Radial versus femoral approach for saphenous vein grafts angiography and interventions

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Background Coronary angiography and intervention to saphenous venous grafts (SVGs) remain challenging. This study aimed to investigate the feasibility and safety of the radial approach compared to femoral access in a large cohort of patients undergoing SVG angiography and intervention.

Methods Data from 1,481 patients from Canada, United States, and Spain who underwent procedures between 2010 and 2016 were collected. Patients must have undergone SVG coronary angiography and/or intervention. Demographics, procedural data, and in-hospital complications were recorded.

Results Procedures were undertaken by either the radial (n = 863, 211 intervention) or femoral (n = 618, 260 intervention) approach. The mean number of SVGs per patient was similar between groups (radial 2.3 ± 0.7 vs femoral 2.6 ± 1.1, $P = .61$), but the radial group required a fewer number of catheters (2.6 ± 1.7 vs 4.1 ± 1.1, $P < .001$). Fluoroscopy time was comparable between groups, and there was a trend toward lower contrast volume in the radial group ($P = .045$). Overall, the total dose of heparin was significantly higher in the radial group ($P < .001$); however, radial patients experienced significantly less access-site bleeding complications ($P < .001$). Outpatients undergoing radial SVG interventions had a higher likelihood of a same-day discharge home ($P < .001$).

Conclusions Radial access for SVG angiography and intervention is safe and feasible, without increasing fluoroscopy time. In experienced centers, radial access was associated with fewer catheters used, lower contrast volume, and lower rate of vascular access-site bleeding complications. Moreover, outpatients undergoing SVG percutaneous coronary intervention though the radial approach had a higher likelihood of a same-day discharge home. (Am Heart J 2019;210:1-8.)

The radial approach for coronary angiography and intervention has been extensively proven safer compared to the femoral approach regarding access-site–related complications and among a broad spectrum of patients and presentations.[1-7] Indeed, it appears that although facing more complex and higher-risk patients, greater benefit is provided when the radial approach is performed.[3,4,6,8-10] Patients with a history of coronary artery bypass graft (CABG) surgery are more frequently older and present with greater comorbidity burden compared with those undergoing angiography and percutaneous coronary intervention (PCI) for native coronary artery disease.[11] However, coronary angiography and PCI to saphenous vein grafts (SVG) remain challenging because of technical aspects and thus might preclude a broader use of the radial approach for these patients.[8] Notably, this subset of patients is often excluded from clinical trials comparing access routes, which ultimately leads to the lack of robust data reporting outcome. Therefore, we sought to investigate the feasibility, safety, and procedural outcomes of patients undergoing SVG angiography and PCI using radial versus femoral approach.

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Methods

Study design and participants

This is a multicenter, international study conducted at 4 experienced radial centers: London Health Sciences Centre, London, Ontario, Canada; The Wright Center for Graduate Medical Education, Scranton, Scranton, PA; The Pennsylvania State University, Heart and Vascular Institute, Hershey, PA; and Cardiovascular Institute, Hospital Clínico San Carlos, Madrid, Spain. Data were prospectively collected in dedicated local data sets and retrospectively analyzed from consecutive left heart catheterization procedures (angiography/PCI) performed in patients with a history of CABG with SVGs between 2010 and 2016. Patients' demographics and procedural and in-hospital outcome were retrieved from the institutions' electronic health record systems. We excluded patients without SVGs (ie, arterial conduits only), known occluded SVGs, or when PCI was solely undertaken to a native vessel, unless performed through an SVG (ie, PCI to the native distal right coronary artery through its SVG). The study protocol was approved by each site investigator's local research ethics boards.

Diagnostic and intervention procedures

The procedures' technical aspects including access site choice, sheath size, and diagnostic catheters were at the operator's discretion. Particularly for radial access patients, angiograms were performed by interventional cardiologists performing >85% of their procedures by the radial approach in all-comers. Intravenous unfractionated heparin 50 U/kg was administered at the beginning of the diagnostic angiogram to prevent radial artery occlusion. Heparin was not systematically administered for femoral diagnostic procedures.

For the purpose of the present study, all the included procedures had to be considered successful. For diagnostic angiography, *procedural success* was defined as angiographic demonstration of all native arteries and bypass grafts (SVGs and/or arterial) unless specific graft(s) is(are) known to be occluded from previous angiogram. Regarding PCI, *procedural success* was defined as the presence of <10% residual stenosis, normal antegrade flow, and absence of dissection. If, for any reason, access-site crossover (due to inability to complete the procedure using the first-choice access) was necessary to successfully complete the procedure, this is reported accordingly.

Periprocedural anticoagulation and antiplatelet strategy, as well as catheters and PCI-related decisions, were undertaken as per interventional cardiologist's discretion. After completion of the radial procedure, the sheath was removed; a hemostatic wrist band was applied; and, whenever possible, patent hemostasis was followed.[12] For femoral patients, the sheath was removed in the catheterization laboratory followed by a closure device insertion or by manual compression in the holding room after achieving an activated clotting time of <160 seconds.

Outcomes and measurements

The primary outcome was the occurrence of access-site–related bleeding complications. The secondary outcomes were fluoroscopy time; contrast volume; number of catheters used; and the occurrence of major adverse cardiovascular events (MACE) comprising death, myocardial infarction (MI), and stroke. Bleeding complications were defined using Bleeding Academic Research Consortium (BARC) definitions.[13] The Early Discharge After Transradial Stenting of Coronary Arteries classification was applied for wrist hematomas with grade I (up to 5 cm), grade II (up to 10 cm), and grade III (>10 cm).[14] Femoral hematomas were likewise graded using the Early Discharge After Transradial Stenting of Coronary Arteries classification. MI was defined according to the "Third Universal Definition of Myocardial Infarction":[15]

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Statistical analyses

Continuous variables are expressed as a mean ± SD and categorical variables as n (%). Comparison of continuous variables was performed using the *t* test, and categorical variables were compared using the χ^2 test. Statistical tests were 2-tailed, and differences were considered statistically significant when a P value was < .05. Data analyses were performed using Statistical Package for Social Sciences version 24 (IBM, Inc, Chicago, IL).

Results

Population

Data on 1,481 patients were gathered, including 863 radial and 618 femoral procedures. Patients undergoing angiography by femoral approach were older (71 ± 10 vs 67 ± 12, $P < .001$); were more often men (81% vs 76%, $P = .01$); had a lower body mass index (29.7 ± 5.8 vs 30.5 ± 8, $P = .02$); had higher prevalence of diabetes (48% vs 39%, $P < .001$), hypertension (93% vs 81%, $P < .001$), and history of MI (63% vs 49%, $P < .001$). The radial group showed a higher prevalence of atrial fibrillation/flutter (40% vs 17%, $P < .001$) and chronic kidney disease (36% vs 27%, $P = .032$). About two-thirds of the patients had undergone the procedure because of stable or unstable angina in both groups, and one-third for non–ST-elevation MI. A minority had procedures because of ST-elevation MI.

Table I. Baseline clinical characteristics of patients undergoing CABG angiography and intervention

Clinical characteristics	Radial (n = 863)	Femoral (n = 618)	*P* value
Age (y)	67 ± 12	71 ± 10	<.001
Male	653 (76)	504 (81)	.01
Body mass index (kg/m^2)	30.5 ± 8.0	29.7 ± 5.8	.02
Diabetes	339 (39)	297 (48)	<.001
Hypertension	695 (81)	574 (93)	<.001
Dyslipidemia	409 (91)	557 (90)	.97
History of heart failure	217 (25)	180 (29)	.09
Chronic atrial fibrillation/flutter	178 (40)	105 (17)	<.001
Previous myocardial infarction	420 (49)	390 (63)	<.001
Previous PCI	310 (36)	226 (37)	.83
Cerebrovascular disease	91 (11)	75 (12)	.34
Peripheral vascular disease	148 (17)	116 (19)	.44
Chronic obstructive pulmonary disease	119 (14)	71 (12)	.19
Chronic kidney disease*	141 (36)	167 (27)	.03
Left ventricular ejection fraction (%)	49.5 ± 14.3	48.2 ± 12.8	.16
Clinical setting			
Stable angina	161/451 (36)	249/616 (40)	.18
Unstable angina	106/451 (24)	126/616 (21)	.23
NSTEMI	118/451 (26)	161/616 (26)	.99
STEMI	8/451 (1.8)	31/616 (5.0)	.005

Values are expressed as n (%) or mean ± SD unless otherwise noted. Some percentages may not add up to 100 because of rounding. *NSTEMI*, non–ST-elevation myocardial infarction; *STEMI*, ST-elevation myocardial infarction.
* Estimated glomerular filtration rate <60 mL/min/1.72m^2.

Table II. Procedural characteristics of patients undergoing CABG angiography and intervention

Procedural data	Radial (n = 863)	Femoral (n = 618)	*P* value
Left radial artery access	582 (67)	–	–
Number of SVGs	2.3 ± 0.7	2.6 ± 1.1	.61
No. of catheters used (angiography only)	2.3 ± 1.5	3.6 ± 1.2	<.001
Access-site crossover	24 (2.8)	10 (1.6)	.08
Sheath size (F)	5.45 ± 0.66	5.54 ± 0.86	.035
Closure device (collagen plug-based)	–	72 (12)	–
Dose heparin (U, angiography only)	5023 ± 1271	2549 ± 812	<.001
Total contrast volume (mL)	203 ± 82	224 ± 99	.045
Total fluoroscopy time (min)	24.9 ± 11.8	25.2 ± 14.6	.88
Periprocedural complications			
Bleeding complications	7 (0.8)	18 (2.9)	.002
BARC type 1	7 (0.8)	16 (2.6)	.006
BARC type 3a	0 (0)	2 (0.3)	.09
Access-site hematoma (any)	8 (0.9)	20 (3.2)	<.001
Death	0 (0)	3* (0.5)	.29
MI	0 (0)	0 (0)	–
Stroke	0 (0)	3 (0.5)	.29

Values are expressed as n (%) or mean ± SD unless otherwise noted. Some percentages may not add up to 100 because of rounding.
* One patient in cardiogenic shock, 1 arrested while on ECMO, and 1 admitted post–ventricular fibrillation arrest and then cardiogenic shock.

Other clinical characteristics were balanced between both groups (Table I).

Procedural data

CABG angiography. In the radial group, left radial access was used in 67% of the cases. There were similar numbers of SVGs per patient (radial 2.3 ± 0.7 vs femoral 2.6 ± 1.1, *P* = .61) and access-site crossovers (radial 2.8% vs femoral 1.6%, *P* = .08) (Table II). The radial group received significantly smaller sheath size (5.45F ± 0.66F vs 5.54F ± 0.86F, *P* = .035) and fewer number of catheters to complete the angiogram (2.3 ± 1.5 vs 3.6 ± 1.2, *P* < .001), required a lower amount of contrast (203 ± 82 vs 224 ± 99 mL, *P* = .045), and had similar fluoroscopy time (24.9 ± 11.8 vs 25.2 ± 14.6 min, *P* = .88) (Table II). The total dose of heparin was significantly higher in the radial group (5023 ± 1271 U vs 2549 ± 812 U, *P* < .001); however, radial patients experienced significantly less BARC type 1 bleedings (0.8% vs 2.6%, *P* = .006) and trended toward less BARC type 3a bleedings (0% vs 0.3%,

Table III. Procedural characteristics of patients undergoing CABG percutaneous intervention

Procedural intervention data	Radial (n = 211)	Femoral (n = 260)	*P* value
Left radial artery access	90 (43)	–	–
Total no. of catheters used (angiography and PCI)	2.6 ± 1.7	4.1 ± 1.1	<.001
Sheath size (F)	6.01 ± 0.24	6.06 ± 0.75	.70
Closure device (collagen plug-based)	–	42 (16)	–
Dual antiplatelet therapy	207 (98)	253 (97)	.60
P2Y12 inhibitor (other than clopidogrel)	3 (3.1)	32 (13)	.002
No. of stents	1.5 ± 0.9	1.5 ± 0.8	.70
Total dose heparin (U, angiography and PCI)	9753 ± 2542	7014 ± 1935	<.001
Procedural success	211 (100)	260 (100)	–
Procedure type			
Diagnostic plus ad hoc PCI to SVG	151 (71)	189 (73)	.89
Fluoroscopy time (min)	24.5 ± 12.1	24.3 ± 14.7	.92
Contrast volume (mL)	205 ± 82	208 ± 83	.76
Diagnostic plus ad hoc PCI to native via SVG	8 (3.8)	10 (3.8)	1.00
Fluoroscopy time (min)	27.0 ± 11.0	28.3 ± 14.9	.76
Contrast volume (mL)	192 ± 85	271 ± 131	.022
Staged PCI to SVG*	52 (25)	61 (23)	.89
Fluoroscopy time (min)†	26.0 ± 2.7	24.3 ± 10.2	.63
Contrast volume (mL)†	185 ± 21	262 ± 103	.16
SVG territory			
Left anterior descending/diagonal	24/114 (21)	50 (19)	.42
Circumflex/marginal	42/114 (37)	113 (44)	
Right coronary artery	48 (42)	97 (37)	
Periprocedural complications			
Bleeding complications	3/114 (2.6)	13 (5.0)	.30
BARC type 1	3/114 (2.6)	9 (3.5)	.68
BARC type 3a	0/114 (0)	4 (1.5)	.18
Access-site hematoma (any)	5/114 (4.4)	14 (5.4)	.69
Death	0 (0)	0 (0)	–
MI	0 (0)	7 (2.7)	.11
Stroke	0 (0)	1 (0.4)	.99
Same-day discharge (for stable angina only)	10/40 (25)	3/94 (3.2)	<.001

Values are expressed as n (%) or mean ± SD unless otherwise noted. Some percentages may not add up to 100 because of rounding.
* Thirteen patients underwent diagnostic angiogram through the femoral access and then were referred for staged PCI, and the operator decided to perform the PCI through the radial access; therefore, we did not consider these cases as crossover.
† Values represent the sum of both angiography and PCI procedures.

P = .09) complications. The overall rate of bleeding complications was lower in the radial group (0.8% vs 2.9%, *P* = .002), as well as were access-site hematoma (0.9% vs 3.2%, *P* < .001). There were numerically more periprocedural MACE in the femoral group (3 deaths and 3 strokes) with none in the radial group (Table II).

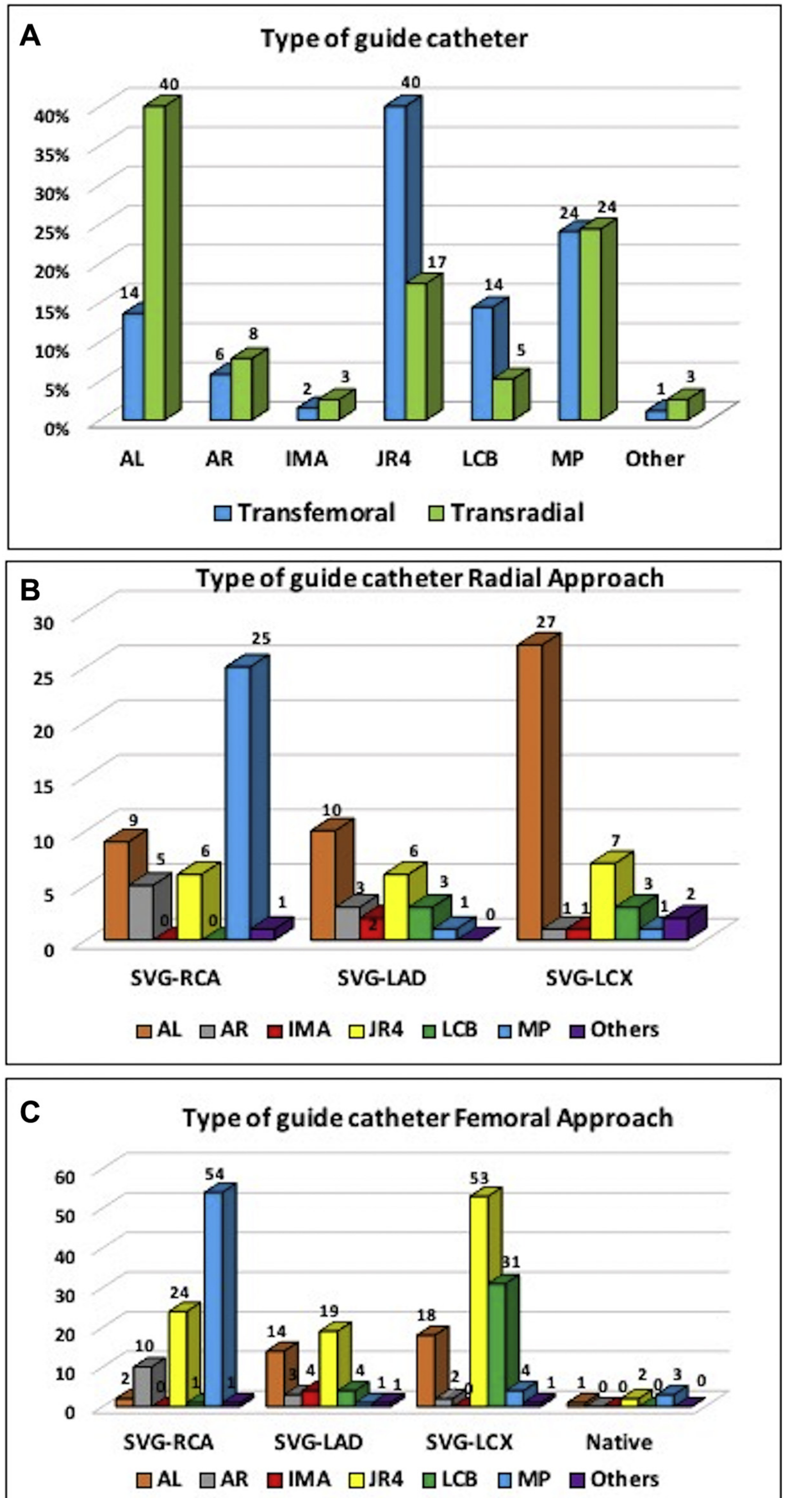
CABG angiography and interventions. A total of 471 patients underwent PCI to an SVG using either the radial (n = 211) or the femoral (n = 260) approach. About 75% of the procedures in both groups were ad hoc PCIs, and the rest were performed in a staged manner. Four percent of the procedures in both groups were PCIs to native vessels through an SVG. The distribution of the treated SVG territory and the number of implanted stents (radial 1.5 ± 0.9 vs femoral 1.5 ± 0.8, *P* = .70) were similar. Overall, the number of catheters including both diagnostic and PCI was significantly lower in the radial group (2.6 ± 1.7 vs 4.1 ± 1.1, *P* < .001), sheath size (6.01F ± 0.24F vs 6.06F ± 0.75F, *P* = .70) and fluoroscopy times were comparable between both groups, and contrast volume was numerically lower in radial procedures for SVG-PCI (Table III).

The use of dual antiplatelet therapy was similar (98% vs 97%, *P* = .60), but the femoral group received more P2Y12 inhibitor (other than clopidogrel) (13% vs 3.1%, *P* = .002) compared to the radial group. The total dose of heparin including both diagnostic and PCI procedures was significantly higher in the radial group (9753 ± 2542 U vs 7014 ± 1935 U, *P* < .001). Bleeding complications and periprocedural MACE were numerically lower in the radial group but did not reach statistical significance between groups (Table III).

Outpatients presenting with stable angina who underwent uncomplicated SVG-PCI through the radial approach were more likely to follow a same-day discharge home (25% vs 3.2%, *P* < .001) (Table III).

The access route influenced the type of guide catheter for SVG-PCI, with Judkins Right 4.0 being the most

Figure 1



A, Overall use of guide catheters' shapes for SVG-PCI. Some percentages may not add up to 100 because of rounding. **B** and **C**, Total numbers according to SVG territory and access approach. *AL*, Amplatz left; *AR*, Amplatz right; *IMA*, internal mamary artery; *LCB*, left coronary bypass; *MP*, multipurpose; *RCA*, right coronary artery; *LAD*, left anterior descencing; *LCX*, left circumflex.

commonly used for femoral procedures and Amplatz Left 1.0 for radial procedures. A multipurpose catheter was equally used in both groups. The remaining catheters' curves are detailed in Figure 1.

Discussion

The results of this study that included almost 1,500 patients with previous CABG undergoing SVG angiography and PCI showed that the radial approach is safe and achieves similar results with overall less number of catheters and trend toward lower contrast volume as compared to the femoral approach. Importantly, overall, patients undergoing procedures through the radial approach had significantly less bleeding complications. Outpatients presenting with stable angina that underwent SVG-PCI were more likely to be discharged the same day after radial procedures.

The adoption of radial approach for coronary angiography and PCI has considerably grown in the last decade worldwide. However, in the United States, data from the CathPCI registry show that this adoption is still slow. Indeed, Feldman et al[8] reported that from 2.8 million PCIs, only 6% were performed via the radial access. Moreover, the authors also showed that 19% of patients with previous CABG underwent cardiac catheterization via the femoral approach; among those, only 8% received radial access. These data suggest a certain reluctance of operators to use radial access in this subset of patients.

Procedural aspects

Previous studies have evaluated the frequency of access-site crossovers. The main reasons for conversion from radial to femoral were, among others, failure to gain access to the radial artery as well as arterial spasm, forearm and subclavian tortuosity, difficulty to cannulate SVGs, and a lack of guiding support for SVG-PCI. Rates of crossover vary considerably in the literature between 1.5% and 17.2% in radial series and 0% and 1.3% in femoral series.[16-22] Our findings show a relatively low and similar crossover rate for both groups. Therefore, it seems that some of the above-mentioned challenges can be tackled when procedures are undertaken by experienced radial operators.[23-25]

In the past, concerns were raised regarding the length of procedures and its relationship with radiation exposure when radial access was used,[18] and the scope of this problem was further magnified for procedures performed by fellows-in-training.[26] Our results suggest similar fluoroscopy times in both groups, and these findings are in accordance with previous reports.[16,17,22] Importantly, these findings are also important in light of the perceived higher risk of radiation exposure for patients and staff but also regarding the efficiency and resource utilization in the catheterization laboratory.

Of note, needing fewer number of catheters when performing radial procedures can, in part, be explained by the increasing use of "radial-specific" or "universal" catheters such as the Tiger ("TIG," Terumo Medical Corporation) that enables radial operators to cannulate native coronary arteries as well as SVGs to the left territories with a single catheter from the right radial rather than using multiple catheters as is often the case with the femoral approach, of course, excluding multipurpose-user operators. Furthermore, engaging the left internal mammary artery with dedicated catheters such as the Internal Mammary Modified (Cordis) or the Bartorelli-Cozzi (Cordis) catheter from the left (or even the right) radial approach simplifies mammary graft angiogram,[23,25] altogether reducing the total number of catheters. Finally, the trend toward lower contrast volume with radial approach noted in our study can, in part, be explained by the less likely need for catheters' exchanges and, thus, less need for repetitive catheter's fill out with contrast. In Figure 2, we describe the suggested or ideal setup for left radial approach to provide patient's and operator's comfort while avoiding radiation exposure.

Figure 2

Left radial approach setup (picture from patient's feet). Once left radial access is obtained, the arm is positioned over the patient's abdomen, and a pillow or wedge pillow is placed under the patient's arm/shoulder for better comfort. Thereafter, the patient is asked to make a fist; then, the drape is twisted around it and propelry fixed using a clamp at the level of the right hip or groin area (circle). Note that by following these simple steps, the distance bewteen the operator's hands to the left wrist is almost the same than that to the right wrist or even the right groin, therefore avoiding lying over the patient's body and/or getting more radiation exposure.

Safety, efficacy, and postprocedural care

Zikas et al[20] showed, in a single-center study, that PCI to SVG, regardless of the chosen access, had similar use of contrast, fluoroscopy time, as well as procedural success. Moreover, the in-hospital MACE were not significantly different between the groups, but not surprisingly, a trend toward lower vascular complication was observed in favor of the radial approach.[20] Although success rates of procedures performed in both approaches might be similar, the radial access stands out for its lower rates of procedural, mostly access-site–related complications and bleedings.[16,19] Notably, the present study shows that the radial approach was associated with substantially lower rate of bleeding complications and hematomas in the entire cohort. However, although there were numerically lower bleeding complications with radial approach in the subset of patients undergoing SVG-PCI, the observed difference did not reach statistical significance; certainly, the sample size was too small to demonstrate any statistically significant difference. Han et al[21] showed similar results in terms of procedural time and success rates, also showing a significant reduction in vascular complications leading to a shorter length of hospital stay. In this regard, our data provide further insight for the post-PCI care because outpatients presenting with stable angina that have undergone SVG-PCI through the radial approach were more likely to be discharged the same day.

Limitations

The main limitation of this study lies in its nonrandomized nature. However, the present data represent a large population of all-comer patients, and our overall findings are in accordance with the large body of evidence. Moreover, its international and multicenter design represents current practices in North American and European centers, thus providing real-world data on this subset of patients. The true magnitude of access-site–related complications may be underestimated because of the retrospective nature of our work, and thus, for instance, nonmajor hematomas or vascular complications that did not require specific attention might not have been documented in patient's medical records. However, the well-known benefits of the radial approach in reducing vascular and bleeding complications should also apply for CABG patients.

Conclusions

Radial access for SVG angiography and intervention is safe and feasible, without increasing fluoroscopy time. In experienced centers, radial access was associated with fewer catheters, lower contrast volume, and lower rate of vascular access-site bleeding complications. Moreover, outpatients undergoing SVG-PCI though the radial approach had a higher likelihood of a same-day discharge home.

Impact on daily life

Patients with a history of coronary artery bypass graft (CABG) surgery are more frequently older and present with greater comorbidity burden compared with those undergoing angiography and percutaneous coronary intervention (PCI) for native coronary artery disease. The present study shows that radial access is safe and feasible, without increasing fluoroscopy time. Moreover, radial approach was associated with fewer catheters used, lower rate of vascular access-site bleeding complications and lower contrast volume.

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Disclosure

The authors have no conflicts of interest to declare.

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