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Ehrin J. Armstrong, MD MSc, Laura Graham, MPH, Stephen W. Waldo, MD, Javier A. Valle, MD MSc, Thomas M. Maddox, MD MSc, Mary T. Hawn, MD

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Incomplete Revascularization is Associated with an Increased Risk of Major Adverse Cardiovascular Events Among Patients Undergoing Noncardiac Surgery

Ehrin J. Armstrong MD MSc[1], Laura Graham MPH[2], Stephen W. Waldo MD[1], Javier A. Valle MD MSc[1], Thomas M. Maddox MD MSc[1], Mary T. Hawn MD[3]

Affiliations:

[1] Section of Cardiology, Denver VA Medical Center and University of Colorado School of Medicine, Aurora, CO, USA
[2] Birmingham VA Medical Center, Birmingham, AL, USA
[3] Department of Surgery, Stanford University, Stanford, CA, USA

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Corresponding Author:
Ehrin J. Armstrong MD
Associate Professor of Medicine
Denver VA Medical Center
1055 Clermont Street
Denver, CO 80220
Telephone: (415)312-2480
Email: Ehrin.armstrong@gmail.com

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ABSTRACT

Background: Patients with coronary artery disease and prior percutaneous coronary intervention (PCI) frequently undergo non-cardiac surgery. These patients may have either had PCI on all obstructive lesions (i.e., complete revascularization) or only on some (i.e., incomplete revascularization).

Objectives: To determine whether incomplete revascularization is associated with a higher risk of major adverse cardiovascular events (MACE) and myocardial infarction among patients undergoing noncardiac surgery.

Methods: Patients were identified using the VA Clinical Assessment, Reporting, and Tracking (CART) program. VA and non-VA surgical records were used to link patients who underwent non-cardiac surgery within two years after stent placement. Incomplete revascularization was defined as a residual stenosis of ≥50% in the left main coronary artery or ≥70% in another major epicardial coronary artery based on operator visual estimate.

Results: 4,332 (34.7%) patients had incomplete revascularization. A total of 567 MACE events occurred within one month postoperatively. Those with incomplete revascularization had an unadjusted 19% increased odds of post-operative MACE, compared to those with complete revascularization (OR 1.19, 95% CI 1.00-1.41). Among the MACE components, postoperative MI appears to contribute the most with a 37% increased risk of postoperative MI among patients with incomplete revascularization (OR 1.37, 95% CI 1.10-1.70). After adjustment, there was a significant interaction between time from PCI and outcomes after non-cardiac surgery; incomplete revascularization was associated with significantly increased risk of postoperative MI primarily if surgery was performed within six weeks after PCI (AOR 1.84, 95% CI 1.04-2.38). The number of vessels with incomplete revascularization was also associated with an increased

risk of postoperative MI: for each additional vessel with incomplete revascularization, there was a 17% increased odds of postoperative MI.

Conclusions: Incomplete revascularization among patients with coronary artery disease is associated with an increased risk of myocardial infarction after non-cardiac surgery.

KEY WORDS: percutaneous coronary intervention; surgery; operative risk; ischemia

CONDENSED ABSTRACT

Patients with coronary artery disease and prior percutaneous coronary intervention (PCI) frequently undergo non-cardiac surgery. These patients may have either had PCI on all obstructive lesions (i.e., complete revascularization) or only on some (i.e., incomplete revascularization). In a national cohort of Veterans, 34.7% of patients had incomplete revascularization. Those with incomplete revascularization had an unadjusted 19% increased odds of post-operative MACE compared to those with complete revascularization. The number of vessels with incomplete revascularization was also associated with an increased risk of postoperative MI: for each additional vessel with incomplete revascularization, there was a 17% increased odds of postoperative MI.

ABBREVIATIONS

PCI, percutaneous coronary intervention

MACE, major adverse cardiovascular events

LAD, left anterior descending

RCA, right coronary artery

BMS, bare metal stent

DES, drug eluting stent

INTRODUCTION

Approximately 20% of patients who undergo percutaneous coronary intervention (PCI) require non-cardiac surgery in the subsequent two years. (1-3) Optimal risk stratification of these patients is crucial, as they represent a high-risk subset of patients who are more likely to experience adverse postoperative events compared to the overall population of patients undergoing non-cardiac surgery. (4-7) Current guidelines for perioperative management have suggested optimal control of risk factors and delaying surgery for a year among patients with drug-eluting stents, but de-emphasize the need for stress testing or evaluation for underlying ischemia in the absence of symptoms. (8,9)

While both patient and lesion-related factors contribute to the risk of non-cardiac surgery among patients with prior PCI, the attributable risk from incomplete revascularization and presumed residual ischemia remains uncertain. (10) It is known that residual ischemia in patients with stable CAD is a risk factor for long-term adverse cardiovascular events, and that patients treated with anatomic complete revascularization (either surgically or percutaneously) have lower cardiovascular event rates. (11-14) More recently, anatomic scoring systems have also suggested an association between incomplete anatomic revascularization after PCI and major adverse cardiovascular events (15,16). Residual ischemia and incomplete revascularization may similarly represent significant risk factors for patients undergoing surgery, however the prevalence and outcomes of patients with incomplete revascularization undergoing noncardiac surgery is not well described.

We hypothesized that patients who had incomplete revascularization and presumed residual ischemia would be at increased risk for major adverse cardiovascular events when undergoing subsequent non-cardiac surgery, and that this risk would be independent of other

established risk factors. We studied this question in a national cohort of Veterans undergoing non-cardiac surgery within two years following PCI.

MEDTHODS

Study Design and Study Population. This was a retrospective cohort study of patients who underwent non-cardiac surgery within two years after coronary stent placement. Patients with a prior history of coronary artery bypass grafting were excluded from the cohort. Coronary artery stent placement was identified using the VA Clinical Assessment, Reporting, and Tracking (CART) system. All coronary stents implanted in VA facilities between 2005-2010 were identified using data elements derived directly from the CART database, which includes pre-specified fields for bare metal stents as well as the type of drug eluting stent.

Subsequent non-cardiac surgery occurring up to 24 months after coronary stent placement was identified using the VA Surgical Quality Improvement Program database (VASQIP); non-cardiac surgery outside of the VA was identified using the Centers for Medicare & Medicaid Services (CMS) database as previously described. (2) Surgeries performed during the same hospitalization as the initial PCI or after an intervening cardiac surgery or placement of a stent at a non-VA facility were excluded. The type of non-cardiac surgery performed was identified using current procedural terminology (CPT) codes 10000-32999 and 34000-69999. Minor surgeries, including endoscopy and outpatient musculoskeletal injections, were excluded. Surgery types were also grouped by organ system and by elective vs. non-elective status.

The study protocol was reviewed and approved by the local VA institutional review board of each coauthor with waiver of informed consent.

Study Variables. The primary outcome was a composite outcome of MACE within 30 days after non-cardiac surgery, defined as the first occurrence of all-cause death, myocardial infarction

(ICD-9-CM codes 410.x1 or VASQIP abstracted MI), or need for coronary revascularization (ICD-9-CM 00.66, 36.01-36.09; CPT: 33510-33519, 33520-33523, 33530-33536, 92973-92984, 92995-92998).

Procedural elements of the initial PCI were derived from CART data entered at the time of the procedure. These variables included the indication for the PCI (acute coronary syndrome with myocardial infarction, acute coronary syndrome without myocardial infarction, or stable angina), the stent type implanted (BMS, DES, or both), target vessel (left main, LAD, RCA, or circumflex), target lesion location (ostial, proximal, mid, or distal within given vessel), presence of significant lesion calcification, presence of lesion at a bifurcation, lesion length, intervention to chronic total occlusion, use of intravascular ultrasound, PCI risk, number of target vessels, stent length, largest stent diameter, and the anticoagulant used during PCI. Incomplete anatomic revascularization was defined as the presence of a ≥50% lesion in the left main coronary artery or ≥70% stenosis in another major epicardial coronary artery ≥2 mm in diameter at the conclusion of the PCI, based on visual estimate by the operator. All of the procedural variables were entered by the treating physician at the time of the intervention and were based on physician judgment at the time of the procedure.

The patient's cardiac risk at the time of non-cardiac surgery using the revised cardiac risk index was estimated using ICD-9 codes for congestive heart failure, stroke, MI, and diabetes; CPT codes associated with high-risk surgery; and laboratory data identifying one or more serum creatinine values greater than 2 mg/dL in the year prior to surgery.

Statistical Analysis. For bivariate analyses, Chi-square test statistics and Wilcoxon rank sum tests were used to compare categorical and continuous variables, respectively. Backwards stepwise selection with an alpha of 0.05 was used to build the most parsimonious logistic

regression model for the association of incomplete revascularization with postoperative MACE and MI. Covariates found to be associated with MACE in bivariate analyses were tested during model selection along with additional variables considered to be clinically significant. The final model included age, history of MI within 6 months of surgery, revised Cardiac Risk Index, procedure type, PCI risk, and time to surgery from PCI. A significant interaction term between time from PCI and outcomes after non-cardiac surgery was identified that persisted even after adjusting for potential confounders. Therefore, the association of incomplete revascularization with postoperative MACE and MI was stratified based on the time from PCI to non-cardiac surgery. All analyses were completed using SAS version 9.2 (SAS institute).

RESULTS

During the study period, 12,486 patients without a history of coronary artery bypass grafting underwent PCI and subsequent non-cardiac surgery (Figure 1). 4,332 patients (34.7%) had incomplete anatomic revascularization. The baseline demographics of patients with and without incomplete revascularization are summarized in Table 1. Patients with incomplete revascularization were more likely to have had a myocardial infarction in the prior six months (13.9% vs. 10.5%, $p<0.001$), were more likely to have a history of congestive heart failure (39.1% vs. 32.8%, $p<0.001$), and were more likely to have diabetes (57.9% vs. 52.8%, $p<0.001$). Patients with incomplete revascularization were also slightly more likely to have undergone a PCI within the prior year (71.7% vs. 69.8%, $p=0.03$)

The angiographic characteristics of the index PCI are detailed in Table 2. Patients with incomplete revascularization were more likely to have been treated for an acute coronary syndrome (71% vs. 64.6%, $p<0.001$), but had a similar distribution of target vessels compared to patients with complete revascularization. Patients with incomplete revascularization were on

average treated with more coronary artery stents and were more likely to have an overall treatment length >30 mm, suggesting a greater burden of atherosclerotic disease among the patients who had incomplete revascularization.

Table 3 details the unrevascularized vessels among patients with incomplete revascularization. The RCA (18%) and the LAD (17.9%) were the vessel most frequently associated with incomplete revascularization, while the circumflex (11.3%) and posterior descending artery (3%) were less frequently associated with incomplete revascularization. The prevalence of any chronic total occlusion in the non-target vessel among patients with incomplete revascularization was 1.3%.

11.1% of the cohort underwent preoperative stress testing in the three months prior to noncardiac surgery. There was no association between incomplete revascularization and the decision to perform preoperative stress testing (10.7% vs. 11.3%, p=0.4).

Tables 4 and 5 demonstrate the unadjusted and adjusted associations of incomplete revascularization with thirty-day major adverse cardiovascular events after non-cardiac surgery. Those with incomplete revascularization had a 19% increased odds of major adverse cardiovascular events in the post-operative period, compared to those with complete revascularization (OR 1.19, 95% CI 1.00-1.41). A significant relationship between the number of unrevascularized vessels and the risk of postoperative adverse outcomes was also observed (Figure 2). When examined as a continuous variable, there was a 17% increase in odds of postoperative MI for every additional vessel with residual stenosis (p<0.001Postoperative myocardial infarction among patients with incomplete revascularization appears to contribute the most to the increased risk of MACE throughout all time periods investigated (3.3% vs. 2.5%, OR 1.37, 95% CI 1.10-1.70).

After multivariable adjustment for patient and procedural risk factors, a significant interaction term remained between the time from PCI to surgery and the risk of postoperative events. Among patients who underwent non-cardiac surgery <6 weeks after PCI, incomplete revascularization was associated with an adjusted odds of 1.84 (95% CI 1.04-2.38) for postoperative MI and 1.22 (95% CI 0.76-1.95) for MACE (Figure 3). In comparison, the risk of postoperative MI or MACE was not significant among patients who underwent non-cardiac surgery between 6 weeks to one year post-PCI. A second increase in postoperative MI risk was also observed if surgery was performed 1 year-2 years post-PCI (AOR 1.42, 95% CI 1.08-1.89). Consistent with this time to surgery interaction, the overall rates of postoperative MI were significantly higher at early and late time points among patients with incomplete revascularization (Figure 4). There was no significant interaction between stent type and the risk of postoperative MACE based on these different time points, suggesting that the early and late risks of postoperative MACE were not dependent on the type of stent implanted (p=0.09 for interaction).

DISCUSSION

Patients with coronary artery disease and prior PCI who undergo non-cardiac surgery have a significantly increased risk of postoperative adverse events when compared to the general population. (4,5) In this study, we found that incomplete revascularization among patients with prior PCI was associated with a significantly increased rate of postoperative MACE as a composite outcome and postoperative myocardial infarction as a component of MACE. We also observed a stepwise association between the number of vessels that were not revascularized and the risk of postoperative myocardial infarction, suggesting that greater ischemic burden was associated with an increased risk of postoperative MI. There was also a significant interaction

between time from PCI and risk of postoperative outcomes, with the greatest attributable risk from incomplete revascularization if the surgery was performed <6 weeks after the initial PCI.

Noncardiac surgery may result in postoperative MI due to numerous mechanisms, including plaque rupture from a pro-inflammatory state, stent thrombosis as a result of antiplatelet interruption, or a so-called demand event due to hemodynamic stress in the setting of a fixed stenosis (Type 2). (17) While we could not adjudicate the classification of MI category in our cohort, the majority of such events attributable to incomplete revascularization are presumably related to a Type 2 myocardial infarction in the setting of angiographically significant residual stenosis. Recent evidence suggests that Type 2 MI is associated with significantly worse adverse outcomes than previously recognized, with a two-fold increased rate of MACE and cardiovascular death when compared to patients without Type 2 MI. (18,19) These findings suggest that mechanisms to risk stratify patients at risk of postoperative MI would minimize the long-term morbidity among patients with coronary artery disease undergoing noncardiac surgery.

Consistent with our primary finding that incomplete revascularization was associated with an increased risk of postoperative MACE and MI, we also observed a dose-response effect between the number of unrevascularized vessels and the risk of postoperative MI, with a 17% increased odds of postoperative MI for each additional vessel that was not revascularized. This finding suggests that a greater atherosclerotic and ischemic burden was associated with an increased risk of adverse events. Consistent with this hypothesis, the nuclear substudy of the COURAGE trial, patients with continued ischemic burden (regardless of PCI or medical therapy) had a significantly increased risk of death or myocardial infarction during follow-up. (20) Recently, the residual SYNTAX score after multivessel PCI was also found to be associated with

an increased risk of death and MACCE during five-year follow-up. (21) Importantly, that study also identified a dose-response relationship between the residual SYNTAX score and risk of adverse events, again confirming the relationship between the anatomic extent of residual coronary artery disease and risk for adverse outcomes.

Our analysis also revealed a significant time interaction, with the risk of postoperative MI highest among patients with incomplete revascularization who underwent surgery within six weeks post-PCI. Multiple mechanisms may account for this time interaction. First, surgeries performed within six weeks were presumably urgent and could not be deferred; however, we adjusted for surgical urgency and complexity in multivariable analysis. Second, surgery within six weeks is likely associated with a higher risk of stent thrombosis. Patients with incomplete revascularization were also treated with longer stent lengths, suggesting a more complex initial PCI and possibly a higher risk of stent-related adverse events in the postoperative period. Third, surgery within six weeks may not provide enough time for optimal medical titration in order to reduce the hemodynamic stress on patients with incomplete revascularization, who might benefit from more intensive medical optimization prior to surgery. Overall, our findings are consistent with prior studies, which have recently shown that the majority of the perioperative risk is attributable to the first six months post-PCI, regardless of stent type or indication for the initial PCI. (7) Patients with incomplete revascularization, who represent a high-risk subgroup of such patients, should also have surgery delayed for at least six weeks and ideally six months post-PCI based on our findings.

Should patients with incomplete revascularization after PCI who require noncardiac surgery undergo additional risk stratification or possibly revascularization prior to surgery? While our data support an association between incomplete revascularization and adverse events,

they do not prove a causal association between complete revascularization and a reduction in cardiovascular risk, which remains controversial. A recent meta-analysis suggested that complete revascularization was associated with decreased mortality, myocardial infarction, and repeat coronary revascularization, regardless of revascularization modality. (13) While revascularization has not been shown to definitely reduce perioperative morbidity prior to major surgery, subsequent analysis suggested that patients with complete revascularization (primarily via CABG) were less likely to develop postoperative MI. Current guidelines have de-emphasized a role for routine stress testing or evaluation for underlying ischemia in the absence of symptoms. (8,9) However, our data suggests that risk stratification using cardiac stress testing in a select subset of patients with known residual angiographic stenoses may be a way to impact postoperative morbidity. If such patients demonstrate residual ischemia, a decision could be made regarding intensification of medical therapy versus further revascularization prior to surgery.

This study should be interpreted based on several aspects of its design. First, the CART data elements allow identification of additional unrevascularized coronary artery vessels, but current data elements in that dataset do not allow the granular extraction necessary to calculate SYNTAX or residual SYNTAX scores. It is therefore not possible to integrate the overall anatomic details of patients with incomplete anatomic revascularization into a single scoring system. Second, we were able to identify patients with incomplete anatomic revascularization based on visual estimate of a 70% lesion that was not revascularized, but not necessarily residual ischemia. Operator visual assessment is known to potentially overestimate the severity of stenosis when compared to more quantitative methods. Additionally, identification of residual ischemia would require stress imaging or invasive FFR technology to determine the extent of

jeopardized myocardium. While incomplete anatomic revascularization is therefore a proxy for residual ischemia, the significant association between the number of vessels with incomplete revascularization and the risk of postoperative MI supports this association between incomplete revascularization and the presumed extent of residual ischemia. Third, the CART data elements do not provide data on aspirin doing or refills, nor were we able to obtain detailed information on clopidogrel usage post-PCI and in the peri-operative period. It is therefore possible that other patient-related or prescribing patterns contributed to the some of the observed association between incomplete revascularization and postoperative outcomes. Fourth, we do not have data on the clinical decision making to perform complete vs. incomplete revascularization, patient anginal symptoms prior to surgery, the mechanisms of post-operative MI, and whether such events were primarily Type 2 (i.e., demand-related), due to plaque rupture, or due to stent thrombosis. However, recent data has suggested that type 2 MI are associated with similarly poor long-term prognosis, suggesting that this is a clinically important endpoint in this patient population. Fifth, we do not have data on patients who underwent PCI and for whom surgery was ultimately deferred, as the cohort was defined by patients who underwent PCI and then subsequent noncardiac surgery. It is possible that a group of patients with residual ischemia and who were therefore considered at high risk for postoperative complications had surgery cancelled or delayed beyond two years. Sixth, we do not have data on whether medical therapy was intensified in the perioperative period among patients with prior PCI, and whether this was associated with any change in ischemic burden.

CONCLUSION

In conclusion, incomplete revascularization among patients who have undergone PCI is associated with a significantly increased risk of MACE after noncardiac surgery. Of the MACE

components, postoperative MI has the strongest association for patients with multiple unrevascularized vessels. Future studies should investigate the utility of further risk stratification among patients with incomplete revascularization, and whether complete revascularization is associated with lower rates of postoperative MACE.

PERSPECTIVES

WHAT IS KNOWN?

Patients with coronary artery disease and prior PCI frequently undergo non-cardiac surgery. The contribution of incomplete revascularization to adverse outcomes is unknown.

WHAT IS NEW?

In a national cohort of Veterans, patients with coronary artery disease and incomplete revascularization who required subsequent non-cardiac surgery had higher rates of major adverse cardiovascular events and myocardial infarction compared to patients with complete revascularization.

WHAT IS NEXT?

Future studies should investigate the contribution of incomplete revascularization to major adverse cardiovascular events after non-cardiac surgery.

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FIGURE LEGEND

Figure 1. Patient Flowchart. The total cohort consisted of 12,486 patients who underwent PCI and then noncardiac surgery within 2 years.

Figure 2. Postoperative Outcomes Within One Month After Surgery By Number of Vessels With Incomplete Revascularization. There was a significant relationship between the number of vessels with incomplete revascularization and the risk of postoperative myocardial infarction or MACE.

Figure 3. Association of Incomplete Revascularization with Increased Rates of Major Adverse Cardiovascular Events and Myocardial Infarction, and Effect of Surgical Timing on the Risk of Myocardial Infarction. Incomplete revascularization was associated with an increased risk of postoperative MACE or myocardial infarction. There was also a significant time interaction between incomplete revascularization and the risk of postoperative outcomes, with the risk increased early (<6 weeks) and late (1-2 years).

Figure 4. Association of Incomplete Revascularization with Postoperative MI in Relation to Timing From Prior Percutaneous Coronary Intervention. The highest risk of postoperative MI occurred early among patients with incomplete revascularization, although there was also a higher risk for adverse events among patients with incomplete revascularization who underwent surgery >1 year post-PCI.

Table 1. Baseline Demographics of the Study Population

			Complete Revascularization		Incomplete Revascularization		
	Overall	**(%)**	**N**	**(%)**	**N**	**(%)**	**P Value**
Overall	12486		8154	(65.3)	4332	(34.7)	
Age							
<60 y	2017	(16.2)	1422	(17.4)	595	(13.7)	<0.001
≥ 60 y	10469	(83.8)	6732	(82.6)	3737	(86.3)	
Race							
White	10823	(88.4)	7046	(88.3)	3777	(88.6)	<0.001
Black	1246	(10.2)	845	(10.6)	401	(9.4)	
Other	177	(1.4)	93	(1.2)	84	(2.0)	
Sex							
Male	12304	(98.5)	8017	(98.3)	4287	(99.0)	0.004
Female	182	(1.5)	137	(1.7)	45	(1.0)	
Revised Cardiac Risk Index							
1	5190	(46.5)	3519	(48.6)	1671	(42.6)	<0.001
2	3845	(34.5)	2404	(33.2)	1441	(36.8)	
≥3	2124	(19.0)	1316	(18.2)	808	(20.6)	
Myocardial Infarction in Past Six Months							
No	11032	(88.4)	7300	(89.5)	3732	(86.2)	<0.001
Yes	1454	(11.6)	854	(10.5)	600	(13.9)	
History of CHF							
No	8116	(65.0)	5479	(67.2)	2637	(60.9)	<.001
Yes	4370	(35.0)	2675	(32.8)	1695	(39.1)	
History of Cerebrovascular Disease							
No	12298	(98.5)	8033	(98.5)	4265	(98.5)	0.78
Yes	188	(1.5)	121	(1.5)	67	(1.6)	
Hypertension in Past Year							
No	891	(7.1)	619	(7.6)	272	(6.3)	0.01
Yes	11595	(92.9)	7535	(92.4)	4060	(93.7)	
Diabetes							

No	5670	(45.4)	3845	(47.2)	1825	(42.1)	<0.001
Non-insulin dependent	4705	(37.7)	3018	(37.0)	1687	(38.9)	
Insulin dependent	2111	(16.9)	1291	(15.8)	820	(18.9)	
Chronic Kidney Disease							
No	10464	(83.8)	6864	(84.2)	3600	(83.1)	0.12
Stage 1-5	1084	(8.7)	677	(8.3)	407	(9.4)	
Dialysis	938	(7.5)	613	(7.5)	325	(7.5)	
Stress Testing within 3 Months							
No	11101	(88.9)	7234	(88.7)	3867	(89.3)	0.35
Yes	1385	(11.1)	920	(11.3)	465	(10.7)	
Previous PCI within 1 Year							0.03
No	8798	(70.5)	5692	(69.8)	3106	(71.7)	
Yes	3688	(29.5)	2462	(30.2)	1226	(28.3)	
Subsequent Operation Type							
Digestive	1303	(10.4)	853	(10.5)	450	(10.4)	0.01
Eye/Ear	2249	(18.0)	1430	(17.5)	819	(18.9)	
Genital/Urinary	1886	(15.1)	1228	(15.1)	658	(15.2)	
Integumentary	1989	(15.9)	1309	(16.1)	680	(15.7)	
Musculoskeletal	1911	(15.3)	1301	(16.0)	610	(14.1)	
Nervous	619	(5.0)	417	(5.1)	202	(4.7)	
Other	148	(1.2)	106	(1.3)	42	(1.0)	
Respiratory	600	(4.8)	396	(4.9)	204	(4.7)	
Vascular	1781	(14.3)	1114	(13.7)	667	(15.4)	
Subsequent Operation Admission							
Outpatient	8029	(64.3)	5244	(64.3)	2785	(64.3)	0.98
Elective Inpatient	3919	(31.4)	2561	(31.4)	1358	(31.4)	
Non-Elective Inpatient	538	(4.3)	349	(4.3)	189	(4.4)	

Table 2. Procedural Characteristics of Percutaneous Coronary Intervention

	Complete Revascularization		Incomplete Revascularization		
	N	**(%)**	**N**	**(%)**	**P Value**
Indication for Intervention					
ACS with MI	859	(10.6)	459	(10.6)	<.001
ACS without MI	4314	(53.0)	2614	(60.4)	
Non-ACS	2965	(36.4)	1254	(29.0)	
Stent Type					
BMS Only	2289	(28.1)	1126	(26.0)	0.07
Both Generation DES	101	(1.2)	66	(1.5)	
First-Generation DES	3734	(45.8)	2012	(46.5)	
Second-Generation DES	1781	(21.8)	1001	(23.1)	
Missing	249	(3.1)	127	(2.9)	
Target Vessel					
LAD	3047	(37.4)	1225	(28.3)	<.001
Circumflex	1499	(18.4)	891	(20.6)	0.003
RCA	2618	(32.1)	1156	(26.7)	<.001
Left Main	198	(2.4)	187	(4.3)	<.001
Target Vessel Location					
Proximal	2684	(32.9)	1383	(31.9)	0.26
Mid	3995	(49.0)	1649	(38.1)	<.001
Distal	1081	(13.3)	548	(12.7)	0.34
Ostial Lesion					
No	7678	(94.2)	3979	(91.9)	<.001
Yes	476	(5.8)	353	(8.2)	
Calcified Lesion					
No	6792	(83.3)	3468	(80.1)	<.001
Yes	1362	(16.7)	864	(19.9)	
PCI Risk					
Non-High	4853	(59.5)	2202	(50.8)	<.001
High	2058	(25.2)	1342	(31.0)	

Missing	1243	(15.2)	788	(18.2)	
Number of Target Vessels					
One	5515	(67.6)	2807	(64.8)	0.001
Two or More	2639	(32.4)	1525	(35.2)	
Number of Stents					
One	5339	(65.5)	2659	(61.4)	<.001
Two	1924	(23.6)	1140	(26.3)	
Three or More	891	(10.9)	533	(12.3)	
Bifurcation					
No	7552	(92.6)	4100	(94.6)	<.001
Yes	602	(7.4)	232	(5.4)	
Pre-Procedure Stenosis (%)	85	(80.0-90.0)	90	(80.0-95.0)	<.001
Post-Procedure Stenosis (%)	0	(0.0-0.0)	0	(0.0-0.0)	0.20
Lesion Length					
≤ 20 mm	4922	(60.4)	2554	(59.0)	0.19
> 20 mm	1085	(13.3)	573	(13.2)	
Missing	2147	(26.3)	1205	(27.8)	
Total Stent Length					
≤30 mm	5503	(67.5)	2773	(64.0)	<.001
>30 mm	2183	(26.8)	1341	(31.0)	
Missing	468	(5.7)	218	(5.0)	
Largest Stent Diameter					
≤ 3 mm	5139	(63.0)	2623	(60.6)	0.002
> 3 mm	2672	(32.8)	1549	(35.8)	
Missing	343	(4.2)	160	(3.7)	
Pre-PCI TIMI Flow					
3	6052	(74.2)	2988	(69.0)	<.001
<3	1648	(20.2)	924	(21.3)	
Missing	454	(5.6)	420	(9.7)	
Final TIMI Flow					
3	7580	(93.0)	3864	(89.2)	<.001
<3	114	(1.4)	47	(1.1)	
Missing	460	(5.6)	421	(9.7)	

Dissection					
No	2059	(96.0)	976	(93.8)	0.01
Yes	86	(4.0)	65	(6.2)	
Chronic Total Occlusion					
No	2010	(88.4)	960	(90.4)	0.09
Yes	263	(11.6)	102	(9.6)	
Intravascular Ultrasound					
No	7343	(90.1)	4033	(93.1)	<.001
Yes	811	(10.0)	299	(6.9)	
Anticoagulant					
Heparin	3128	(54.8)	1774	(56.2)	0.20
Bivalirudin	2116	(37.1)	1086	(34.4)	0.01
Low Molecular Weight Heparin	142	(2.5)	95	(3.0)	0.14
Access Site					
Femoral	7593	(93.1)	3945	(91.1)	<.001
Radial	363	(4.5)	230	(5.3)	
Brachial	52	(0.6)	54	(1.3)	
Other	3	(0.0)	6	(0.1)	
Missing	143	(1.8)	97	(2.2)	
Time to Surgery, days					
<6 weeks	407	(5.0)	265	(6.1)	0.01
6 weeks to <6 months	1573	(19.3)	887	(20.5)	
6 to < 12 months	1986	(24.4)	1064	(24.6)	
12 to 24 months	4185	(51.3)	2116	(48.9)	

* 337 procedures (2.7%) had both a DES and a non-DES coded for the PCI. These are included in both the DES and BMS stratified tables.

Table 3. Angiographic Characteristics of Patients with Incomplete Revascularization.

	Overall	
	N	**(%)**
Number of Vessels, median (Q1, Q3)	1	(1, 2)
Vessel with Incomplete Revascularization		
RCA, n (%)		
No	10235	(82.0)
Yes	2251	(18.0)
LAD, n (%)		
No	10248	(82.1)
Yes	2238	(17.9)
Circumflex, n (%)		
No	11075	(88.7)
Yes	1411	(11.3)
PDA, n (%)		
No	12116	(97.0)
Yes	370	(3.0)
Other, n (%)		
No	11716	(93.8)
Yes	770	(6.2)

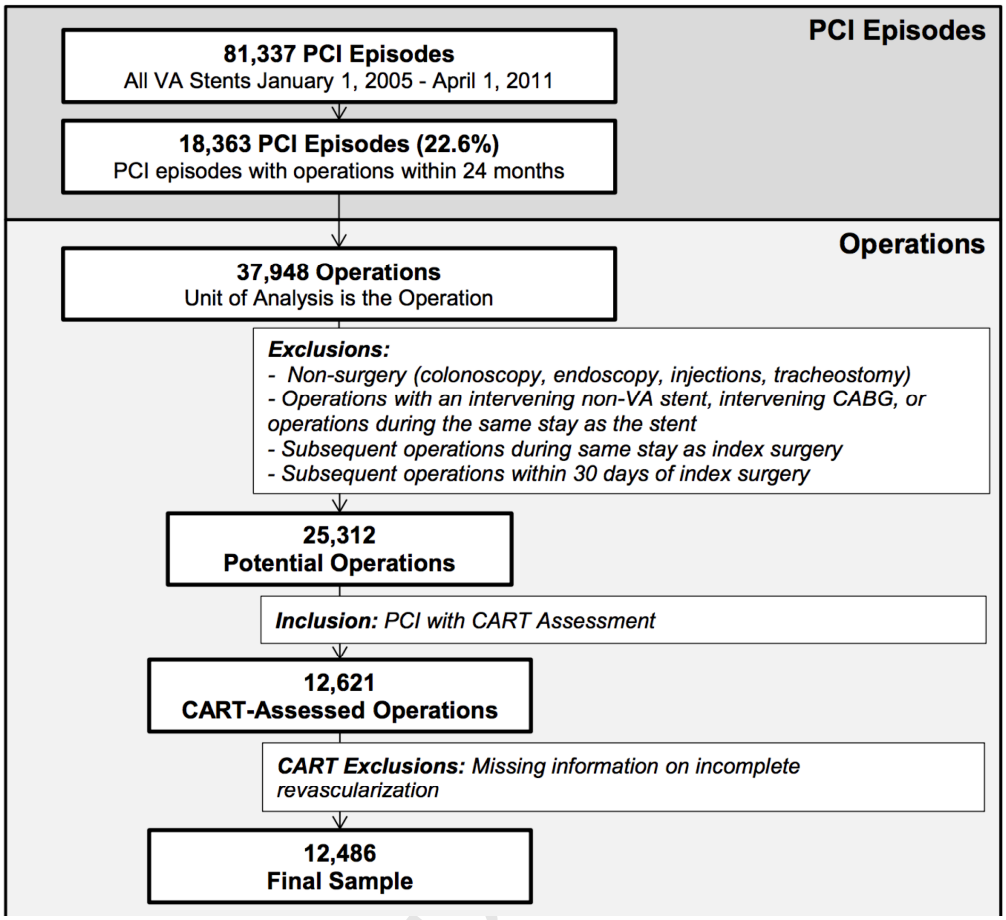
Table 4. Thirty-day Outcomes.

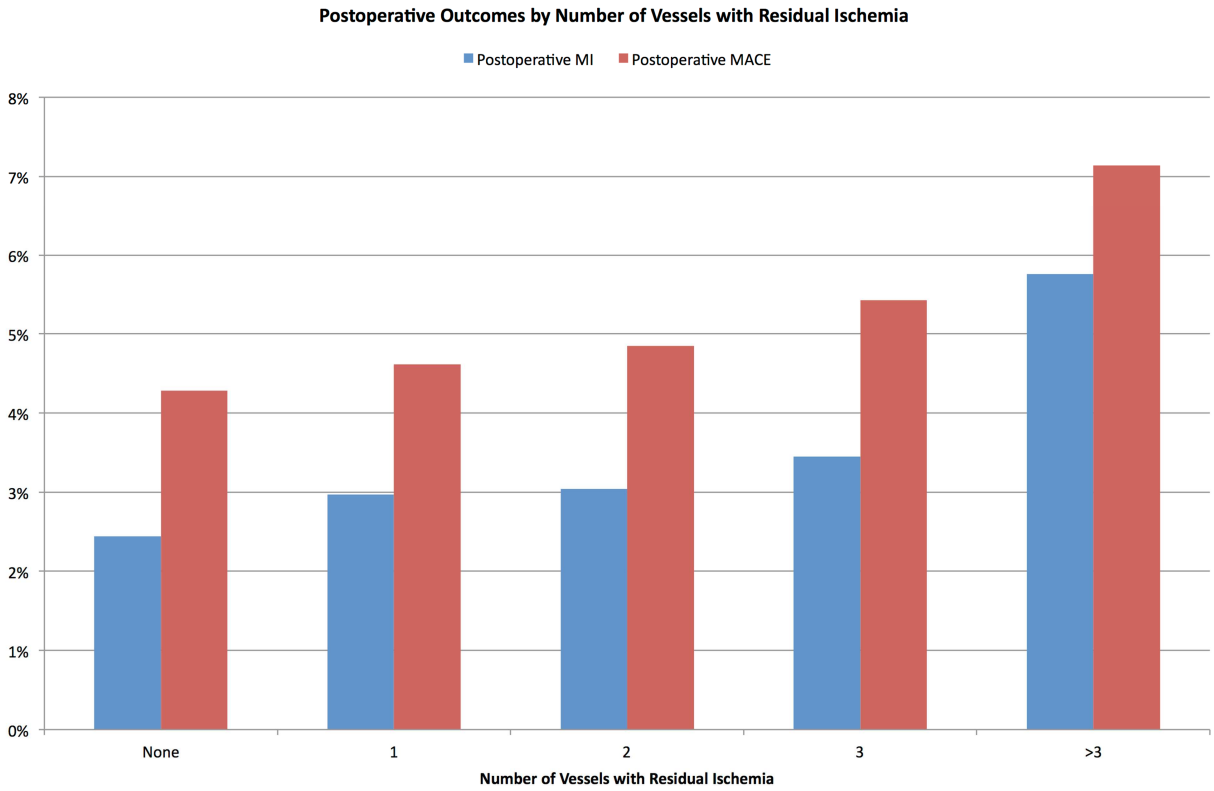
	Complete Revascularization		Incomplete Revascularization				
	N	(%)	N	(%)	OR	(95% CI)	p-value
MACE	349	(4.3)	218	(5.0)	1.19	(1.00-1.41)	0.05
MI	200	(2.5)	144	(3.3)	1.37	(1.10-1.70)	0.01
Revascularization	83	(1.0)	46	(1.1)	1.04	(0.73-1.50)	0.82
Death	111	(1.4)	68	(1.6)	1.16	(0.85-1.57)	0.35

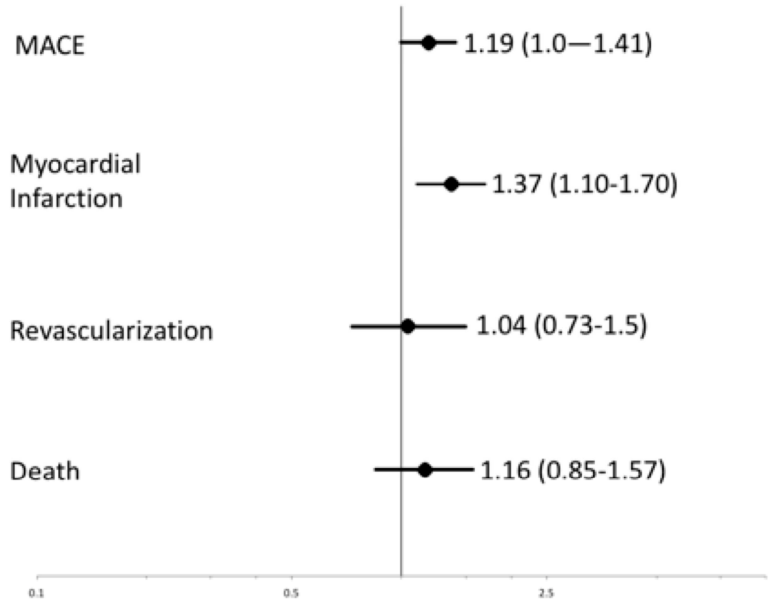
Table 5. Odds of Postoperative Outcomes for Patients with Incomplete Revascularization as Compared to those with Complete Revascularization.

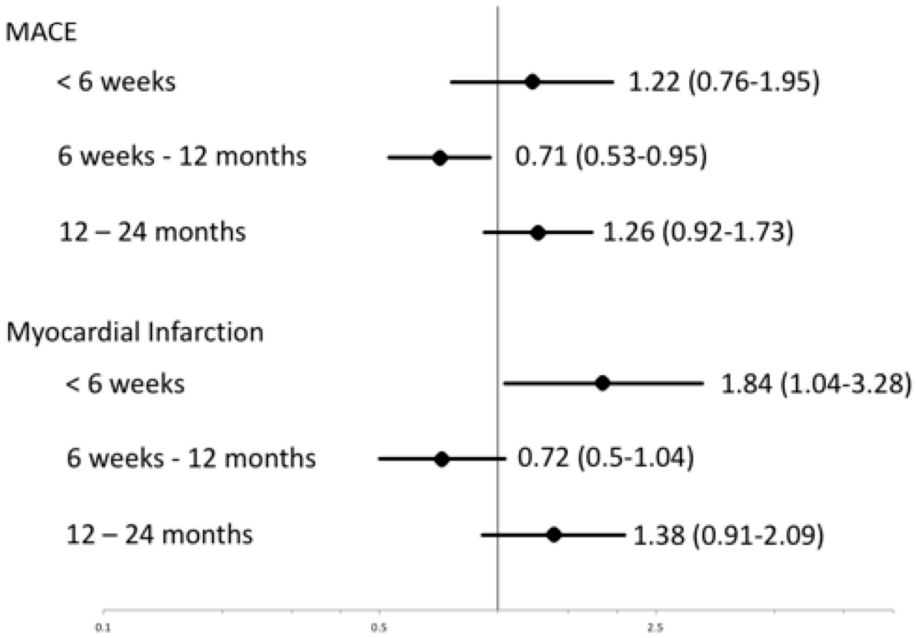
	Postoperative MI		**Postoperative MACE**	
	Unadjusted OR (95% CI)	**Adjusted* OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted* OR (95% CI)**
<6 weeks	**1.79 (1.07-2.99)**	**1.84 (1.04-3.28)**	1.26 (0.84-1.91)	1.22 (0.76-1.95)
6 weeks to < 12 month	1.00 (0.71-1.40)	0.72 (0.50-1.04)	0.90 (0.69-1.19)	**0.71 (0.53-0.95)**
12 to 24 months	**1.60 (1.12-2.28)**	1.38 (0.91-2.09)	**1.42 (1.08-1.89)**	1.26 (0.92-1.73)

* Adjusted for Recent MI Age, CRI, Procedure Specialty, LAD treated, PCI Risk


PCI Episodes
81,337 PCI Episodes
All VA Stents January 1, 2005 - April 1, 2011
18,363 PCI Episodes (22.6%)
PCI episodes with operations within 24 months
Operations
37,948 Operations
Unit of Analysis is the Operation
Exclusions:
- Non-surgery (colonoscopy, endoscopy, injections, tracheostomy)
- Operations with an intervening non-VA stent, intervening CABG, or operations during the same stay as the stent
- Subsequent operations during same stay as index surgery
- Subsequent operations within 30 days of index surgery
25,312
Potential Operations
Inclusion: PCI with CART Assessment
12,621
CART-Assessed Operations
CART Exclusions: Missing information on incomplete revascularization
12,486
Final Sample




MACE
1.19 (1.0—1.41)
Myocardial Infarction
1.37 (1.10-1.70)
Revascularization
1.04 (0.73-1.5)
Death
1.16 (0.85-1.57)
0.1
0.5
2.5


MACE
< 6 weeks
1.22 (0.76-1.95)
6 weeks - 12 months
0.71 (0.53-0.95)
12 – 24 months
1.26 (0.92-1.73)
Myocardial Infarction
< 6 weeks
1.84 (1.04-3.28)
6 weeks - 12 months
0.72 (0.5-1.04)
12 – 24 months
1.38 (0.91-2.09)
0.1
0.5
2.5