**Radial versus Femoral Approach for Saphenous Vein Grafts Angiography and Interventions**

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**ABSTRACT**

**Aims**

Coronary angiography and intervention to saphenous venous grafts (SVGs) remains 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 and Results**

Data from 1481 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. 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 versus femoral 2.6±1.1, P=0.61) but the radial group required a fewer number of catheters (2.6±1.7 versus 4.1±1.1, P<0.001). Fluoroscopy time was comparable between groups, and there was a trend towards lower contrast volume in the radial group (P=0.045). In overall, the total dose of heparin was significantly higher in the radial group (P<0.001); however, radial patients experienced significantly less access-site bleeding complications (P<0.001). Outpatients undergoing radial SVG interventions had a higher likelihood of a same-day discharge home (P<0.001).

**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-PCI though the radial approach had a higher likelihood of a same-day discharge home.

**CONDENSED ABSTRACT**

The current study investigated the safety and feasibility of performing SVG angiography and interventions using the radial access as compared to the femoral approach. Procedural-related data such as fluoroscopy time and access-site crossovers were comparable for both groups. Fewer total number of catheters, lower periprocedural and bleeding complications, and lower volume of contrast were observed in the radial group. Moreover, outpatients undergoing SVG interventions though the radial approach had a higher likelihood of a same-day discharge home.

## ABBREVIATION LIST

BARC: bleeding academic research consortium

CABG: coronary artery bypass graft

DAPT: dual antiplatelet therapy

EASY: early discharge after transradial stenting of coronary arteries

MACE: major adverse cardiovascular events

MI: myocardial infraction

PCI: percutaneous coronary intervention

SVG: saphenous vein graft

**INTRODUCTION**

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 while 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) remains challenging due to 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.

**METHODS**

**Study design and participants**

This is a multi-center, international study conducted at four experienced radial centers: London Health Sciences Centre, London, Ontario, Canada; The Wright Center for Graduate Medical Education, Scranton, Scranton, Pennsylvania, USA; The Pennsylvania State University, Heart and Vascular Institute, Hershey, Pennsylvania, USA; and Cardiovascular Institute, Hospital Clínico San Carlos, Madrid, Spain. Data were prospectively collected in dedicated local datasets and retrospectively analyzed from consecutive left heart catheterization procedures (angiography/PCI) performed in patients with a history of CABG with SVGs between 2010-2016. Patients’ demographics, procedural and in-hospital outcome were retrieved from the institutions’ electronic health record systems. We excluded patients without SVGs (i.e. arterial conduits only), known occluded SVGs, or when PCI was solely undertaken to a native vessel, unless performed through an SVG (i.e. 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 over 85% of their procedures by the radial approach in all-comers. Intravenous unfractionated heparin 50 units/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, allthe included procedures had to be considered successful. For diagnostic angiography, procedural success was defined as angiographic demonstration of all native arteries andbypass grafts (SVGs and/or arterial) unless specific graft/s 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 cross-over (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 applied, and, whenever possible, patent hemostasis was followed.12 For femoral patients, the sheath was removed in the cath lab 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 utilized and the occurrence of major adverse cardiovascular events (MACE) comprising death, myocardial infarction, and stroke. Bleeding complications were defined using Bleeding Academic Research Consortium (BARC) definitions.13 The Early Discharge After Transradial Stenting of Coronary Arteries (EASY) 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 EASY classification. Myocardial infarction was defined according to the Third Universal Definition of Myocardial Infarction.15

**Statistical analyses**

Continuous variables are expressed as a mean ± standard deviation and categorical variables as n (%). Comparison of continuous variables was performed using the t-test, and categorical variables were compared using the Chi-square test. Statistical tests were two-tailed, and differences were considered statistically significant when a P-value was <0.05. Data analyses were performed using Statistical Package for Social Sciences (SPSS) version 24 (IBM, Inc. in Chicago, Illinois, USA).

**RESULTS**

**Population**

Data on 1481 patients were gathered, including 863 radial and 618 femoral procedures. Patients undergoing angiography by femoral approach were older (71±10 versus 67±12, P<0.001), more often men (81% versus 76%, P=0.01), had a lower body mass index (29.7±5.8 versus 30.5±8, P=0.02), higher prevalence of diabetes (48% versus 39%, P<0.001), hypertension (93% versus 81%, P<0.001), and history of MI (63% vs. 49%, P<0.001). The radial group showed a higher prevalence of atrial fibrillation/flutter (40% vs. 17%, P<0.001) and chronic kidney disease (36% vs. 27%, P= 0.032). About two-thirds of the patients had undergone the procedure due to stable or unstable angina in both groups, and one-third for non-ST elevation MI. A minority had procedures due to STEMIs. Other clinical characteristics were balanced between both groups (**Table 1**).

**Procedural data**

***Coronary artery bypass graft 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 versus femoral 2.6±1.1, P=0.61) and access-site cross-overs (radial 2.8% versus femoral 1.6%, P=0.08), **Table 2**. The radial group received significantly smaller sheath size (5.45±0.66 French versus 5.54±0.86 French, P=0.035), fewer number of catheters to complete the angiogram (2.3±1.5 versus 3.6±1.2, P<0.001), required a lower amount of contrast (203±82 versus 224±99 mL, P=0.045) and had similar fluoroscopy time (24.9±11.8 versus 25.2±14.6 minutes, P=0.88), **Table 2**. The total dose of heparin was significantly higher in the radial group (5023±1271 versus 2549±812 units, P<0.001); however, radial patients experienced significantly less BARC type 1 bleedings (0.8% versus 2.6%, P=0.006) and trended towards less BARC type 3a bleedings (0% versus 0.3%, P=0.09) complications. The overall rate of bleeding complications was lower in the radial group (0.8% versus 2.9%, P=0.002), as well as were access-site hematoma (0.9% versus 3.2%, P<0.001). There were numerically more periprocedural MACE in the femoral group (3 deaths and 3 strokes) with none in the radial group, **Table 2**.

***Coronary artery bypass graft 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 as well as the number of implanted stents (radial 1.5±0.9 versus femoral 1.5±0.8, P=0.70) were similar. In overall, the number of catheters including both, diagnostic and PCI, was significantly lower in the radial group (2.6±1.7 versus 4.1±1.1, P<0.001), and sheath size (6.01±0.24 French versus 6.06±0.75 French, P=0.70) and fluoroscopy times were comparable in between both groups, and contrast volume was numerically lower in radial procedures for SVG-PCI, **Table 3.**

The use of dual antiplatelet therapy was similar (98% versus 97%, P=0.60) but the femoral group received more P2Y12 inhibitor (other than clopidogrel) (13% versus 3.1%, P=0.002) 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 versus 7014±1935 units, P<0.001). Bleeding complications and periprocedural MACE were numerically lower in the radial group but did not reach statistical significance between groups, **Table 3**.

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% versus 3.2%, P<0.001), **Table 3**.

The access route influenced the type of guide catheter for SVG-PCI, with Judkins Right 4.0 being the most 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 1500 patients with previous CABG undergoing SVG angiography and PCI showed that the radial approach is safe and achieves similar results with overall fewer number of catheters and trend towards lower contrast volume as compared to the femoral approach. Importantly, in 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 shows that this adoption is still slow. Indeed, Feldman at 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 cross-overs. 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 cross-over vary considerably in the literature between 1.5% to 17.2% in radial series and 0% to 1.3% in femoral series.16-22 Our findings show a relatively low, and similar cross-over 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 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 towards lower contrast volume with radial approach noted in our study can, in part, be explained by the less likely need for catheters’ exchanges, thus, less need for repetitive catheters’ fill out with contrast.

**Safety, Efficacy and Post-procedural 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 While 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, even though 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 can demonstrate any statistically significant difference. Han and colleagues21 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 provides further insight for the post-PCI care since, 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 non-randomized nature. However, the present data represents a large population of all-comers patients and our overall findings are in accordance with the large body of evidence. Moreover, its international and multi-center 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 due to the retrospective nature of our work and thus, for instance, non-major hematomas or vascular complications that did not require specific attention might not have been documented in patient’s charts. However, the well-known benefits of the radial approach in reducing vascular and bleeding complications should also apply for CABG patients.

**CONCLUSION**

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

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**Figure legend**

**Figure 1. A)** Overall use of guide catheters shapes for saphenous vein graft (SVG) percutaneous coronary intervention. Some percentages may not add up to 100 because of rounding. Pannels **B)** and **C)** total numbersaccording 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.

**Table 1: Baseline clinical characteristics of patients undergoing coronary artery bypass graft angiography and intervention**

|  |  |  |  |
| --- | --- | --- | --- |
| **Clinical characteristics** | **Radial**  **(n=863)** | **Femoral**  **(n=618)** | **P-value** |
| Age (years) | 67±12 | 71±10 | <0.001 |
| Male | 653 (76) | 504 (81) | 0.01 |
| Body mass index (kg/m2) | 30.5±8.0 | 29.7±5.8 | 0.02 |
| Diabetes | 339 (39) | 297 (48) | <0.001 |
| Hypertension | 695 (81) | 574 (93) | <0.001 |
| Dyslipidemia | 409 (91) | 557 (90) | 0.97 |
| History of heart failure | 217 (25) | 180 (29) | 0.09 |
| Chronic atrial fibrillation/flutter | 178 (40) | 105 (17) | <0.001 |
| Previous myocardial infarction | 420 (49) | 390 (63) | <0.001 |
| Previous PCI | 310 (36) | 226 (37) | 0.83 |
| Cerebrovascular disease | 91 (11) | 75 (12) | 0.34 |
| Peripheral vascular disease | 148 (17) | 116 (19) | 0.44 |
| Chronic obstructive pulmonary disease | 119 (14) | 71 (12) | 0.19 |
| Chronic kidney disease\* | 141 (36) | 167 (27) | 0.03 |
| Left ventricular ejection fraction (%) | 49.5±14.3 | 48.2±12.8 | 0.16 |
| Clinical setting € |  |  |  |
| Stable angina | 161/451 (36) | 249/616 (40) | 0.18 |
| Unstable angina | 106/451 (24) | 126/616 (21) | 0.23 |
| NSTEMI | 118/451 (26) | 161/616 (26) | 0.99 |
| STEMI | 8/451 (1.8) | 31/616 (5.0) | 0.005 |

Values are expressed as n (%), mean±SD unless otherwise noted. CIED: cardiac implantable electronic device. \*Estimated glomerular filtration rate <60 mL/min/1.72m2. Some percentages may not add up to 100 because of rounding. PCI: percutaneous coronary intervention. NSTEMI: non-ST elevation myocardial infarction. STEMI: ST elevation myocardial infarction.

**Table 2. Procedural characteristics of patients undergoing coronary artery bypass graft 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 | 0.61 | | | |
| Number of catheters used (angiography only) | 2.3±1.5 | 3.6±1.2 | <0.001 | | | |
| Access-site cross-over | 24 (2.8) | 10 (1.6) | 0.08 | | | |
| Sheath size (French) | 5.45±0.66 | 5.54±0.86 | 0.035 | | | |
| Closure device (collagen plug-based) | - | 72 (12) | - | | | |
| Dose heparin (units, angiography only) | 5023±1271 | 2549±812 | <0.001 | | | |
| Total contrast volume (mL) | 203±82 | 224±99 | 0.045 | | | |
| Total fluoroscopy time (minutes) | 24.9±11.8 | 25.2±14.6 | 0.88 | | | |
| **Periprocedural complications** |  |  |  | | | |
| Bleeding complications | 7 (0.8) | 18 (2.9) | 0.002 | | | |
| BARC type 1 | 7 (0.8) | 16 (2.6) | 0.006 | | | |
| BARC type 3a | 0 (0) | 2 (0.3) | 0.09 | | | |
| Access-site hematoma (any) | 8 (0.9) | 20 (3.2) | | <0.001 |
| Death | 0 (0) | 3\* (0.5) | | 0.29 |
| Myocardial infarction | 0 (0) | 0 (0) | | - |
| Stroke | 0 (0) | 3 (0.5) | | 0.29 |

Values are expressed as n (%), mean±SD unless otherwise noted. Some percentages may not add up to 100 because of rounding. SVG: saphenous vein graft. PCI: percutaneous coronary intervention. BARC: Bleeding Academic Research Consortium. \*One patient in cardiogenic shock, 1 arrested while on ECMO, and 1 admitted post ventricular fibrillation arrest, then cardiogenic shock.

**Table 3: Procedural characteristics of patients undergoing coronary artery bypass graft percutaneous intervention**

|  |  |  |  |
| --- | --- | --- | --- |
| **Procedural intervention data** | **Radial**  **(n=211)** | **Femoral**  **(n=260)** | **P-value** |
| Left radial artery access | 90 (43) | - | - |
| Total number of catheters used (angiography and PCI) | 2.6±1.7 | 4.1±1.1 | <0.001 |
| Sheath size (French) | 6.01±0.24 | 6.06±0.75 | 0.70 |
| Closure device (collagen plug-based) | - | 42 (16) | - |
| Dual antiplatelet therapy | 207 (98) | 253 (97) | 0.60 |
| P2Y12 inhibitor (other than clopidogrel) | 3 (3.1) | 32 (13) | 0.002 |
| Number of stents | 1.5±0.9 | 1.5±0.8 | 0.70 |
| Total dose heparin (units, angiography and PCI) | 9753±2542 | 7014±1935 | <0.001 |
| Procedural success | 211 (100) | 260 (100) | - |
| **Procedure type** |  |  |  |
| Diagnostic plus ad hoc PCI to SVG | 151 (71) | 189 (73) | 0.89 |
| Fluoroscopy time (minutes) | 24.5±12.1 | 24.3±14.7 | 0.92 |
| Contrast volume (mL) | 205±82 | 208±83 | 0.76 |
| Diagnostic plus ad hoc PCI to native via SVG | 8 (3.8) | 10 (3.8) | 1.00 |
| Fluoroscopy time (minutes) | 27.0±11.0 | 28.3±14.9 | 0.76 |
| Contrast volume (mL) | 192±85 | 271±131 | 0.022 |
| Staged PCI to SVG\* | 52 (25) | 61 (23) | 0.89 |
| Fluoroscopy time (minutes)\*\* | 26.0±2.7 | 24.3±10.2 | 0.63 |
| Contrast volume (mL)\*\* | 185±21 | 262±103 | 0.16 |
| **SVG territory** |  |  |  |
| Left anterior descending/diagonal | 24/114 (21) | 50 (19) | 0.42 |
| 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) | 0.30 |
| BARC type 1 | 3/114 (2.6) | 9 (3.5) | 0.68 |
| BARC type 3a | 0/114 (0) | 4 (1.5) | 0.18 |
| Access-site hematoma (any) | 5/114 (4.4) | 14 (5.4) | 0.69 |
| Death | 0 (0) | 0 (0) | - |
| Myocardial infarction | 0 (0) | 7 (2.7) | 0.11 |
| Stroke | 0 (0) | 1 (0.4) | 0.99 |
| Same-day discharge (for stable angina only) | 10/40 (25) | 3/94 (3.2) | <0.001 |

Values are expressed as n (%), mean±SD unless otherwise noted. Some percentages may not add up to 100 because of rounding. PCI: percutaneous coronary intervention. SVG: saphenous vein graft. BARC: Bleeding Academic Research Consortium. \*13 patients underwent diagnostic angiogram through the femoral access, then referred for staged-PCI and the operator decided to perform the PCI through the radial access, therefore, we did not consider these cases as cross-over. \*\*Values represent the sum of both, angiography and PCI procedures.