were readmitted within 30 days who did not undergo repeat PCI, SPARCS was used to identify the primary reason for readmission (principal diagnosis). Data on patients who underwent subsequent PCI in their readmission were obtained from PCIRS because it contains more comprehensive information. New York's vital statistics data were used to identify deaths that occurred within 30 days after discharge from the hospital. Figure 1 provides a flow chart of how datasets were combined for use in the analyses.

Study group and endpoints. The focus of the study was all New York State patients undergoing PCI between January 1, 2007, and November 30, 2007 (the most recently audited data in the state) that resulted in live discharges. These patients were followed after discharge to determine whether they died or were readmitted to the hospital within 30 days after discharge from the index PCI. Initially, there were 46,699 PCI procedures performed. We excluded those that were performed on patients who had a previous PCI within 30 days (n = 2,662), had coronary artery bypass graft (CABG) surgery before PCI in the same admission (n = 24), were transferred to another acute care facility (n = 212), died during the index hospitalization (n = 291), and were not New York State residents (n = 1,809). After then removing 1,608 patients whose medical records could not be found in administrative data, the study group included 40,093 PCIs performed on 37,234 patients. The study was

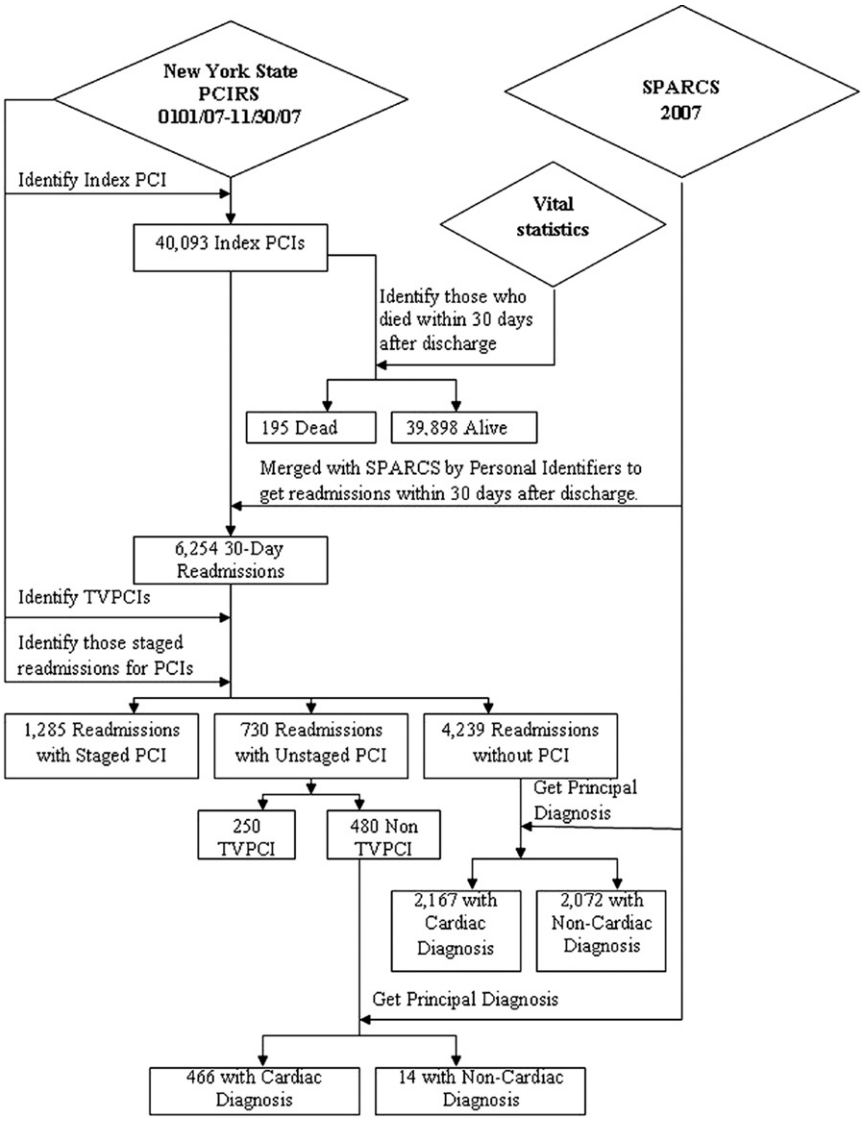

Figure 1. Flow Chart of Data in Analysis Process

Flow chart for identification of patients in various subanalyses. PCI = percutaneous coronary intervention; PCIRS = Percutaneous Coronary Interventions Reporting System; SPARCS = Statewide Planning and Research Cooperative System; TVPCI = target vessel percutaneous coronary intervention.

limited to New York State residents to minimize the chance that unknown out-of-state readmissions occurred. A total of 52 hospitals (all hospitals in which PCI was performed during the study period) were included in the study.

A subgroup of special interest was the group of patients who were staged (planned) to undergo PCI within 30 days of being discharged after the index admission.

Staged readmissions are defined as readmissions that were planned in the index admission (as evidenced by coding a data element in the index admission indicating the intention to perform PCI in a future admission for a diseased coronary vessel not attempted during the index admission). Also, there has to be evidence that the patient underwent a subsequent PCI in a nontarget lesion within 30 days of the index procedure. If patients who were initially indicated as "staged" were readmitted unexpectedly for target lesion revascularization, these patients were not regarded as staged regardless of the initial plan.

The primary endpoint in the study was the 30-day readmission rate. Thirty-day after-discharge mortality rates were also obtained using New York vital statistics data.

Statistical analysis. Readmissions were classified by age ($\leq$65 and $\geq$65 years) and acute myocardial infarction (AMI) status in the index PCI. The chi-square test was

used to test for the differences in the proportions of readmissions among patients over and under age 65 years, and among AMI and non-AMI patients. Reasons for unstaged readmissions were then examined. Target vessel PCI (the need for re-intervention in the vessel chosen for the index procedure) was considered a reason regardless of the patient's principal diagnosis. For unstaged patients not undergoing target vessel PCI, the reason for readmission was defined to be the principal diagnosis of the patient in SPARCS, which was represented by an ICD-9-CM (International Classification of Diseases-9th Revision-Clinical Modification) code.

The independent relationship between unstaged readmissions within 30 days after discharge and a wide variety of potential risk factors (demographic, ventricular function, vessels diseased, previous myocardial infarction, previous interventions, a large number of comorbidities, complications of PCI that occurred during the index admission, length of stay) was examined by developing a stepwise logistic regression model with readmissions (yes, no) as the binary dependent variable. All significant independent predictors were then entered into a logistic regression model with generalized estimating equations to account for clustering of patients within hospitals (3). The purpose of this analysis was to enable hospitals and physicians to identify patients who are at the highest risk of readmission so that those patients can be monitored more closely.

All tests were conducted at the 0.05 level, all confidence limits were 2-sided, and all analyses were conducted in SAS version 9.1 (SAS Institute, Cary, North Carolina).

Results

The all-cause 30-day readmission rate was 15.6%, the staged readmission rate was 3.2% of all patients (and 20.6% of all readmissions), and the readmission rate for unstaged patients was 12.4%. The variation across hospitals in the percentage of PCI patients staged for a subsequent PCI ranged from 0% to 8% among hospitals with at least 50 PCIs. A total of 863 of the 6,254 readmissions (13.8%) were patients who suffered an AMI within 24 h before undergoing PCI in the index admission. Also, 17.3% (863 of 4,993) of the AMI patients were readmitted, compared with 15.4% of all patients without AMI ($p = 0.0005$). Of the patients age 65 years and older, 17.2% were readmitted, compared with 13.9% of the patients under age 65 years ($p < 0.0001$) (Table 1).

With regard to all patients readmitted for other than a staged procedure (Table 2), 250 (5.0%) underwent a target vessel PCI during their readmission. Among patients without target vessel PCI, the most common cardiac-related reasons for readmission were chronic ischemic heart disease (22.9%), chest pain (11.1%), heart failure (7.6%), arrhythmias (4.4%), and AMI (2.9%). For patients readmitted for noncardiac reasons, the most common principal diagnoses were complications as a result of a previous procedure/medical care (6.7% of unstaged patients), digestive system (6.0%), circulatory system other than cardiac (5.7%), and respiratory system (4.9%). Table 2 also presents reasons for readmission according to whether patients experienced an AMI before the index admission.

Table 1. Staged and Unstaged Readmissions

Variable	Number of Readmissions (Readmission Rate in Percentage) AMI (n = 4,993)	No AMI (n = 35,100)	Total	p Value
Age <65 yrs (n = 19,289)	509	2,175	2,684 (13.9)	<0.0001*
Age ≥65 yrs (n = 20,804)	354	3,216	3,570 (17.2)	
Total	863 (17.3)	5,391 (15.4)	6,254 (15.6)	
p Value	0.0005†			

Values are for readmissions within 30 days after PCI among patients with or without AMI in the index PCI: New York, between January 1, 2007, and November 30, 2007. *p Value from chi-square test for comparing the proportion of readmissions between patients younger than age 65 years and those 65 or older. †p Value from chi-square test for comparing the proportion of readmissions between patients with AMI and those without AMI in the index PCI.

AMI = acute myocardial infarction; PCI = percutaneous coronary intervention.

A total of 2,015 (32.2%) of the patients readmitted within 30 days underwent a repeat PCI (staged or otherwise) during the readmission, and 1.3% of the readmissions underwent CABG surgery during the readmission (not shown). Of these repeat PCIs, 730 (36.2%) were unstaged and 1,285 (63.8%) were staged. Overall, 4 deaths (0.3%) occurred among staged readmissions, and the mortality rate for unstaged readmissions was 1.8% (0.7% for patients undergoing PCI and 2.0% for other patients, $p < 0.0001$). A total of 95.5% of staged readmissions were to the hospital of the index admission, whereas only 58.8% of unstaged readmissions were to the same hospital (89.5% when the unstaged readmission was for PCI, and 53.5% when a PCI was not performed in the unstaged readmission).

Table 3 presents the significant predictors of unstaged readmissions within 30 days. As indicated, the number of years over age 65, females, low ejection fraction, multivessel disease, AMI within 1 to 14 days, peripheral vascular disease, malignant ventricular arrhythmia, chronic obstructive pulmonary disease, diabetes, and renal failure were all associated with higher readmission rates. Also, having a post-PCI stroke, renal failure following PCI, and longer lengths of stay in the index admission were all associated with higher rates of readmission.

Discussion

A key procedure to examine for hospital readmissions is PCI because it is one of the most common procedures

Table 2. Principal Diagnosis (Reason for Readmission)

Principal Diagnosis of Unstaged Readmissions	N (Column Percentage)			
	AMI in Index PCI	No AMI in Index PCI	Total	Chi-Square p Value
Target vessel PCI	51 (7.13)	199 (4.68)	250 (5.03)	0.006
Readmission without target vessel PCI				
Cardiac				
Chronic ischemic heart disease	142 (19.86)	974 (22.90)	1,116 (22.46)	0.07
Chest pain	66 (9.23)	470 (11.05)	536 (10.79)	0.15
Heart failure	83 (11.61)	323 (7.59)	406 (8.17)	0.0003
Arrhythmias	28 (3.92)	187 (4.40)	215 (4.33)	0.56
Myocardial infarction	47 (6.57)	124 (2.91)	171 (3.44)	<0.0001
Atherosclerosis	1 (0.14)	84 (1.97)	85 (1.71)	0.0005
Other cardiac diseases*	21 (2.94)	83 (1.95)	104 (2.09)	0.09
Noncardiac				
Complication as a result of previous procedure/medical care	62 (8.67)	285 (6.70)	347 (6.98)	0.06
Digestive system	45 (6.29)	257 (6.04)	302 (6.08)	0.79
Circulatory system, except cardiac	43 (6.01)	242 (5.69)	285 (5.74)	0.73
Respiratory system	24 (3.36)	209 (4.91)	233 (4.69)	0.07
Endocrine, nutritional, and metabolic	11 (1.54)	126 (2.96)	137 (2.76)	0.03
Kidney and urinary tract	12 (1.68)	105 (2.47)	117 (2.35)	0.20
Infectious and parasitic diseases	9 (1.26)	70 (1.65)	79 (1.59)	0.44
Musculoskeletal system and connective tissue	10 (1.40)	49 (1.15)	60 (1.21)	0.61
Cancer	2 (0.28)	57 (1.34)	59 (1.19)	0.02
Injuries, poison and toxic effect of drugs	10 (1.34)	49 (1.14)	59 (1.17)	0.57
Skin, subcutaneous tissue and breast	4 (0.56)	48 (1.13)	52 (1.05)	0.17
Blood and blood-forming organs and immunologic disorders	8 (1.12)	43 (1.01)	51 (1.03)	0.79
Other noncardiac diseases†	36 (5.03)	269 (6.32)	305 (6.14)	0.18
Total	715	4,254	4,969	

Values are n (%). Values are for unstaged readmissions within 30 days after PCI among patients with or without acute MI in the index PCI: New York, between January 1, 2007, and November 30, 2007. *Includes other acute and subacute forms of ischemic heart disease, diseases of pericardium, aortic aneurysm and dissection, acute pericarditis, angina pectoris, conduction disorders, acute and subacute endocarditis, other diseases of endocardium, other aneurysm, cardiomyopathy, and ill-defined descriptions and complications of heart disease. †Include diseases of hepatobiliary system and pancreas, mental diseases and disorders, diseases of nervous system, alcohol/drug use or induced mental disorders, pregnancy, childbirth and puerperium, diseases of reproductive system, diseases of eye, ear, nose, mouth, and throat, and ungroupable diseases.
Abbreviations as in Table 1.

performed in the United States, with 622,000 procedures performed in 2007, and because of its cost ($48,399 mean charges per patient in 2006) (4). Coronary stent placement accounts for 1.6% of all Medicare readmissions, and it is being considered for public reporting by the Centers for Medicare and Medicaid Services (1).

Despite these compelling reasons to study readmissions for PCI, we have found only a single study in the literature on readmissions for PCI. Curtis et al. (5) used Medicare claims data from 2005 to identify the percentages of all-cause 30-day readmissions for all PCI patients older than 65 years, as well as for AMI and non-AMI patients who underwent PCI. They found an all-cause readmission rate of 14.6%, with 17.5% for AMI patients and 13.6% for non-AMI patients. Also, 25.8% of the readmissions underwent PCI and 1.7% underwent CABG surgery (5). Two similar studies that identified causes for readmission following CABG surgery have also been published (6,7).

The New York State PCIRS is especially well suited to examine readmissions for PCI. Unlike other available databases, it can identify which PCI patients were staged to undergo a subsequent PCI, so that these patients can be separated from other PCI patients when examining causes of readmissions and policies for reducing readmissions.

Also, unlike the American College of Cardiology's National Cardiac Data Registry, New York's PCIRS can link patients across readmissions to multiple hospitals so that reasons for and predictors of readmissions can be explored, and PCIRS is population based (not restricted to a select group of participating hospitals). Unlike Medicare data, it can explore readmissions for patients of all ages. This is important

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Table 3. Significant Independent Predictors of Unstaged Readmissions Within 30 Days After PCI: New York, between January 1, 2007, and November 30, 2007

Predictors	Prevalence (%)	Estimate	OR	95% CI Lower	95% CI Upper	p Value*
Demographic						
Age >65 yrs	—	0.0149	1.02	1.01	1.02	<0.0001
Female	33.01	0.2795	1.32	1.25	1.40	<0.0001
Black	10.89	0.0581	1.06	0.96	1.17	0.24
Pre-operative risk factors						
Ejection fraction						
≥40%	88.71		1.00	—	—	
<20%	0.73	0.7307	2.08	1.62	2.66	<0.0001
20%–29%	3.23	0.2727	1.31	1.13	1.53	0.0004
30%–39%	7.33	0.1833	1.20	1.07	1.35	0.002
Number of diseased vessels						
<3	86.09		1.00	—	—	
≥3	13.91	0.1090	1.12	1.01	1.23	0.03
Pre-procedural MI						
>14 days or no MI	82.38		1.00	—	—	
<6 h	1.97	−0.1562	0.86	0.75	0.98	0.02
6–23 h†	2.74	−0.0028	1.00	0.87	1.15	0.97
1–14 days	12.91	0.1442	1.16	1.05	1.27	0.003
Peripheral vascular disease	7.38	0.3574	1.43	1.29	1.59	<0.0001
Malignant ventricular arrhythmia	0.51	0.4058	1.50	1.03	2.18	0.03
COPD	6.14	0.4688	1.60	1.44	1.77	<0.0001
Diabetes	33.02	0.1902	1.21	1.13	1.30	<0.0001
Renal failure						
Creatinine ≤1.5 mg/dl	89.82		1.00	—	—	
Creatinine 1.6–3.0 mg/dl	5.85	0.2148	1.24	1.12	1.37	<0.0001
Creatinine >3.0 mg/dl	0.54	0.6658	1.95	1.33	2.86	0.0007
Requiring dialysis	1.96	0.6054	1.83	1.54	2.18	<0.0001
In-hospital post-procedural complications						
Stroke	0.13	1.0511	2.86	1.50	5.47	0.002
Renal failure	0.08	0.8647	2.37	1.21	4.65	0.01
Other factors						
Length of stay after index PCI						
≤1 day	69.36		1.00	—	—	
2 days	12.19	0.2958	1.34	1.22	1.49	<0.0001
3 days	6.96	0.5146	1.67	1.47	1.91	<0.0001
≥4 days	11.49	0.8111	2.25	2.00	2.54	<0.0001

*All odds ratios and p values are from a stepwise logistic regression used for risk adjustment with significance level 0.05, but some might be no longer significant in the generalized estimating equation model after adjusting for within-hospital correlation. Additional candidates for the model were left main disease, hemodynamic instability, shock, congestive heart failure in the same admission, and the following post-procedural complications: Q-wave MI, acute occlusion in the target vessel, acute occlusion in a significant side branch, arterial or venous injury, emergency cardiac surgery. †MI 6 to 23 h was forced into the model. C = 0.64 Hosmer–Lemeshow chi-square statistic for goodness of fit = 10.16, p = 0.25.

COPD = chronic obstructive pulmonary disease; OR = odds ratio; PCI = percutaneous coronary intervention.

because the cost to society of readmissions accrues for all patients, and estimating this burden by extrapolating readmissions for Medicare patients can be misleading. Furthermore, PCIRS contains clinical data elements not in Medicare databases for purposes of identifying predictors of readmission.

In our study consisting of PCI patients of all ages in New York State, we found an all-cause readmission rate of 15.6%. The staged readmission rate was 3.2%, and the unstaged readmission rate was 12.4% (20.6% of all readmissions were staged). There was a 17.3% overall readmission rate for patients presenting at the index admission with AMI and a 15.3% rate for patients presenting without AMI. A total of 32.2% of the readmissions underwent PCI, and 1.3% underwent CABG surgery in the readmission.

We also found that patients under age 65 years were somewhat less likely to be readmitted than the group of older patients in the Curtis et al. (5) study, but that our comparable group of patients older than 65 were more likely to be readmitted. For patients under 65, we found a readmission rate of 13.9%, compared with 17.2% for patients 65 years and older (and compared with 14.6% for Medicare patients reported by Curtis et al. [5]).

Numerous pre-procedural patient risk factors, 2 complications (stroke and renal failure following PCI), and long length of stay were all related to higher readmission rates. This is valuable information because it can be used to alert hospitals to be particularly cautious with treatment and discharge policies for patients with specific comorbidities, and can be used to target outpatient follow-up of patients at high risk for readmission.

We were also able to subdivide readmissions on the basis of whether or not patients were readmitted electively for staged PCI. We found that 20.6% of all 30-day readmissions were staged readmissions whereby some diseased coronary vessels are treated in a subsequent readmission because it is deemed wise to treat only the culprit vessel during the index admission. This is important information because staged readmissions, although they may not always be advisable or in the best interest of patients, are certainly different from readmissions for complications of the index PCI, and should not be regarded as adverse outcomes, as noted by Bove and Spertus (8). It is also true that multivessel revascularization during the index procedure or later during the index revascularization may sometimes be associated with better outcomes, although this strategy is clearly not appropriate for all patients, particularly acute AMI patients (9–11). However, if staged procedures were regarded as adverse outcomes from the standpoint of denying payment, this might simply result in staged procedures with a further delay between treatment episodes.

For readmitted patients who are not staged, our results demonstrate that there is a wide variety of reasons for readmission. Target vessel PCI is clearly a complication of the index procedure, and arguably most principal diagnoses that are cardiac-related indicate problems either resulting from or not remedied by the index procedure. A caveat of the study is that it is not always possible to discern when patients were readmitted for complications of the index PCI as opposed to unrelated problems. Noncardiac principal diagnoses may be a complication of the procedure (e.g., an ICD-9-CM code for "complication due to previous procedure"), may be unrelated to the procedure (cancer, or mental diseases), or it may be unclear whether there is a relationship.

It is also notable that 42% of all unstaged readmissions within 30 days occurred within 1 week. This suggests that keeping patients in the hospital longer during the index admission may have been effective in decreasing the readmission rate. A consensus document by Chambers et al. (12) recommends which patients can receive PCI as outpatients, which patients require a 1-day inpatient stay, and which patients require longer stays. These criteria could be beneficial in identifying patients who could have avoided readmission by having a longer index admission and could also be used to save resources by identifying patients who do not need an in-patient stay.

A caveat of the study is that administrative data were the only data available for determining reasons for readmission. Although we are not aware of other databases that have any better information, this is unfortunate because principal diagnoses, such as "chronic ischemic heart disease," "atherosclerosis," and "chest pain" are not specific enough to determine the real reason for readmission, and leave some doubt as to whether the readmission was necessitated by a complication of the index procedure. Since "chronic ischemic heart disease" is coded for so many readmissions, we recommend future studies to review all records with this administrative code to determine the real reason for admission. Nevertheless, we believe our study is the first one to examine PCI readmissions with access to clinical data for index admissions and readmissions involving repeat revascularization, as well as the first study to report staged readmissions

Conclusions

This study has documented that readmission rates for PCI are quite high, and that most readmissions are not for staged procedures. For staged patients, possible strategies for decreasing readmissions for PCI include increasing the use of multivessel revascularization during the index admission in lieu of staging. However, the cost effectiveness of this option is dependent on patients' specific characteristics/risk factors. Although, as noted in the previous text, some work has been done in this area (9–11), much more needs to be done, particularly with regard to elective (no recent AMI) patients and with regard to cost.

For unstaged patients, possible strategies include reducing complication rates and intensifying outpatient follow-up of patients at highest risk of readmission. Our study is also the first study to identify clinical predictors of readmissions in this population. This knowledge is critical in efforts to reduce future admissions by targeting patients most in need of monitoring for outpatient follow-up.4,5

Acknowledgments

The authors would like to thank New York State's Cardiac Advisory Committee for their encouragement and support of this study; and Kimberly S. Cozzens and Cynthia Johnson and the cardiac catheterization laboratories of the participating hospitals for their tireless efforts to ensure the timeliness, completeness, and accuracy of the registry data.

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REFERENCES

1. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in Medicare fee-for-service program. N Engl J Med 2009;360:1418–28.
2. Benbassat J, Taragin M. Hospital readmissions as a measure of quality of health care: advantages and limitations. Arch Intern Med 2000;160:1074–81.
3. Zeger SL, Liang KY, Albert PS. Models for longitudinal data: a generalized estimating equation approach. Biometrics 1988;42:1049–60.
4. American Heart Association. Heart Disease and Stroke Statistics—2009 Update. Dallas, TX: American Heart Association, 2009.
5. Curtis JP, Schreiner G, Wang Y, et al. All-cause readmission and repeat revascularization after percutaneous coronary intervention in a cohort of Medicare patients. J Am Coll Cardiol 2009;54:903–7.
6. Hannan EL, Racz MJ, Walford G, et al. Predictors of readmission for complications of coronary artery bypass graft surgery. JAMA 2003;290:773–80.
7. Hannan EL, Zhong Y, Lahey S, et al. Thirty-day readmissions following CABG surgery in New York, J Am Coll Cardiol Intv 2011;4:569–76.
8. Bove AA, Spertus JA. Meeting the challenges of outcomes measures. J Am Coll Cardiol 2010;55:75–6.
9. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1999 Guidelines for the Management of Patients with Acute Myocardial Infarction). J Am Coll Cardiol 2004;44:e1–211.
10. Antman EM, Hand M, Armstrong PW, et al. 2007 focused update of the ACC/AHA 2004 guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1999 Guidelines for the Management of Patients with Acute Myocardial Infarction). J Am Coll Cardiol 2008;51:210–47.
11. Hannan EL, Samadashvili Z, Walford G, et al. Culprit vessel percutaneous coronary intervention versus multi-vessel and staged percutaneous coronary intervention for ST-segment elevation myocardial infarction patients with multi-vessel disease. J Am Coll Cardiol Intv 2010;3:22–31.
12. Chambers CE, Dehmer GJ, Cox DA, et al. Defining the length of stay following percutaneous coronary intervention: an expert consensus document from the Society for Cardiovascular Angiography and Interventions. Catheter Cardiovasc Interv 2009;73:847–58.

Key Words: 30-day readmissions ■ PCI ■ risk factors.