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Characteristics and Outcomes of Patients With History of CABG Undergoing Cardiac Catheterization Via the Radial Versus Femoral Approach

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ABSTRACT

OBJECTIVES The aims of this study were to examine rates of radial artery access in post-coronary artery bypass grafting (CABG) patients undergoing diagnostic catherization and/or percutaneous coronary intervention (PCI), whether operators with higher procedural volumes and higher percentage radial use were more likely to perform diagnostic catherization and/or PCI via the radial approach in post-CABG patients, and clinical and procedural outcomes in post-CABG patients who undergo diagnostic catherization and/or PCI via the radial or femoral approach.

BACKGROUND There are limited data comparing outcomes of patients with prior CABG undergoing transradial or transfemoral diagnostic catheterization and/or PCI.

METHODS Using the National Cardiovascular Data Registry CathPCI Registry, all diagnostic catheterizations and PCIs performed in patients with prior CABG from July 1, 2009, to March 31, 2018 (n = 1,279,058, 1,173 sites) were evaluated. Temporal trends in transradial access were examined, and mortality, bleeding, vascular complications, and procedural metrics were compared between transradial and transfemoral access.

RESULTS The rate of transradial access increased from 1.4% to 18.7% over the study period. Transradial access was associated with decreased mortality (adjusted odds ratio [OR]: 0.83; 95% confidence interval [CI]: 0.75 to 0.91), decreased bleeding (OR: 0.57; 95% CI: 0.51 to 0.63), decreased vascular complications (OR: 0.38; 95% CI: 0.30 to 0.47), increased PCI procedural success (OR: 1.11; 95% CI: 1.06 to 1.16; $p < 0.0001$), and significantly decreased contrast volume across all procedure types. Transradial access was associated with shorter fluoroscopy time for PCI-only procedures but longer fluoroscopy time for diagnostic procedures plus ad hoc PCI and diagnostic procedures only. Operators with a higher rate of transradial access in non-CABG patients were more likely to perform transradial access in patients with prior CABG.

CONCLUSIONS The rate of transradial artery access in patients with prior CABG undergoing diagnostic catheterization and/or PCI has increased over the past decade in the United States, and it was more often performed by operators using a transradial approach in non-CABG patients. Compared with transfemoral access, transradial access was associated with improved clinical outcomes in patients with prior CABG. (J Am Coll Cardiol Intv 2021;14:907–16) © 2021 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

CABG = coronary artery bypass grafting

CI = confidence interval

IPW = inverse propensity weighting

OR = odds ratio

PCI = percutaneous coronary intervention

The rate of radial artery access for cardiac catheterization has increased significantly over the past decade, driven in part by several key clinical trials reporting improved patient outcomes concomitant with the development of radial training programs (1-3). Despite this increase, a large subset of patients who have undergone coronary artery bypass grafting (CABG) are significantly underrepresented within radial access trials (1-3). Many post-CABG patients have increased burden of comorbidities, including peripheral artery disease, but operators may be hesitant to use radial artery access in these patients out of concern for increased technical challenges with bypass graft angiography from radial approach and increased radiation exposure. Proficiency with the radial approach in non-CABG patients may affect the willingness of operators to use radial access for patients with prior CABG.

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There have been two randomized controlled trials of left radial access versus femoral access in patients with prior CABG undergoing cardiac catheterization (4,5). The RADIAL-CABG (Radial Versus Femoral Access for Coronary Artery Bypass Graft Angiography and Intervention) trial was a single-center study that randomized 128 post-CABG patients to evaluate the primary endpoint of contrast volume used. The results of the study concluded that contrast volume, procedure duration, operator radiation exposure, and rate of access-site crossover were significantly higher in patients undergoing diagnostic cardiac catheterization via left radial access compared with femoral access. In contrast, the L-RECORD (Left Radial Compared to Femoral Approach for Coronary Angiography in Patients With Previous CABG) trial was a more contemporary multicenter trial that randomized 150 prior CABG patients referred for coronary angiography to radial versus femoral access and showed no differences in procedure time, fluoroscopy time, radiation dose, and contrast volume (5).

Using the National Cardiovascular Data Registry CathPCI Registry, we sought to examine: 1) rates of radial artery access used in post-CABG patients undergoing diagnostic catherization and/or PCI over the past decade; 2) whether operators with higher annualized procedural volumes and higher percentage radial use among non-CABG patients were more likely to perform diagnostic catherization and/or PCI via the radial approach in patients with prior CABG; and 3) rates of clinical and procedural outcomes in post-CABG patients who undergo diagnostic catherization and/or PCI via the radial or femoral approach.

METHODS

The data, analytic methods, and study materials will be made available to other researchers for approved, funded, reasonable requests in order to reproduce the results.

DATA SOURCES. Authorization for this study, proper ethical oversight, and waiver of the requirement to obtain written informed consent were granted by Chesapeake Institutional Review Board. This study was conducted using data collected from the CathPCI Registry, an initiative of the American College of Cardiology Foundation and cosponsored by the Society for Cardiovascular Angiography and Interventions. This registry collects data on patient and hospital characteristics, clinical presentation, length of hospital stay, treatments, and in-hospital outcomes for PCI procedures from >1,000 sites across the United States (6).

STUDY COHORT. To define the study cohort, we included all PCI and diagnostic catheterization admissions collected using version 4 of the data collection form from July 1, 2009, through March 31, 2018. We started with a population of 12,506,202 PCI and diagnostic catheterization admissions across 1,866 sites. We excluded patients without histories of CABG (n = 10,567,026), patients who presented with ST-segment elevation myocardial infarction, and patients with cardiogenic shock within 24 h of PCI or at the beginning of the PCI procedure (n = 88,415). Patients who had their procedures performed via nonfemoral or nonradial access were excluded (n = 9,070). We excluded patients who underwent salvage diagnostic catheterization or PCI (n = 37,835) or who were younger than 18 years of age (n = 28). We

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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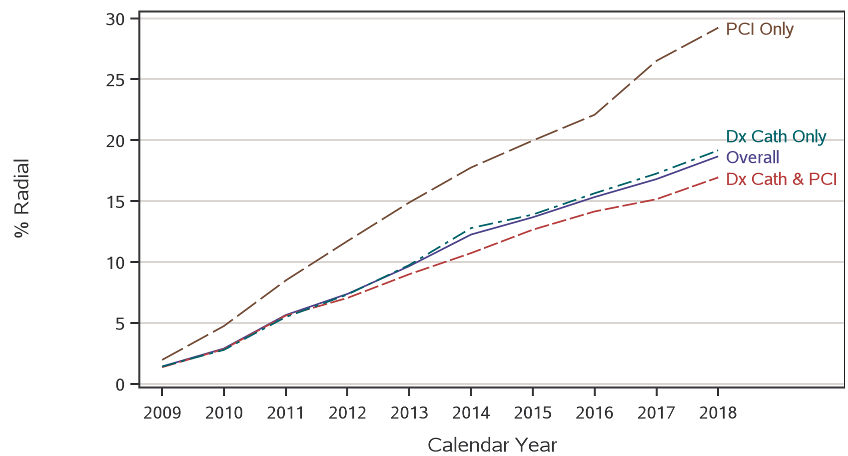
FIGURE 1 **Temporal Trends in the Use of Radial Access During the Study Period by Procedure Type**



N eligible

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Overall	64895	149146	146949	147866	146601	153598	150419	147020	141087	31477
Dx Cath & PCI	22265	51011	50348	50813	51198	51724	53592	54164	54209	12541
Dx Cath Only	39493	91192	90476	92047	90466	96935	91359	87382	81457	17704
PCI Only	3137	6943	6125	5006	4937	4939	5468	5474	5421	1232

Temporal trend in the use of radial artery access in patients undergoing diagnostic catheterization (Dx Cath), diagnostic catheterization and percutaneous coronary intervention (PCI), and PCI only. The percentage of radial artery access increased across all groups over the study period.

also excluded sites that submitted <50 diagnostic cardiac catheterization procedures per year or reported having less than twice as many diagnostic cardiac catheterization procedures relative to PCI procedures (n = 524,780). The final cohort was 1,279,058 index procedures at 1,173 sites.

OPERATOR ANALYSIS. For the operator-level analysis, all operator-level variables were derived from only PCI admissions, as diagnostic cardiac catheterization data are not received from all sites. This analysis represents a subset analysis of PCI operators from the final patient-level study population. Operators who performed zero PCIs during the study period (but may have performed diagnostic-only cardiac catheterizations) were not included. Admissions were excluded when the diagnostic catheterization and PCI operator differed. Additionally, admissions with invalid National Provider Identifier numbers were excluded.

We started with 12,078 operators with valid National Provider Identifier numbers who performed ≥1 PCI via the radial or femoral approach during the study period. We excluded operators who performed ≤30 PCIs on patients without prior CABG (n = 2,496). We excluded these operators in order to have a reasonable denominator for calculating the operator's overall radial PCI rate. Operators who did not perform any PCIs on eligible admissions in the final patient-level study population as outlined previously were excluded (n = 2,918). The final operator-level population included 6,664 PCI operators. Note that the data collection form does not allow specification of left versus right radial access.

STUDY OUTCOMES. We examined in-hospital mortality, bleeding complications, vascular complications, total contrast volume, and total procedure fluoroscopy time among all patients undergoing diagnostic catheterization and/or PCI. Bleeding was defined as any one of the following: bleeding event within 72 h (hematocrit decrease ≥10% and/or hemoglobin decrease ≥3 g/dl, transfusion of whole blood or packed red blood cells, procedural intervention/surgery at the bleeding site), hemorrhagic stroke, or tamponade. The rate of renal failure was also assessed, which was simply defined as a new requirement for renal dialysis. Among PCI groups, we examined procedural success, which we considered to have occurred when the number of lesions dilated equaled the number of lesions attempted.

STATISTICAL ANALYSIS. We assessed temporal trends from 2009 to 2018 in rates of radial approach in patients by procedure type per calendar year (i.e., diagnostic catheterization and PCI, diagnostic catheterization only, and PCI only). Baseline patient and hospital characteristics of patients with prior CABG undergoing the radial or femoral approach were

TABLE 1 Baseline Characteristics of Patients Who Underwent Diagnostic Cardiac Catheterization and PCI

	Overall (N = 1,279,058)	Femoral (n = 1,148,842)	Radial (n = 130,216)	p Value
Age (yrs)*	70 (62-77)	70 (62-77)	70 (62-77)	0.41
Female	340,154 (26.6)	308,850 (26.9)	31,304 (24.0)	<0.0001
Race, Back	84,342 (6.6)	76,400 (6.7)	7,942 (6.1)	<0.0001
Admission location*				<0.0001
Emergency department	184,315 (34.9)	167,830 (35.3)	16,485 (31.2)	
Transfer in	68,239 (12.9)	61,081 (12.9)	7,158 (13.5)	
Private health insurance	793,534 (62.0)	710,737 (61.9)	82,797 (63.6)	<0.0001
Post-procedural LOS (days)	2 (1–2)	2 (1–2)	2 (1–2)	<0.0001
>1 and <2 days	458,690 (35.9)	401,936 (35.0)	56,754 (43.6)	
>2 and <4 days	632,551 (49.5)	575,386 (50.1)	57,165 (43.9)	
>4 days	187,817 (14.7)	171,520 (14.9)	16,297 (12.5)	
BMI (kg/m^2)	29.3 (25.9-33.4)	29.2 (25.8-33.3)	29.7 (26.2-34.2)	<0.0001
Comorbidities				
Prior MI	626,648 (49.0)	562,948 (49.0)	63,700 (48.9)	0.57
Prior CHF*	129,629 (24.5)	115,966 (24.4)	13,663 (25.8)	<0.0001
Diabetes	626,837 (49.0)	563,437 (49.0)	63,400 (48.7)	0.014
PAD*	119,470 (22.6)	106,583 (22.4)	12,887 (24.4)	<0.0001
Current or recent smoker*	90,171 (17.1)	81,391 (17.1)	8,780 (16.6)	0.0026
Prior PCI	672,586 (52.6)	602,771 (52.5)	69,815 (53.6)	<0.0001
Dialysis	43,427 (3.4)	41,555 (3.6)	1,872 (1.4)	<0.0001
Admission presentation				<0.0001
No symptoms	122,983 (9.6)	111,486 (9.7)	11,497 (8.8)	
Atypical chest pain	89,121 (7.0)	80,250 (7.0)	8,871 (6.8)	
Stable angina	249,481 (19.5)	220,742 (19.2)	28,739 (22.1)	
Unstable angina	596,894 (46.7)	538,053 (46.8)	58,841 (45.2)	
NSTEMI	220,135 (17.2)	197,920 (17.2)	22,215 (17.1)	
LV dysfunction	262,109 (20.5)	235,061 (20.5)	27,048 (20.8)	0.0086
PCI indication*				<0.0001
PCI for unstable angina or NSTEMI	330,982 (66.1)	298,103 (66.2)	32,879 (65.3)	
Staged PCI	29,425 (5.9)	25,542 (5.7)	3,883 (7.7)	
Lesion location				0.013
Left main coronary artery	33,074 (6.6)	29,806 (6.6)	3,268 (6.5)	
Proximal LAD	28,532 (5.7)	25,537 (5.7)	2,995 (6.0)	
Proximal RCA, mLAD, or pLCx	118,553 (23.7)	106,504 (23.7)	12,049 (24.0)	
Lesion in graft				<0.0001
Arterial graft	12,976 (2.6)	11,684 (2.6)	1,292 (2.6)	
Vein graft	154,855 (30.9)	140,575 (31.2)	14,280 (28.4)	
No graft	332,461 (66.4)	297,708 (66.1)	34,753 (69.0)	
Post-procedural outcomes				
Periprocedural MI*	7,999 (1.6)	7,357 (1.6)	642 (1.3)	<0.0001
Cardiogenic shock	4,773 (0.37)	4,421 (0.38)	352 (0.27)	<0.0001
CVA	2,865 (0.22)	2,642 (0.23)	223 (0.17)	<0.0001
Renal failure	2,368 (0.19)	2,176 (0.20)	192 (0.15)	0.0003
Vascular complications	2,710 (0.21)	2,605 (0.23)	105 (0.08)	<0.0001
Bleeding event within 72 h	8,104 (0.63)	7,660 (0.67)	444 (0.34)	<0.0001
Bleeding at access site	2,663 (0.21)	2,537 (0.22)	126 (0.10)	0.04
Version 4 definition of bleeding*	14,022 (2.8)	13,195 (2.9)	827 (1.6)	<0.0001
PCI procedural success*	462,127 (94.1)	415,460 (94.1)	46,667 (94.6)	<0.0001
Hospital features				
Teaching hospital	605,254 (47.3)	536,479 (46.7)	68,775 (52.8)	<0.0001
Average annual PCI volume	598 (361-906)	587 (360-906)	653 (377-951)	<0.0001
Hospital region				<0.0001
West	159,746 (12.5)	143,342 (12.5)	16,404 (12.6)	
Midwest	354,845 (27.7)	324,544 (28.3)	30,301 (23.3)	
South	601,895 (47.1)	542,686 (47.2)	59,209 (455)	
Northeast	162,559 (12.7)	138,257 (12.0)	24,302 (18.7)	

Values are median (interquartile range) or n (%). *Variable collected only for patients undergoing PCI, which comprises the denominator for this variable.

BMI = body mass index; CHF = congestive heart failure; CVA = cerebrovascular accident; LAD = left anterior descending coronary artery; LOS = length of stay; LV = left ventricular; MI = myocardial infarction; mLAD = medial left anterior descending coronary artery; NSTEMI = non-ST-segment elevation myocardial infarction; PAD = peripheral artery disease; PCI = percutaneous coronary intervention; pLCx = proximal left circumflex coronary artery; RCA = right coronary artery.

TABLE 2 Operator Radial Rate in the Analysis Population (With History of CABG) Stratified by Operator Radial PCI Rate in Non-CABG Patients

	Among All Operators		Among Operators With >5 PCIs		Among All Operators With >10 PCIs	
Operator Measure	Spearman Correlation	p Value	Spearman Correlation	p Value	Spearman Correlation	p Value
Annualized overall PCI volume in registry (no prior CABG)	0.33	<0.0001	0.34	<0.0001	0.33	<0.0001
Radial rate among registry PCIs (no prior CABG)	0.73	<0.0001	0.80	<0.0001	0.83	<0.0001

CABG = coronary artery bypass grafting; PCI = percutaneous coronary intervention.

examined among the total study cohort (i.e., diagnostic catheterization and PCI, diagnostic catheterization only, and PCI only) and by procedure type. To test for differences in baseline patient or hospital characteristics by radial or femoral access for each procedure type, we used the chi-square or Fisher exact test for categorical variables and the Wilcoxon rank sum test for continuous variables.

OPERATOR-LEVEL ANALYSIS. For the operator-level analysis, we calculated total and annualized PCI volumes using all PCI procedures on patients without prior CABG entered into CathPCI using version 4 of the data collection form (July 1, 2009, through March 31, 2018). Operator annualized volume was calculated as total number of PCI procedures divided by number of years between first and last PCI performed: (last PCI admission date − first PCI admission date + 1)/365. We chose to define operator volume using patients with and without prior CABG because this measure is likely independent of operator volume among the study population, and we wanted to assess for an association between total annualized volume and percent radial use.

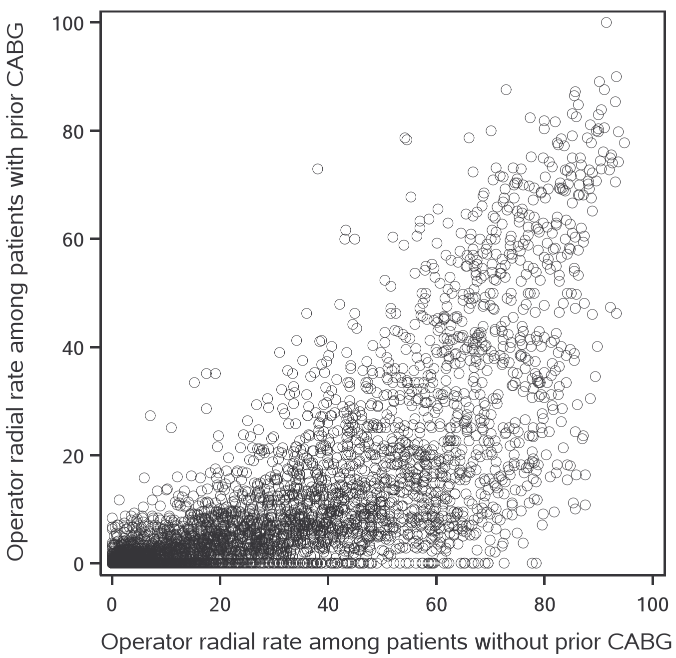
We then calculated rates of radial PCI among PCI admissions in the study population (with histories of CABG) and among patients without prior CABG. The operator's radial PCI rate among the study population was calculated as the total number of PCI procedures performed via radial approach among the study population divided by the total number of PCI procedures performed via radial or femoral approach among the study population. Similarly, the operator's radial PCI rate among the patients without prior CABG was calculated as the total number of PCI procedures performed via radial approach among patients without prior CABG divided by the total number of PCI procedures performed via radial or femoral approach among patients without prior CABG. We summarized the operator's radial PCI rate among this study population with the operator's PCI volume and radial PCI rate among patients without prior CABG using Spearman's rank correlations. To reduce random noise in the operator's radial rate among the analysis population, we repeated the descriptive analysis restricting to operators with >5 and >10 PCIs in the analysis population.

OUTCOMES ANALYSIS. We examined the association between radial or femoral access and outcomes using inverse propensity weighting (IPW) for risk adjustment and generalized estimating equations to account for within-operator clustering. In-hospital mortality, bleeding, vascular complications, and procedural success were assessed using a logistic regression model. Total fluoroscopy time and contrast volume were examined using linear regression. In outcome models, we tested for an interaction between procedure type (diagnostic catheterization and PCI, diagnostic catheterization only, PCI only) and access type (radial vs. femoral). Logistic regression was then used to estimate a propensity score for radial versus femoral access, adjusted for procedure type, a priori selected clinical variables (age, sex, race, body mass index, prior PCI, prior myocardial infarction, diabetes, family history of coronary artery disease, renal failure or glomerular filtration rate <30 ml/min, heart failure according to New York Heart Association functional class within 2 weeks [IV, I/II/III, or none], procedure status [urgent, emergency, or elective], multivessel disease, and operator's annualized PCI volume), and interactions between procedure type and clinical variables that remained in the model after backward selection. A sensitivity analysis was performed limiting the sample to only those patients who underwent graft PCI.

RESULTS

Between July 1, 2009, and March 31, 2018, a total of 1,279,058 index procedures were performed at 1,173 sites. Of the final study cohort, 451,865 of the procedures (35.3%) involved both diagnostic cardiac catheterization and PCI, 778,511 (60.9%) involved diagnostic cardiac catheterization alone, and 48,682 (3.8%) involved PCI alone.

FIGURE 2 Operator Radial Rate Among Patients With Prior CABG Undergoing >10 PCIs by Operator Radial Rate Among Patients Without Prior CABG Undergoing > 10 PCIs



Scatterplot of operator radial rate among the analysis population (with history of coronary artery bypass grafting [CABG]) versus operator radial rate among patients without histories of CABG in operators who had performed >10 radial percutaneous coronary interventions (PCIs) during the study period. Among all operators, an increasing operator radial rate in patients without histories of CABG was associated with an increasing operator radial rate in patients with histories of CABG (Spearman correlation coefficient = 0.73; $p < 0.001$). In those operators who performed more than 10 radial PCIs in patients without histories of CABG, this association was strengthened (Spearman correlation = 0.83; $p < 0.001$).

TEMPORAL TRENDS IN RADIAL ARTERY ACCESS. Figure 1 depicts the temporal trends in the use of radial artery access in patients undergoing diagnostic catheterization, diagnostic catheterization and PCI, and PCI only. The percentage of radial artery access increased across all groups over the study period. In 2009, the overall rate of radial access in patients with prior CABG was 1.4% and had increased to 18.7% by 2018. The rate of radial artery access increased from 1.4% to 19.2% for patients undergoing diagnostic cardiac catheterization alone and from 1.4% to 17.0% for patients undergoing diagnostic cardiac catheterization and PCI. For PCI only, the rate of radial artery access increased from 2.0% to 29.2% over the study period.

BASELINE CHARACTERISTICS. Table 1 describes the baseline patient, procedural, and hospital characteristics among all patients undergoing diagnostic catheterization, diagnostic catheterization and PCI, or PCI only by radial versus femoral access. The median age of the study cohort was 70 years in both the radial and femoral access groups. Women were less likely to undergo radial cardiac catheterization compared with men (9.2% radial rate in women vs. 10.5% radial rate in men; $p < 0.01$). Black patients were also less likely to undergo radial cardiac catheterization (9.4% radial rate in black patients vs. 10.2% radial rate in non-Black patients; $p < 0.01$). Patients with histories of PCI and peripheral artery disease were more likely to undergo radial access than femoral access ($p < 0.01$ for all). Patients with post-procedure lengths of stay ≥1 but ≤2 days were more likely to have undergone radial access, while those patients with longer lengths of stay (≥2 days) were more likely to have undergone femoral access ($p < 0.0001$).

Patients cared for at hospitals with the highest average annual PCI volumes (≥2,000 cases) were more likely to undergo radial access compared with those at hospitals with the lowest annual PCI volumes (<500 cases) (26.2% vs. 9.1%; $p < 0.01$) (Table 1). Additionally, patients cared for at teaching hospitals were more likely to undergo radial access (52.8% vs. 46.7%; $p < 0.0001$). Patients treated at hospitals in the Northeast were also more likely to undergo radial access, while those treated at hospitals in the South and Midwest were more likely to undergo femoral access ($p < 0.0001$). The baseline characteristics of patients who underwent diagnostic catheterization only, diagnostic catheterization with PCI, and PCI only are shown in Supplemental Tables 1 and 2, respectively.

OPERATOR-LEVEL ANALYSIS. Among all operators, an increasing operator radial rate in patients without histories of CABG was associated with an increasing operator radial rate in patients with histories of CABG (Spearman correlation coefficient = 0.73; $p < 0.001$) (Table 2). This association was stronger among operators who had performed >5 radial PCIs and >10 radial PCIs during the study period, respectively (Spearman correlation coefficients of 0.80 and 0.83, respectively; $p < 0.001$ for both). Figure 2 depicts the scatterplot of operator radial rate among the analysis population (with histories of CABG) versus the operator radial rate among patients without histories of CABG in operators who had performed >10 radial PCIs during the study period.

OUTCOMES ANALYSIS. Table 3 demonstrates the unadjusted outcomes stratified by access and

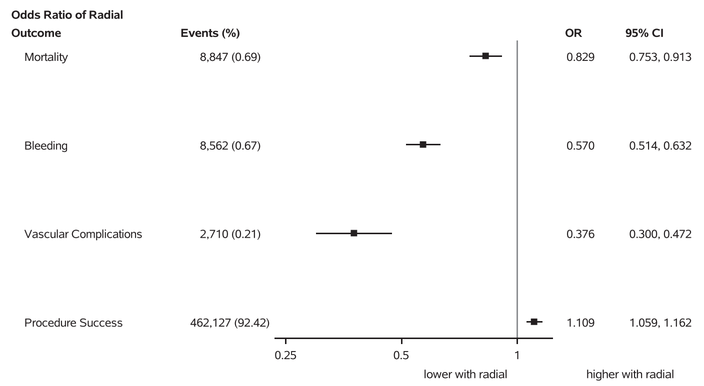
TABLE 3 Unadjusted Outcomes by Procedure and Access Type

	Radial Dx Cath and PCI (n = 43,128)	Femoral Dx Cath and PCI (n = 408,737)	Radial Dx Cath Only (n = 79,879)	Femoral Dx Cath Only (n = 698,632)	Radial PCI Only (n = 7,209)	Femoral PCI Only (n = 41,473)
Outcomes						
In-hospital mortality	208 (0.48)	2,653 (0.65)	457 (0.57)	5,345 (0.77)	14 (0.19)	170 (0.41)
Bleed: within 72 h, hemorrhagic stroke, or tamponade	281 (0.65)	4,702 (1.15)	156 (0.20)	2,799 (0.40)	39 (0.54)	585 (1.41)
Any vascular complication	61 (0.14)	1,399 (0.34)	32 (0.04)	1,055 (0.15)	12 (0.17)	151 (0.36)
Procedural success						
Unsuccessful	1,573 (3.65)	15,854 (3.88)	NA	NA	217 (3.01)	1,592 (3.84)
Partially successful	662 (1.54)	6,916 (1.69)	NA	NA	122 (1.69)	887 (2.14)
Successful	39,931 (92.66)	377,430 (92.44)	NA	NA	6,736 (93.46)	38,030 (91.79)
Catheterization laboratory visit						
Fluoroscopy time (min)*						
n	42,411	403,517	78,883	690,804	7,131	40,983
Median	19.10	15.40	9.20	6.70	13.30	13.40
25th percentile	13.00	10.40	5.80	4.30	7.90	7.60
75th percentile	27.40	23.00	14.40	10.70	22.60	23.50
Fluoroscopy dose (mGy)*						
n	16,068	123,797	26,974	201,028	2,082	10,911
Median	1,817.0	1,680.0	897.00	812.00	1,290.5	1,424.0
25th percentile	1,034.0	904.00	505.00	434.00	652.00	626.00
75th percentile	2,951.0	2,783.0	1,498.0	1,346.0	2,367.0	2,742.0
Contrast volume (ml)*						
n	43,005	407,608	79,601	696,479	7,192	41,365
Median	181.00	200.00	110.00	120.00	115.00	140.00
25th percentile	137.00	150.00	80.00	90.00	75.00	90.00
75th percentile	245.00	255.00	150.00	160.00	170.00	200.00

Values are n (%) unless otherwise indicated. *Variable collected only for patients undergoing percutaneous coronary intervention (PCI), which comprises the denominator for this variable. Cath = catheterization; Dx = diagnostic.

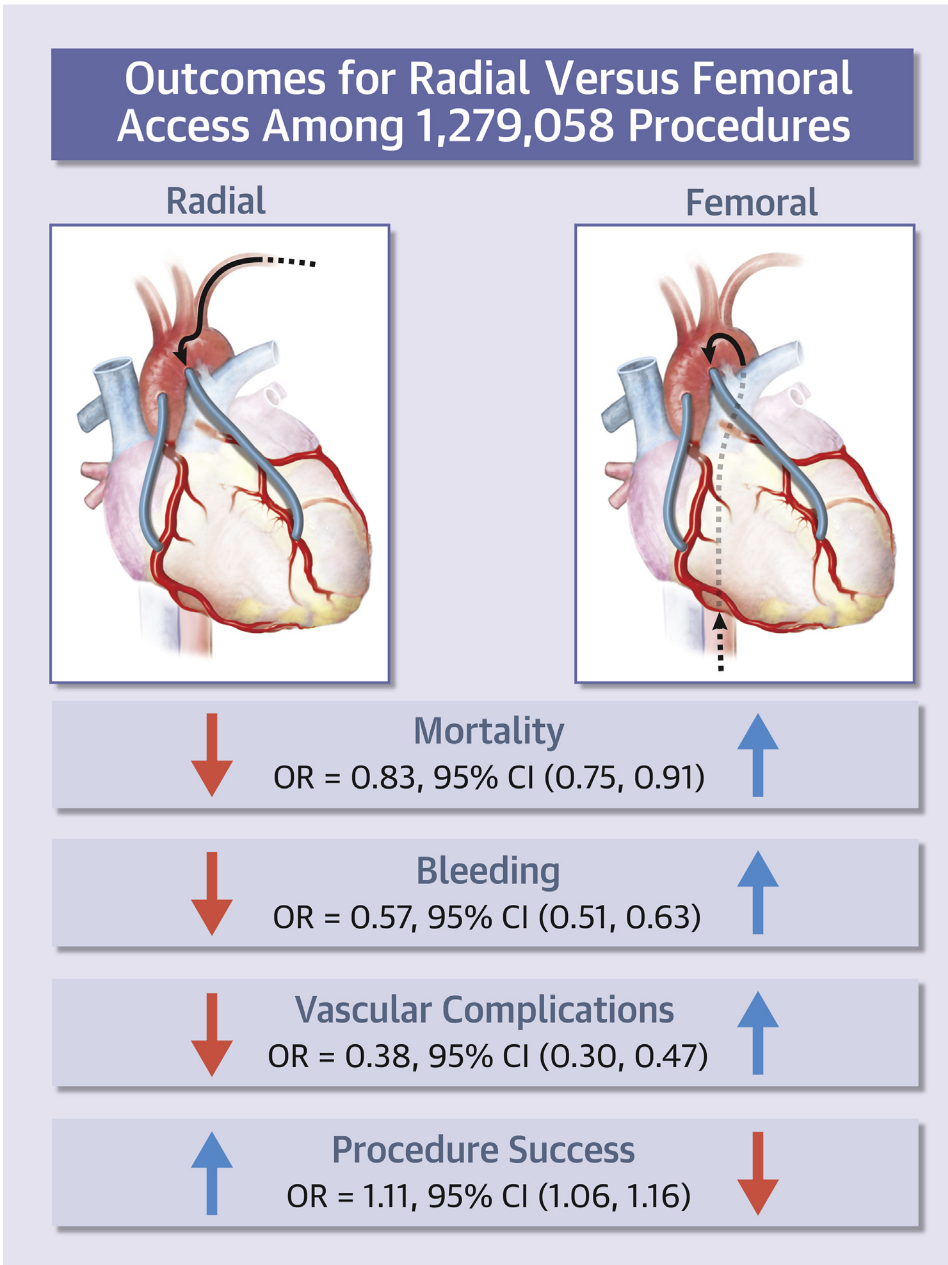
procedure type. After IPW, all candidate variables for the propensity score model had absolute values of standardized differences <0.10. Interactions between radial and procedure type were significant for contrast volume and fluoroscopy time, but not for the other outcomes of interest. After IPW, radial access was associated with decreased mortality (odds ratio [OR]: 0.83; 95% confidence interval [CI]: 0.75 to 0.91), decreased bleeding (OR: 0.57; 95% CI: 0.51 to 0.63), decreased vascular complications (OR: 0.38; 95% CI: 0.30 to 0.47), and increased PCI procedural success (OR: 1.11; 95% CI: 1.06 to 1.16) (**Figure 3**). Additionally, patients who had radial access were less likely to have bleeding events within 72 h (0.34% vs. 0.67%; $p < 0.01$). Radial access was associated with longer fluoroscopy time (12.1 min vs. 9.4 min) but lower contrast volume (130 ml vs. 145 ml) ($p < 0.0001$ for both). A sensitivity analysis was performed among patients who underwent bypass graft PCI only, and the results were consistent with the overall study findings (Supplemental Appendix). For the bleeding endpoint, there was a significant interaction between access site and procedure type (PCI vs. diagnostic catheterization) such that radial access was associated with an even greater reduction in bleeding compared with femoral access among patients undergoing bypass graft PCI (OR: 0.13; 95% CI: 0.04 to 0.40; $p < 0.01$) (Supplemental Appendix).

FIGURE 3 Effect of Radial Access on Patient Outcomes



After inverse propensity weighting, radial access was associated with decreased mortality (odds ratio [OR]: 0.83; 95% confidence interval [CI]: 0.75 to 0.91), decreased bleeding (OR: 0.57; 95% CI: 0.51 to 0.63), decreased vascular complications (OR: 0.38; 95% CI: 0.30 to 0.47), and increased PCI procedural success (OR: 1.11; 95% CI: 1.06 to 1.16).

CENTRAL ILLUSTRATION **Effect of Radial Access Versus Femoral Access in Patients With Prior Coronary Artery Bypass Grafting**



Manly, D.A. et al. J Am Coll Cardiol Intv. 2021;14(8):907-16.

DISCUSSION

Using a large, national registry of patients undergoing diagnostic catherization and/or PCI, we examined the trends and outcomes of radial versus femoral access in patients with prior CABG. Over the study period, radial access in post-CABG patients increased from 1.4% to 18.7%. Post-CABG patients with histories of peripheral artery disease and those presenting with acute coronary syndromes were more likely to undergo radial access. Operators who were more likely to use radial access in non-CABG patients were more likely to use radial access in post-CABG patients. Importantly, radial access was associated with reduced mortality, bleeding, vascular complications, and contrast volume in post-CABG patients at the expense of slightly longer fluoroscopy time.

The adoption of transradial coronary angiography in the United States has continued to rise, and our data demonstrate that radial artery access in post-CABG patients has followed this trend across all procedure types; however, rates continue to lag behind non-CABG patients (7). Part of this delayed adoption may be driven by the learning curve of transradial coronary and bypass angiography or, as suggested by the RADIAL-CABG trial, that transradial cardiac catheterization involves more contrast and necessitates more x-ray exposure. A CathPCI Registry study by Hess et al. (8) demonstrated that as transradial volume increased, more complex cases were completed via the radial artery, including in patients with histories of CABG. The learning curve for operators in that analysis was 30 to 50 transradial cases. The lag in transradial adoption will likely continue to narrow as data and exposure to transradial procedures continue to increase. A recent American Heart Association expert consensus statement advocated for a “radial first” approach, especially in patients with acute coronary syndromes (9), which may encourage further adoption of radial access for patients with CABG.

The association between radial access and improved procedure safety are consistent with prior studies comparing radial and femoral approaches (1–3). However, our data are seemingly disparate from the findings of the RADIAL-CABG trial (4). We found that contrast volume was lower with radial artery access across all procedure subtypes. Interestingly, the effect of radial on contrast volume was greatest with PCI only and lowest with diagnostic catheterization only. This may be because diagnostic angiography often requires more contrast volume to find and inject the native coronary arteries and bypass grafts, therefore attenuating the differential effect of access site. Similarly, fluoroscopy time was higher with radial artery access when diagnostic catheterization only or diagnostic catheterization and PCI were performed, however, fluoroscopy time was reduced with radial artery access for PCI only. In addition, the RADIAL-CABG trial showed a higher rate of access-site crossover from radial to femoral access, but there was no specific protocol guidance on techniques to minimize crossover. Although we are unable to assess access site crossover using the CathPCI Registry, an endpoint of access-site crossover is highly dependent on operator proficiency with the radial approach. Distinct from the RADIAL-CABG trial, our analysis included multiple centers, likely including operators with greater transradial experience, and a much larger sample size. In that context, we found a significant association between radial access and a reduction in vascular complications, bleeding, and mortality compared with femoral artery access (**Central Illustration**).

STUDY LIMITATIONS. First, this was not a randomized controlled trial but rather an observational evaluation of contemporary trends and outcomes in patients undergoing cardiac catheterization following CABG. As a result, there may have been a selection bias favoring transradial access (lower complexity anatomy and/or other procedural considerations) or residual confounding variables that were not accounted for in the outcomes analysis. For example, CABG-related factors such as use of bilateral mammary artery grafts, the left radial artery as a bypass conduit, and number of bypass grafts may influence operator selection of access site and are not available in the registry data.

Second, the CathPCI Registry accounts only for in-hospital events. Clinical outcomes associated with access site after hospital discharge were not examined.

Finally, the results may not represent practices among all U.S. hospitals, as not all sites participate in National Cardiovascular Data Registry data collection, and we excluded sites with small numbers of procedures.

CONCLUSIONS

The rate of radial artery access in patients with prior CABG undergoing diagnostic catheterization and/or PCI has increased over the past decade in the United States. Operators who were more likely to use radial access in non-CABG patients were also more likely to use radial access in post-CABG patients. Compared with femoral access, radial access in post-CABG patients was associated with increased fluoroscopy time for diagnostic procedures but decreased adverse clinical events. These data suggest that wider adoption of radial access for coronary angiography and PCI in patients with prior CABG may significantly improve clinical outcomes.

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PERSPECTIVES

WHAT IS KNOWN? There is accumulating evidence that cardiac catheterization via radial artery access reduces bleeding and vascular complications compared with femoral artery access. But whether this benefit translates to patients with prior CABG is not clear.

WHAT IS NEW? The present study demonstrates that radial artery access in post-CABG patients has increased steadily across the United States over time and is associated with improved clinical outcomes compared with femoral artery access.

WHAT IS NEXT? These results from an observational registry need to be confirmed in a randomized trial.

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KEY WORDS CABG, cardiac catheterization, femoral access, PCI, radial access

APPENDIX For supplemental tables, please see the online version of this paper.