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CLINICAL RESEARCH

CORONARY

Percutaneous Coronary Intervention in Native Coronary Arteries Versus Bypass Grafts in Patients With Prior Coronary Artery Bypass Graft Surgery

Insights From the Veterans Affairs Clinical Assessment, Reporting, and Tracking Program

Emmanouil S. Brilakis, MD, PhD,[a] Colin I. O'Donnell, MS,[b,c,d] William Penny, MD,[e] Ehrin J. Armstrong, MD, PhD,[b,c,d] Thomas Tsai, MD, MSc,[b,c,d] Thomas M. Maddox, MD, MSc,[b,c,d] Mary E. Plomondon, PhD,[b,c,d] Subhash Banerjee, MD,[a] Sunil V. Rao, MD,[f] Santiago Garcia, MD,[g] Brahmajee Nallamothu, MD,[h] Kendrick A. Shunk, MD, PhD,[i] Kreton Mavromatis, MD,[j] Gary K. Grunwald, PhD,[b,c,d] Deepak L. Bhatt, MD, MPH[k]

ABSTRACT

OBJECTIVES The aim of this study was to examine the frequency, associations, and outcomes of native coronary artery versus bypass graft percutaneous coronary intervention (PCI) in patients with prior coronary artery bypass grafting (CABG) in the Veterans Affairs (VA) integrated health care system.

BACKGROUND Patients with prior CABG surgery often undergo PCI, but the association between PCI target vessel and short- and long-term outcomes has received limited study.

METHODS A national cohort of 11,118 veterans with prior CABG who underwent PCI between October 2005 and September 2013 at 67 VA hospitals was examined, and the outcomes of patients who underwent native coronary versus bypass graft PCI were compared. Logistic regression with generalized estimating equations was used to adjust for correlation between patients within hospitals. Cox regressions were modeled for each outcome to determine the variables with significant hazard ratios (HRs).

RESULTS During the study period, patients with prior CABG represented 18.5% of all patients undergoing PCI (11,118 of 60,171). The PCI target vessel was a native coronary artery in 73.4% and a bypass graft in 26.6%: 25.0% in a saphenous vein graft and 1.5% in an arterial graft. Compared with patients undergoing native coronary artery PCI, those undergoing bypass graft PCI had higher risk characteristics and more procedure-related complications. During a median follow-up period of 3.11 years, bypass graft PCI was associated with significantly higher mortality (adjusted HR: 1.30; 95% confidence interval: 1.18 to 1.42), myocardial infarction (adjusted HR: 1.61; 95% confidence interval: 1.43 to 1.82), and repeat revascularization (adjusted HR: 1.60; 95% confidence interval: 1.50 to 1.71).

CONCLUSIONS In a national cohort of veterans, almost three-quarters of PCIs performed in patients with prior CABG involved native coronary artery lesions. Compared with native coronary PCI, bypass graft PCI was significantly associated with higher incidence of short- and long-term major adverse events, including more than double the rate of in-hospital mortality. (J Am Coll Cardiol Intv 2016;9:884–93) © 2016 by the American College of Cardiology Foundation.

It is widely believed that native coronary arteries should be the preferred target of percutaneous coronary intervention (PCI) in patients with prior coronary artery bypass graft (CABG) surgery, if technically feasible, because native coronary artery PCI appears to be associated with better short-and long-term outcomes compared with bypass graft PCI. However, there are limited data to substantiate this belief (1-6).

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We previously reported that patients with prior CABG undergoing PCI between 2004 and 2009 in the National Cardiovascular Data Registry (NCDR) CathPCI Registry represented 17.5% of the total PCI volume (300,902 of 1,721,046) during that period (7). The PCI target was a native coronary artery in 62.5% and a bypass graft in 37.5%: saphenous vein graft (SVG) (104,678 [34.9%]), arterial graft (7,517 [2.5%]), or both arterial graft and SVG (718 [0.2%]). Compared with patients undergoing native coronary artery PCI, those undergoing bypass graft PCI had higher risk characteristics and more procedural complications (7). However, clinical practice has evolved since, and prior analyses were limited to periprocedural and in-hospital outcomes, which are known to be worse in patients who undergo bypass graft interventions. The impact of target vessel on long-term outcomes has received limited study (3,4,6).

The goals of the present study were to: 1) determine the frequency of prior CABG among veterans undergoing PCI in the Veterans Affairs (VA) system; 2) examine the target vessel (native coronary artery vs. SVG vs. arterial graft) in those patients; and 3) compare the immediate post-procedural and long-term outcomes after PCI in native coronary arteries versus coronary bypass grafts.

ABBREVIATIONS AND ACRONYMS

CABG = coronary artery bypass graft

CART = Clinical Assessment, Reporting, and Tracking

CI = confidence interval

DES = drug-eluting stent(s)

MI = myocardial infarction

NCDR = National Cardiovascular Data Registry

OR = odds ratio

PCI = percutaneous coronary intervention

SVG = saphenous vein graft

VA = Veterans Affairs

METHODS

STUDY DESIGN, SETTING, AND POPULATION. We performed a retrospective study of a national cohort of post-CABG veterans who underwent PCI at 67 VA PCI centers from October 1, 2005, through September 30, 2013. For patients who underwent multiple procedures during the study period, the first PCI was defined as the index procedure, and outcomes were assessed through September 30, 2014.

DATA SOURCE. The VA Clinical Assessment, Reporting, and Tracking (CART) program is a national clinical quality improvement program among VA

From the [a]VA North Texas Healthcare System and University of Texas Southwestern Medical Center, Dallas, Texas; [b]VA Eastern Colorado Health Care System, Denver, Colorado; [c]University of Colorado, Denver Anschutz Medical Campus, Aurora, Colorado; [d]Colorado Cardiovascular Outcomes Research Consortium, Denver, Colorado; [e]San Diego VA Healthcare System, San Diego, California; [f]Durham VA Medical Center and Duke University, Durham, North Carolina; [g]Minneapolis VA Healthcare System and University of Minnesota, Minneapolis, Minnesota; [h]University of Michigan, Ann Arbor, Michigan; [i]San Francisco VA Medical Center and University of California, San Francisco, San Francisco, California; [j]Atlanta VA Medical Center and Emory University, Atlanta, Georgia; and the [k]VA Boston Healthcare System, Brigham and Women's Hospital, and Harvard Medical School, Boston, Massachusetts. Dr. Brilakis has received consulting and speaking honoraria from Abbott Vascular, Asahi, Boston Scientific, Elsevier, Somahlution, St. Jude Medical, and Terumo; and has received research support from InfraRedx and Boston Scientific; and his spouse is an employee of Medtronic. Dr. Garcia is a recipient of a career development award (1IK2CX000699-01) from the VA Office of Research and Development. Dr. Garcia is a consultant for Surmodics. Dr. Rao is a consultant for Medtronic. Dr. Armstrong is a consultant for Abbott Vascular, Medtronic, Merck, and Spectranetics. Dr. Bhatt is a member of the advisory boards of Cardax, Elsevier Practice Update Cardiology, Medscape Cardiology, and Regado Biosciences; is a member of the boards of directors of the Boston VA Research Institute, the Society of Cardiovascular Patient Care; is chair of the American Heart Association Get With the Guidelines Steering Committee; is a member of the data monitoring committees of the Duke Clinical Research Institute, the Harvard Clinical Research Institute, the Mayo Clinic, and the Population Health Research Institute; has received honoraria from the American College of Cardiology (senior associate editor, *Clinical Trials and News*, ACC.org), Belvoir Publications (editor-in-chief, *Harvard Heart Letter*), the Duke Clinical Research Institute (clinical trial steering committees), the Harvard Clinical Research Institute (clinical trial steering committee), HMP Communications (editor-in-chief, *Journal of Invasive Cardiology*), the *Journal of the American College of Cardiology* (guest editor, associate editor), the Population Health Research Institute (clinical trial steering committee), Slack Publications (chief medical editor, *Cardiology Today's Intervention*), WebMD (continuing medical education steering committees); is deputy editor of *Clinical Cardiology*; has received research funding from Amarin, AstraZeneca, Bristol-Myers Squibb, Eisai, Ethicon, Forest Laboratories, Ischemix, Medtronic, Pfizer, Roche, Sanofi, and The Medicines Company; is a site co-investigator for Biotronik and St. Jude Medical; is a trustee of the American College of Cardiology; and has conducted unfunded research for FlowCo, PLx Pharma, and Takeda. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose. The views expressed in this paper are those of the authors and do not necessarily reflect the position or policy of the U.S. Department of Veterans Affairs or the U.S. government.

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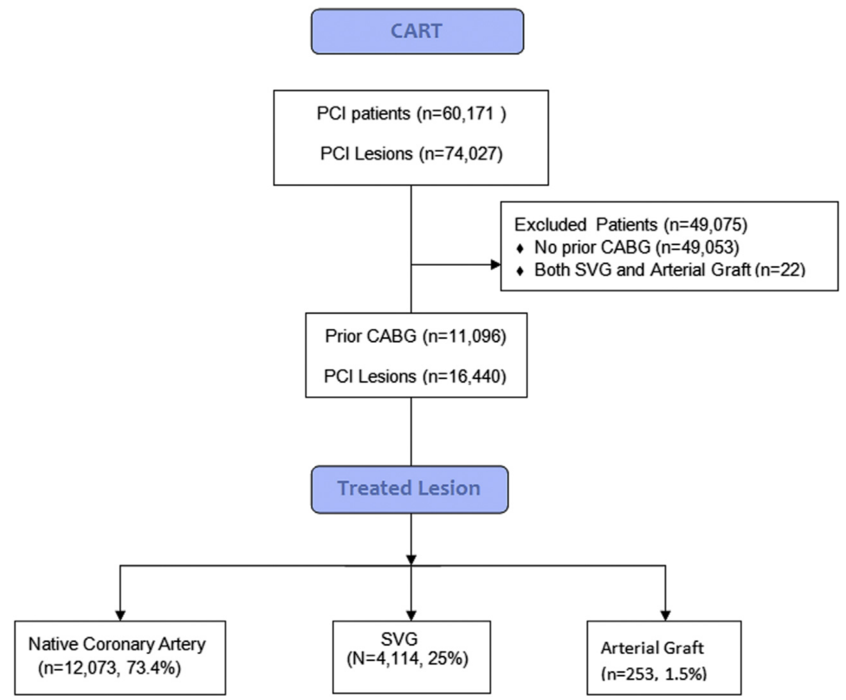
FIGURE 1 Outline of Patient and Lesion Selection for the Present Study



CABG = coronary artery bypass grafting; CART = Clinical Assessment, Reporting, and Tracking; PCI = percutaneous coronary intervention; SVG = saphenous vein graft.

catheterization laboratories (8). It uses a software application for medical record documentation of key patient and procedural data for all procedures conducted at the VA catheterization laboratories nationwide. The software is embedded within the VA electronic health record, allowing linkage to longitudinal outcome data. Moreover, it is also linked to fee-based data to account for veterans who receive non-VA care. CART data elements are standardized according to the American College of Cardiology's NCDR CathPCI Registry (9). A dedicated staff provides continuous monitoring, maintenance, and updating of the application. Quality checks of CART data are periodically conducted for completeness and accuracy. Additional details of CART and the validity, completeness, and timeliness of the CART data have been previously described (10).

TABLE 1 Number of Patients Within Time Intervals Where Date of Coronary Artery Bypass Graft Surgery Was Known, Classified According to Type of Vessel Treated

	0-1 yr Post-CABG	1-5 yrs Post-CABG	5-10 yrs Post-CABG	>10 yrs Post-CABG
Total patient count	392 (100%)	1,365 (100%)	962 (100%)	1,385 (100%)
Native coronary artery PCI	266 (67.9%)	892 (65.3%)	611 (63.5%)	834 (60.2%)
Bypass graft PCI	126 (32.1%)	473 (34.7%)	351 (36.5%)	551 (39.8%)

Values are n (%). The date of prior CABG was available for 4,104 patients (37.0% of the cohort).
CABG = coronary artery bypass graft surgery; PCI = percutaneous coronary intervention.

EXPOSURE VARIABLE. The primary exposure variable of interest was the PCI target vessel during index PCI. Patients were divided between those undergoing native coronary artery versus bypass graft PCI. Patients undergoing PCI of both a native coronary artery and a bypass graft were considered to be part of the bypass graft PCI group. First-generation drug-eluting stents (DES) were defined as paclitaxel-eluting or sirolimus-eluting stents, and second-generation DES were defined as everolimus-eluting or zotarolimus-eluting stents.

OUTCOME ASSESSMENT. Outcomes assessed included both short-term (procedure-related in-laboratory complications) and long-term (mortality, myocardial infarction [MI], revascularization) outcomes:

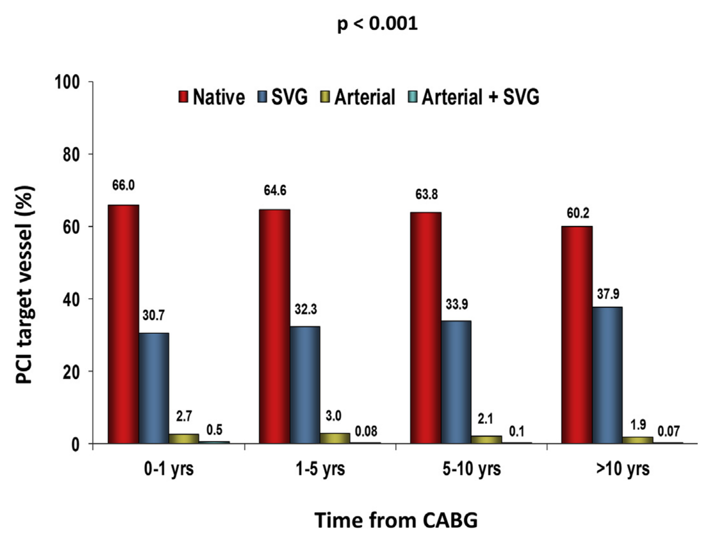
1. Procedure-related in-laboratory complications: We assessed the incidence of death, periprocedural

MI, no-reflow, dissection, perforation, and acute target vessel closure. The treating physician directly entered this information into CART as a discrete data elements (10).

2. MI: We used the VA national patient care database to assess the occurrence and timing of MI hospitalizations that were on the basis of validated inpatient primary International Classification of Diseases, Ninth Revision, discharge diagnosis codes (10). A random sample of patients with MI also underwent individual chart review to validate this outcome in accordance with the third universal definition of MI (11). Codes for MI hospitalizations during the first 14 days after PCI discharge date were subsequently disregarded because a review of cases showed that most of these codes were related to the index hospitalization.
3. All-cause mortality: The VA vital status file was used to assess mortality outcome. This file has 98.3% sensitivity and 97.6% exact agreement with dates compared with the National Death Index (12).
4. Repeat revascularization: The VA national database was queried for cases of revascularization. Revascularization was defined by the identification of repeat PCI (from CART data or administrative procedure codes) or CABG (from administrative procedure codes) in the data following the index PCI (or final visit of a staged set of PCIs) that was used in the analysis.

STATISTICAL ANALYSIS. Comparison of baseline characteristics and in-laboratory complications between the native coronary and bypass graft PCI groups was performed using Fisher exact tests for each categorical or dichotomous variable and Mann-Whitney-Wilcoxon nonparametric tests for continuous variables. Generalized estimating equation logistic regression was used to examine parameters associated with performing native coronary PCI. Cox regression models with stent type and target vessel type as predictors and a random-effects term for hospital (frailty) were used to estimate hazard ratios for variables of interest that may affect outcomes. Adjustment was performed for 48 covariates, including baseline patient characteristics and pharmacology regimens (Online Table 1). Log-minus-log plots of survival, ln[−ln(S)], were produced to evaluate the proportional hazards assumption between treated vessel type. We used the product-limit method to determine Kaplan-Meier curves for event-free survival and compared the 2 groups using the log-rank test.

FIGURE 2 Comparison of the Percutaneous Coronary Intervention Target Vessel in Patients With Prior Coronary Artery Bypass Graft Surgery During Different Time Intervals From Coronary Artery Bypass Graft Surgery



CABG = coronary artery bypass grafting; PCI = percutaneous coronary intervention; SVG = saphenous vein graft.

For all analyses reported, p values are 2-sided, and p values <0.05 were considered to indicate statistical significance. All analyses were performed using SAS version 9.4 (SAS Institute, Cary, North Carolina). The Institutional Review Board at the VA Eastern Colorado Health Care System approved this study.

RESULTS

PATIENT POPULATION. During the study period, a total of 74,027 PCIs were performed in 60,171 patients nationwide in the VA health care system, of whom 11,118 (18.5%) were prior CABG patients (22 patients who underwent PCI to both a SVG and an arterial graft were excluded) (Figure 1). A total of 16,440 lesions were treated in patients with prior CABG and were located as follows: native coronary artery (n = 12,073 [73.4%]), SVG (n = 4,114 [25.0%]), and arterial graft (n = 253 [1.5%]). The proportion of PCIs performed on bypass grafts relative to native vessels increased as a function of time elapsed after CABG (Table 1, Figure 2).

BASELINE CHARACTERISTICS. The patient characteristics, procedural indications, and procedural outcomes are summarized in Table 2. The median age was 65.5 years (IQR: 61.0 to 73.3 years), 99% were men, and 84% were white. Compared with patients

TABLE 2 Comparison of Baseline Patient Characteristics of Patients With Prior Coronary Bypass Graft Surgery Undergoing Percutaneous Coronary Artery Intervention Classified According to the Treated Vessel

	Native Only (n = 7,469)	Bypass Grafts (n = 3,346)	p Value
Demographics			
Age (yrs)	65 (61–72)	67 (62–75)	<0.001
Men	99%	99%	0.03
White race	84%	85%	0.11
Comorbidities			
Hypertension	95%	96%	0.02
Hyperlipidemia	96%	96%	0.24
Diabetes mellitus	54%	58%	<0.001
Ever smoked	60%	56%	<0.001
Prior MI	50%	50%	0.626
Prior PCI	53%	47%	<0.001
Congestive heart failure	33%	35%	0.06
Cerebrovascular disease	11%	11%	1.00
Peripheral arterial disease	29%	32%	0.002
Chronic kidney disease	21%	24%	0.007
Dialysis	3%	3%	0.802
Chronic lung disease	26%	23%	0.001
Body mass index (kg/m^2)	30 (27–34)	30 (26–33)	0.011
Depression	36%	33%	0.004
Obstructive sleep apnea	22%	19%	0.002
Laboratory tests			
Total cholesterol (mg/dl)	155 (134–181)	156 (135–185)	0.042
LDL cholesterol (mg/dl)	85 (68–106)	85 (68–108)	0.253
HDL cholesterol (mg/dl)	36 (31–43)	36 (31–42)	<0.001
Glomerular filtration rate (ml/min/1.73 m^2)	71 (59–87)	69 (56–84)	<0.001
Presentation			
Symptoms			<0.001
Stable angina	36%	24%	<0.001
ACS: unstable angina	28%	28%	1.000
ACS: NSTEMI	16%	28%	<0.001
ACS: STEMI	3%	5%	<0.001
Other	5%	5%	0.221
Years from CABG to PCI	2.17 (0.81–4.24)	2.29 (0.67–5.58)	0.091

Values are median (interquartile range) or %.

ACS = acute coronary syndrome(s); HDL = high-density lipoprotein; LDL = low-density lipoprotein; MI = myocardial infarction; NSTEMI = non-ST-segment elevation acute myocardial infarction; STEMI = ST-segment elevation acute myocardial infarction; other abbreviations as in Table 1.

who underwent native coronary artery PCI, those who underwent bypass graft PCI were older, more likely to have diabetes mellitus and chronic kidney disease, and more likely to have depression and obstructive sleep apnea. High-density lipoprotein cholesterol was low (median <40 mg/dl) in all patient groups. Patients who underwent native coronary artery PCI were more likely to present with stable angina and less likely to present with acute coronary syndromes.

On multivariate logistic generalized estimating equation analysis several other parameters were

TABLE 3 Comparison of Lesion Characteristics, Treatments, and Immediate Procedural Outcomes in Patients With Prior Coronary Bypass Graft Surgery Undergoing Percutaneous Coronary Artery Intervention Classified According to the Type of Vessel That Was Treated

	Native Only (n = 9,635)	Bypass Grafts (n = 4,259)	p Value
Femoral access	8,708 (90%)	3,916 (92%)	0.003
Target native vessel			
LAD/diagonal	2,267 (24%)	858 (20%)	<0.001
Circumflex	3,507 (36%)	1,539 (36%)	0.774
Right coronary artery	2,941 (31%)	1,227 (29%)	0.043
Left main	796 (8%)	0 (0%)	<0.001
Other	97 (1%)	128 (3%)	<0.001
Unknown	27 (<0.01%)	507 (12%)	<0.001
Lesion characteristics			
Chronic total occlusion	4.50%	1.93%	<0.001
Stent thrombosis	0.51%	0.71%	0.112
Restenotic lesion	9.1%	8.7%	0.512
Lesion location			
Aortic anastomosis	–	18%	
Body	–	54%	
Distal anastomosis	–	13%	
Unknown	–	15%	
Lesion length (mm)	14 (10–20)	13 (10–20)	0.941
Treatment			
Unfractionated heparin	33%	35%	0.111
Enoxaparin	1.7%	1.5%	0.522
Bivalirudin	30%	28%	0.052
Glycoprotein IIb/IIIa inhibitor	21%	19%	0.01
Multivessel PCI	12%	11%	0.378
Intra-aortic balloon pump	0.90%	1.61%	<0.001
Number of stents implanted	1 (1–1)	1 (1–1)	<0.001
Drug-eluting stents	77.2%	65.3%	<0.001
First-generation DES	32.9%	33.6%	0.49
Second-generation DES	60.4%	56.4%	<0.001
Pre-procedural TIMI flow grade			<0.001
3	78.2%	68.2%	
2	12.3%	18.3%	
1	3.9%	5.9%	
0	5.7%	7.6%	
Post-procedural TIMI flow grade			<0.001
3	97.0%	95.2%	
2	1.1%	2.0%	
1	0.4%	1.0%	
0	1.5%	1.8%	
Fluoroscopy time (min)	19.1 (12.0–29.9)	22.0 (14.4–31.4)	<0.001
Contrast use (ml)	200 (130–275)	200 (125–275)	0.67

Values are n (%), %, or median (interquartile range).

DES = drug-eluting stent(s); LAD = left anterior descending; PCI = percutaneous coronary intervention; TIMI = Thrombolysis In Myocardial Infarction.

associated with bypass graft PCI (odds ratio [OR] >1 is more likely to receive graft bypass PCI), including right coronary artery stenosis >70% (OR: 0.09; 95% confidence interval [CI]: 0.07 to 0.13), left main stenosis >50% (OR: 0.07; 95% CI: 0.04 to 0.12), pre-PCI TIMI (Thrombolysis In Myocardial Infarction) grade 3 flow (OR: 0.77; 95% CI: 0.65 to 0.90), high-risk lesion (OR: 2.11; 95% CI: 1.74 to 2.55), diabetes (OR: 1.14; 95% CI: 1.03 to 1.26), presentation with ST-segment elevation acute MI (OR: 1.62; 95% CI: 1.24 to 2.11), and glomerular filtration rate (OR: 0.98; 95% CI: 0.97 to 0.99 per 5-U increase).

PROCEDURAL CHARACTERISTICS. Table 3 describes baseline procedural characteristics in the 2 study groups. Compared with patients who underwent bypass graft PCI, those who underwent native coronary artery PCI were more likely to undergo PCI of a chronic total occlusion, to have TIMI flow grade 3 both before and after PCI, and to receive glycoprotein IIb/IIIa inhibitors but less likely to receive an intra-aortic balloon pump. Most bypass graft target lesions were located at the body of the graft. An embolic protection device was used in 26.3% of SVG PCIs. Most patients (77.8%) received at least 1 DES, whereas 19.6% received at least 1 bare-metal stent. Bypass graft PCI patients were less likely to receive DES relative to native vessel PCI patients (65% vs. 72%; $p < 0.01$).

CLINICAL OUTCOMES. Procedure-related in-laboratory complications. All reported procedure-related in-laboratory complications are presented in Table 4. Patients undergoing bypass graft PCI had higher in-hospital mortality (1.79% vs. 0.83%; adjusted OR: 6.6; 95% CI: 0.6 to 7.0) and higher risk for no reflow (3.37% vs. 0.40%; adjusted OR: 7.0; 95% CI: 4.8 to 10.3), periprocedural MI (1.00% vs. 0.43%; adjusted OR: 2.3; 95% CI: 1.1 to 4.7), and cardiogenic shock (0.36% vs. 0.13%, adjusted OR: 2.1; 95% CI: 0.6 to 7.0), though lower risk for coronary dissection (0.94% vs. 2.08%; adjusted OR: 0.4; 95% CI: 0.3 to 0.7).

FOLLOW-UP OUTCOMES. Outcomes, including the composite outcomes (death, MI, and revascularization), occurred in fewer than 50% of patients during the follow-up period. The median follow-up duration was 3.11 years. During the first year post-PCI, the overall incidence rates of death, MI, and coronary revascularization were 6.7%, 4.3%, and 22.8%, respectively, increasing to 14.4%, 8.6%, and 31.3%, respectively, at 3 years and to 19.4%, 10.2%, and 33.7% at 5 years (Table 5, Figure 3). The incidence of adverse events was higher during the early post-PCI period and subsequently decreased (Figure 3).

TABLE 4 Procedure-Related Complications in Patients With Prior Coronary Bypass Graft Surgery Undergoing Percutaneous Coronary Artery Intervention Classified According to the Type of Vessel That Was Treated

Outcome	Native Only (n = 7,469)	SVGs (n = 3,346)	p Value	Adjusted Odds Ratio (95% CI)	p Value
In-hospital mortality	0.83%	1.79%	<0.001	6.6 (0.7-60.0)	0.094
Procedural complications	5.80%	7.7%	<0.001	1.5 (1.2-1.9)	0.001
Dysrhythmia	0.68%	0.77%	0.633	1.5 (0.8-2.8)	0.241
Periprocedural MI	0.43%	1.00%	0.001	2.3 (1.1-4.7)	0.024
Cardiogenic shock	0.13%	0.36%	0.013	2.1 (0.6-7.0)	0.219
Stroke	0.00%	0.06%	0.098	Not estimable	
No-reflow	0.40%	3.37%	<0.0001	7.0 (4.8-10.0)	0.0001
Dissection	2.08%	0.94%	<0.0001	0.4 (0.3-0.7)	0.0001
Perforation	0.20%	0.30%	0.302	1.1 (0.5-2.2)	0.822
Acute closure	0.44%	0.36%	0.640	0.8 (0.4-1.6)	0.488
Successful reopening	0.25%	0.25%	1.000	1.1 (0.5-2.6)	0.760
Bleeding	0.49%	0.44%	0.773	0.6 (0.2-1.8)	0.406
Other complications	4.11%	5.23%	0.009	1.5 (1.2-2.0)	0.003

CI = confidence interval; MI = myocardial infarction; SVG = saphenous vein graft.

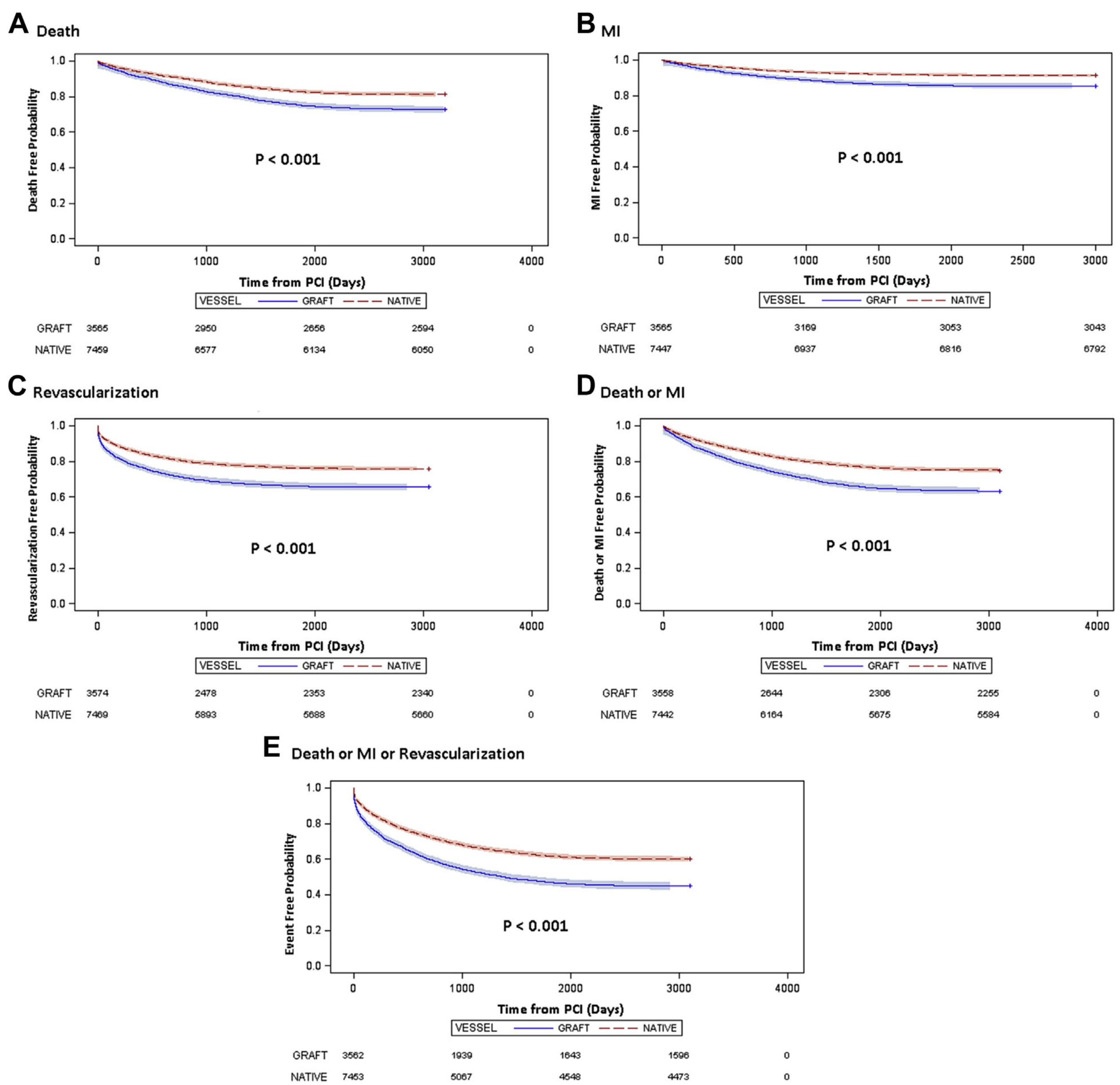
On Cox regression analysis, patients who underwent bypass graft PCI had a significantly higher incidence of post-hospital discharge death (adjusted hazard ratio: 1.30; 95% CI: 1.18 to 1.42), MI (adjusted

TABLE 5 Long-Term Clinical Outcomes of Patients With Prior Coronary Bypass Graft Surgery Who Underwent Percutaneous Coronary Artery Intervention Classified According to the Type of Vessel That Was Treated

	Native Only (n = 7,930)	Bypass Graft (n = 3,616)	p Value
Death			
1-yr	439 (5.85)	306 (8.57)	<0.001
3-yr	954 (12.71)	644 (18.03)	<0.001
5-yr	1,280 (17.05)	871 (24.39)	<0.001
MI			
1-yr	270 (3.6)	211 (5.91)	<0.001
3-yr	536 (7.15)	418 (11.71)	<0.001
5-yr	622 (8.3)	504 (14.11)	<0.001
Revascularization			
1-yr	1,082 (14.4)	813 (22.7)	<0.001
3-yr	1,596 (21.24)	1,121 (31.3)	<0.001
5-yr	1,747 (23.25)	1,207 (33.71)	<0.001
Death or MI			
1-yr	667 (8.91)	479 (13.44)	<0.001
3-yr	1,369 (18.28)	956 (26.83)	<0.001
5-yr	1,722 (22.99)	1,214 (34.07)	<0.001
Death or MI or revascularization			
1-yr	1,529 (20.39)	1,102 (30.89)	<0.001
3-yr	2,466 (32.88)	1,663 (46.62)	<0.001
5-yr	2,845 (37.93)	1,885 (52.85)	<0.001

Values are n (%).
MI = myocardial infarction.

FIGURE 3 **Long-Term Clinical Outcomes of Patients With Prior Coronary Artery Bypass Graft Who Underwent Percutaneous Coronary Intervention, Classified According to the Percutaneous Coronary Intervention Target Vessel (Native Coronary Artery vs. Bypass Graft)**



MI = myocardial infarction; PCI = percutaneous coronary intervention.

hazard ratio: 1.61; 95% CI: 1.43 to 1.82), and repeat revascularization (adjusted hazard ratio: 1.60; 95% CI: 1.50 to 1.71) (Table 5, Figure 3).

DISCUSSION

To the best of our knowledge, this is the largest study performed to date examining the long-term outcomes of patients with prior CABG who underwent bypass graft versus native coronary artery PCI. Bypass graft PCI was significantly less frequent than native coronary artery PCI, was performed in patients who had more comorbidities, and was independently associated with worse acute and long-term outcomes.

In our study, approximately 1 in 5 patients (18.5%) undergoing PCI between 2005 and 2013 within the VA system had prior CABG, which is similar to the proportion observed in the NCDR between 2004 and 2009 (17.5%) (7). There was a higher percentage of a native vessel as the PCI target in the present study compared with the NCDR (73.4% vs. 62.5%), but bypass grafts were more likely to be the PCI target vessel with increasing time after CABG in both cohorts, consistent with the accelerated pace of late SVG failure (13,14). Nearly all target bypass grafts were SVGs, a reflection of the excellent outcomes achieved with use of the internal mammary arteries as conduits (13).

In the present study, patients who underwent bypass graft rather than native coronary PCI were older, had more comorbidities, and were more likely to receive bare-metal stents, which may in part explain the worse clinical outcomes in this patient group. Although statistical adjustment may be imperfect in retrospective studies, our multivariate analyses confirmed that bypass graft (essentially SVG) PCI was significantly associated with worse outcomes. SVG lesions are often degenerated, complex lesions that may predispose to distal embolization. Indeed, SVG PCI was associated with higher risk for no-reflow and periprocedural MI in our study, even though embolic protection devices are used more commonly in the VA system (38%) (15) compared with general practice, as reported by the NCDR (22%) (16,17). Similar findings were reported in prior studies (3), including in patients with ST-segment elevation acute MI: in the APEX-AMI (Assessment of Pexelizumab in Acute Myocardial Infarction) trial in patients with prior CABG who presented with ST-segment elevation MI, TIMI flow grade 3 was achieved less often in bypass grafts (67% vs. 88%), and bypass graft PCI patients had higher 90-day mortality (19% vs. 5.7%) compared with native artery PCI patients (5).

Even with use of DES (14) (including second-generation DES) (18), repeat revascularization is higher after SVG compared with native coronary artery PCI (**Figure 3**), likely because of higher rates of inflammation and thrombus formation (19). Moreover, intermediate SVG lesions have high rates of progression and failure (20,21), leading to increased need for repeat revascularization (4). Rates of MI were also higher among patients undergoing SVG PCI in our study, which could reflect the increased likelihood of SVG stent failure to present as an acute coronary syndrome or as complete occlusion (22). Patients who underwent SVG PCI were less likely to receive DES, which could be due to safety concerns (higher mortality was observed with DES in the RRISC [Reduction of Restenosis in Saphenous vein grafts With Cypher sirolimus-Eluting Stent] trial [23] but not in subsequent studies [24,25]) and more comorbidities, potentially raising concerns about the feasibility of long-term dual-antiplatelet therapy in these patients.

Our study is the largest of its kind performed to date on long-term outcomes after PCI of native versus bypass graft PCI in patients with prior CABG. An NCDR analysis of 300,902 patients with prior CABG who underwent PCI between 2004 and 2009 showed that bypass graft PCI was associated with higher in-hospital mortality (adjusted OR: 1.22; 95% CI: 1.12 to 1.32) (7). Similar findings were observed by Bundhoo et al. (4), who demonstrated 3-fold higher target vessel revascularization with SVG versus native coronary PCI (15% vs. 4.9%; $p = 0.031$) and by Xanthopoulou et al. (6), although outcomes were similar in a study by Varghese et al. (3).

The improved short- and long-term outcomes observed suggest that native coronary arteries should be the preferred PCI target vessels for patients with prior CABG, whenever possible. Although it is not known if the advantage of native coronary PCI will be affected if the native lesions selected are of higher complexity than in this study, contemporary PCI equipment and techniques (26) have increased the rate of successful revascularization for complex lesions, such as chronic total occlusions (27,28). Use of femoral access may facilitate such procedures, compared with radial access (29).

STUDY LIMITATIONS. First, it was an observational retrospective study and not a prospective randomized-controlled trial and hence was subject to all the limitations of observational studies. Second, the choice of PCI target was at discretion of the operator, and the clinical characteristics of the 2 groups of patients were significantly different. Although multivariate analyses were performed, there remains a possibility that unmeasured confounders accounted for some of the variability in in-hospital outcomes after native coronary artery or bypass graft PCI. Third, there was no core laboratory assessment of patients' angiograms and composite assessments of the coronary anatomy. Fourth, most included patients were men, limiting extrapolation to women, although most patients with prior CABG are men. Women have smaller diameter coronary arteries and as a result could have higher restenosis and repeat revascularization rates. Fifth, some veterans may not have had all follow-up evaluations and procedures performed within the VA system, potentially leading to underestimation of their risk for subsequent events. Sixth, underreporting of embolic protection device use and of some complications might have occurred, although this would be unlikely for severe complications, such as perforation. Seventh, the use of embolic protection devices was relatively low (26.3%), yet it was higher than in the NCDR (21.2%) (30). Potential reasons for the low frequency of embolic protection use include cost, technical complexity, limited familiarity with use of those devices, inability to protect certain (such as distal anastomotic lesions) with currently available devices, and skepticism about their benefits, especially when other embolization prevention strategies, such as vasodilator administration and stent undersizing, are used (31).

CONCLUSIONS

Bypass graft PCI was significantly less frequent than native coronary artery PCI in patients with prior CABG, was performed in patients who had more comorbidities, and was associated with 30% higher mortality, 61% higher risk for MI, and 60% higher risk for repeat revascularization during long-term follow-up. Until randomized clinical trials are performed comparing PCI in bypass grafts with native target vessels, native coronary arteries remain the target vessel of choice, when they are amenable to PCI.

REPRINT REQUESTS AND CORRESPONDENCE: Dr. Emmanouil S. Brilakis, Dallas VA Medical Center (111A), 4500 South Lancaster Road, Dallas, Texas 75216. E-mail: emmanouil.brilakis@va.gov.

PERSPECTIVES

WHAT IS KNOWN? Patients with prior CABG surgery often undergo PCI. The association between the PCI target vessel (native coronary artery vs. bypass graft) and short- and long-term outcomes has received limited study.

WHAT IS NEW? In a large, multicenter, VA registry, almost three-quarters of PCIs performed in patients with prior CABG involved native coronary artery lesions. Compared with native coronary PCI, bypass graft PCI was significantly associated with a higher incidence of short- and long-term major adverse events.

WHAT IS NEXT? In the future, prospective randomized-controlled trials are needed to confirm that native coronary arteries are the target vessels of choice in patients with prior CABG. At present, given the better outcomes achieved with PCI of native coronary arteries, every effort should be undertaken to overcome obstacles to native coronary artery recanalization in patients with prior CABG, such as treatment of chronic total occlusions.

REFERENCES

1. Liu W, Liu YY, Mukku VK, Shi DM, Lu SZ, Zhou YJ. Long-term outcome of native artery versus bypass graft intervention in prior coronary artery bypass graft patients with ST-segment elevation myocardial infarction. Chin Med J (Engl) 2013;126:2281–5.

2. Garcia-Tejada J, Velazquez M, Hernandez F, et al. Percutaneous revascularization of grafts versus native coronary arteries in postcoronary artery bypass graft patients. Angiology 2009;60:60–6.

3. Varghese I, Samuel J, Banerjee S, Brilakis ES. Comparison of percutaneous coronary intervention in native coronary arteries vs. bypass grafts in patients with prior coronary artery bypass graft surgery. Cardiovasc Revasc Med 2009;10:103–9.

4. Bundhoo SS, Kalla M, Anantharaman R, et al. Outcomes following PCI in patients with previous CABG: a multi centre experience. Catheter Cardiovasc Interv 2011;78:169–76.

5. Welsh RC, Granger CB, Westerhout CM, et al. Prior coronary artery bypass graft patients with ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention. J Am Coll Cardiol Intv 2010;3:343–51.

6. Xanthopoulou I, Davlouros P, Tsigkas G, Panagiotou A, Hahalis G, Alexopoulos D. Long-term clinical outcome after percutaneous coronary intervention in grafts vs native vessels in patients with previous coronary artery bypass grafting. Can J Cardiol 2011;27:716–24.

7. Brilakis ES, Rao SV, Banerjee S, et al. Percutaneous coronary intervention in native arteries versus bypass grafts in prior coronary artery bypass grafting patients a report from the national cardiovascular data registry. J Am Coll Cardiol Intv 2011;4:844–50.

8. Maddox TM, Plomondon ME, Petrich M, et al. A national clinical quality program for Veterans Affairs catheterization laboratories (from the Veterans Affairs Clinical Assessment, Reporting, and Tracking program). Am J Cardiol 2014;114:1750–7.

9. Brindis RG, Fitzgerald S, Anderson HV, Shaw RE, Weintraub WS, Williams JF. The American College of Cardiology-National Cardiovascular Data Registry™ (ACC-NCDR™): building a national clinical data repository. J Am Coll Cardiol 2001;37:2240–5.

10. Byrd JB, Vigen R, Plomondon ME, et al. Data quality of an electronic health record tool to support VA cardiac catheterization laboratory quality improvement: the VA Clinical Assessment, Reporting, and Tracking System for Cath Labs (CART) program. Am Heart J 2013;165:434–40.

11. Thygesen K, Alpert JS, Jaffe AS, et al. Third universal definition of myocardial infarction. J Am Coll Cardiol 2012;60:1581–98.

12. Sohn MW, Arnold N, Maynard C, Hynes DM. Accuracy and completeness of mortality data in the Department of Veterans Affairs. Popul Health Metr 2006;4:2.

13. Goldman S, Zadina K, Moritz T, et al. Long-term patency of saphenous vein and left internal mammary artery grafts after coronary artery bypass surgery: results from a Department of Veterans Affairs Cooperative Study. J Am Coll Cardiol 2004;44:2149–56.

14. Brilakis ES, Lee M, Mehilli J, et al. Saphenous vein graft interventions. Curr Treat Options Cardiovasc Med 2014;16:301.

15. Aggarwal V, Stanislawski MA, Maddox TM, et al. Safety and effectiveness of drug-eluting versus bare-metal stents in saphenous vein bypass graft percutaneous coronary interventionsinsights from the Veterans Affairs CART program. J Am Coll Cardiol 2014;64:1825–36.

16. Brilakis ES, Wang TY, Rao SV, et al. Frequency and predictors of drug-eluting stent use in saphenous vein bypass graft percutaneous coronary interventions: a report from the American College of Cardiology National Cardiovascular Data CathPCI registry. J Am Coll Cardiol Intv 2010;3:1068–73.

17. Mehta SK, Frutkin AD, Milford-Beland S, et al. Utilization of distal embolic protection in saphenous vein graft interventions (an analysis of 19,546 patients in the American College of Cardiology-National Cardiovascular Data Registry). Am J Cardiol 2007;100:1114–8.

18. Pokala NR, Menon RV, Patel SM, et al. Long-term outcomes with first- vs. second-generation drug-eluting stents in saphenous vein graft lesions. Catheter Cardiovasc Interv 2015 May 29 [E-pub ahead of print].

19. Depre C, Havaux X, Wijns W. Pathology of restenosis in saphenous bypass grafts after long-term stent implantation. Am J Clin Pathol 1998; 110:378–84.

20. Abdel-Karim AR, Da Silva M, Lichtenwalter C, et al. Prevalence and outcomes of intermediate saphenous vein graft lesions: findings from the stenting of saphenous vein grafts randomized-controlled trial. Int J Cardiol 2013;168:2468–73.

21. Rodes-Cabau J, Bertrand OF, Larose E, et al. Comparison of plaque sealing with paclitaxel-eluting stents versus medical therapy for the treatment of moderate nonsignificant saphenous vein graft lesions. The Moderate Vein Graft Lesion Stenting With the Taxus Stent and Intravascular Ultrasound (VELETI) Pilot Trial. Circulation 2009; 120:1978–86.

22. Lichtenwalter C, de Lemos JA, Roesle M, et al. Clinical presentation and angiographic characteristics of saphenous vein graft failure after stenting: insights from the SOS (Stenting of Saphenous Vein Grafts) trial. J Am Coll Cardiol Intv 2009;2:855–60.

23. Vermeersch P, Agostoni P, Verheye S, et al. Increased late mortality after sirolimus-eluting stents versus bare-metal stents in diseased saphenous vein grafts: results from the randomized DELAYED RRISC trial. J Am Coll Cardiol 2007;50: 261–7.

24. Brilakis ES, Lichtenwalter C, de Lemos JA, et al. A randomized controlled trial of a paclitaxel-eluting stent versus a similar bare-metal stent in saphenous vein graft lesions the SOS (Stenting of Saphenous Vein Grafts) trial. J Am Coll Cardiol 2009;53:919–28.

25. Mehilli J, Pache J, Abdel-Wahab M, et al. Drug-eluting versus bare-metal stents in saphenous vein graft lesions (ISAR-CABG): a randomised controlled superiority trial. Lancet 2011;378:1071–8.

26. Brilakis ES, Banerjee S, Lombardi WL. Retrograde recanalization of native coronary artery chronic occlusions via acutely occluded vein grafts. Catheter Cardiovasc Interv 2010;75:109–13.

27. Christopoulos G, Menon RV, Karmpaliotis D, et al. Application of the “hybrid approach” to chronic total occlusions in patients with previous coronary artery bypass graft surgery (from a Contemporary Multicenter US registry). Am J Cardiol 2014;113:1990–4.

28. Michael TT, Karmpaliotis D, Brilakis ES, et al. Impact of prior coronary artery bypass graft surgery on chronic total occlusion revascularisation: insights from a multicentre US registry. Heart 2013;99:1515–8.

29. Michael TT, Alomar M, Papayannis A, et al. A randomized comparison of the transradial and transfemoral approaches for coronary artery bypass graft angiography and intervention: the RADIAL-CABG Trial (RADIAL Versus Femoral Access for Coronary Artery Bypass Graft Angiography and Intervention). J Am Coll Cardiol Intv 2013;6:1138–44.

30. Brennan JM, Al-Hejily W, Dai D, et al. Three-year outcomes associated with embolic protection in saphenous vein graft intervention: results in 49 325 senior patients in the Medicare-linked National Cardiovascular Data Registry CathPCI Registry. Circ Cardiovasc Interv 2015;8:e001403.

31. Mahmood A, Khair T, Abdel-Karim AR, et al. Contemporary approaches to saphenous vein graft interventions: a survey of 275 interventional cardiologists. Catheter Cardiovasc Interv 2012;79: 834–42.

KEY WORDS bypass graft, coronary bypass graft surgery, percutaneous coronary intervention

APPENDIX For a supplemental table, please see the online version of this article.