**Same-day Inter-Facility Transfer for Percutaneous Coronary Intervention**

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**ABSTRACT**

**Background:** The use of radial approach for coronary angiography, followed by same-day inter-facility transfer for percutaneous coronary intervention (PCI) has not yet been evaluated. We sought to assess the safety and feasibility of using the transradial as compared to the transfemoral approach in patients undergoing diagnostic angiogram with same-day transfer to a PCI facility.

**Objectives:** Assessing the feasibility and safety of transradial access for same day inter-facility transfer.

**Methods:** Patients that underwent diagnostic catheterization between January 2011 and June 2017 in a referring facility, and were transferred for same-day PCI were included. Patients’ demographics, as well as procedural data and in-hospital outcome, were collected.

**Results:** Three hundred fifty-two participants were included. Of these, 36 (10.2%) patients received transradial access.Patients in the transradial group were older (68±10 versus 62±12 years, P=0.007), and received a significantly higher total dose of heparin including both, diagnostic and PCI procedures (5935±1865 versus 10029±2771 units, P<0.001). None of the transradial patients experienced bleeding or access-related complications. In the transfemoral group, 9 (3%) vascular-access complications were recorded. Contrast volume was lower for transradial patients (177±47 versus 216±75 mL, P<0.001). A higher proportion of outpatients after transradial procedures were discharged from the PCI-centre the same day (53% versus 1.3%, P<0.001).

**Conclusions:** Transradial access for inter-facility transfer for PCI after diagnostic angiogram appears safe and feasible, without increasing the risk for ischemic hand complications. Transradial access was associated with fewer bleeding and vascular access-site complications, and with a higher likelihood for a same-day discharge home in outpatients.

**INTRODUCTION**

The transradial approach for coronary angiography and intervention has gained popularity worldwide. Advantages include, among others, a greater patient’s comfort and rapid post-procedural ambulation, reduction in the risk of bleeding, vascular complications and improved mortality outcomes in high-risk patient populations.1-8 These benefits have been demonstrated in a broad spectrum of patients and clinical scenarios.1-8 While percutaneous coronary interventions (PCIs) are often undertaken ad-hoc following coronary angiography, many healthcare systems conduct coronary angiography in community hospitals without PCI capabilities,9,10 and therefore, if significant lesions are documented, patients have to be transferred for PCI to a PCI capable centre.

The use of radial approach for coronary angiography, followed by same-day inter-facility transfer for PCI, in such healthcare systems, has not yet been evaluated. Therefore, we sought to assess the safety and feasibility of using the transradial as compared to the transfemoral approach in patients undergoing diagnostic angiogram who were subsequently transferred the same-day to a PCI facility.

**MATERIAL AND METHODS**

**Population**

Between January 2011 and June 2017, we retrospectively analyzed patients who underwent coronary angiography for elective or non-ST-segment elevation acute coronary syndrome (ACS) indications at Victoria Hospital, a non-PCI capable facility. This hospital is not set to perform urgent catheterization and is not part of the ST-elevation myocardial infarction (STEMI) program, and has no surgical background. Therefore, STEMI patients were not included since were directly transferred to the PCI-centre. If patients were found to have significant coronary lesions deemed to be treated the same day, the angiogram was remotely reviewed by the interventional cardiologist, and the patients were transferred by ambulance to the University Hospital, London Health Sciences Centre, London, Ontario, for PCI as per local protocol. Patients were excluded from the study for the following reasons: 1) If a diagnostic angiogram was performed with no indication for PCI. 2) If PCI was performed in a different day (i.e. transferred to PCI the day after the angiogram or had a scheduled elective PCI as outpatient). Baseline clinical and periprocedural data were documented. To assess the potential impact of different access-site practice in clinical outcomes, characteristics and clinical outcomes of patients undergoing transradial procedures were compared to those undergoing transfemoral approach. The study was approved by the Western University Research Ethics Board.

**Diagnostic and Intervention Procedures**

The procedures’ technical aspects including access site choice, sheath size, and diagnostic catheters were at the physicians’ discretion. A group of 4 operators are invasive (non-interventional) cardiologists performing more than 100 diagnostic angiograms per year at the non-PCI centre. Seven experienced interventional cardiologists performing about 400 angiograms/200 PCIs yearly/per operator and also actively involved in the 24/7 STEMI program are performing the procedures at the PCI-centre. Particularly for transradial patients, angiograms were performed by interventional cardiologists performing over 80% of their procedures by the radial approach. Routine assessment of the palmar-arch circulation was carried out by plethysmography as described by Barbeau et al.,11 waveforms A, B, and C were eligible, and 50 units/kg of unfractionated heparin were administered intravenously at the beginning of the diagnostic angiogram, to prevent radial artery occlusion. Heparin was not systematically given for TF diagnostic procedures. Prior to inter-facility transfer, the radial (Figure 1) or femoral sheath was sutured in place and connected to a pressurized heparinized saline flush using a standard arterial line setup. Inter-facility transport was carried out by local emergency medical services.

Upon arrival at University Hospital Campus, patients were taken to the catheterization laboratory, were draped in the usual manner, and the in-place sheath was replaced and usually upsized (i.e., 5-French to 6-French) in a sterile manner. Peri-procedural anticoagulation and antiplatelet strategy, as well as catheters and PCI-related decisions, were undertaken as per interventional cardiologist discretion. Note that the initial access-site choice for angiography was maintained for further PCI. Therefore, there were no cases of intentional or unintentional (i.e., difficulties during PCI) crossover.

After completion of the transradial procedure, the sheath was removed, and a hemostatic wristband applied for 1-hour carefully achieving patent hemostasis.12 For transfemoral 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 less than 160 seconds. Most patients were then kept in hospital overnight, and in selected cases, patients were discharged-home 3-4 hours post-PCI.

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 the gradation of wrist hematomas.14 Briefly, Grade I (up to 5 cm), Grade II (up to 10 cm), and Grade III (>10 cm). Femoral hematomas were also graded upon the EASY classification.

**Statistical analyses**

Continuous variables are expressed as a mean ± standard deviation and categorical variables as n (%). Comparison of continuous variables was performed using the two-sided Student’s 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., Chicago, Illinois, USA).

**RESULTS**

A total of 352 patients were included in the study. Of these, 36 (10.2%) patients were performed through the transradial approach. Baseline patient’s characteristics are described in Table 1. Overall, patient’s demographics were similar, but patients in the transradial group were older (68±10 versus 62±12 years, P=0.007). Lower hemoglobin levels (129±18 versus 136±19 g/L, p=0.046) and higher prevalence of peripheral vascular disease (11% versus 3%, p=0.044) were observed for the transradial group Procedural characteristics and outcomes are shown in Table 2. The total dose of heparin including both, diagnostic and PCI procedures was significantly higher in the transradial group, 5935±1865 versus 10029±2771 units, P<0.001); however, none of the transradial patients experienced bleeding or access-related complications. In the transfemoral group, 1 (0.3%) patient had a minor oozing (BARC type 1), and 9 (2.8%) experienced access-related complications (P=0.606). Among these, two patients had post-procedural pseudoaneurysm that was successfully treated with local injection of thrombin, one patient needed administration of 2 packed red blood cell units due to bleeding from a femoral access-site (BARC type 3a), and six patients had a documented groin hematoma that was treated conservatively. Finally, one patient in the transfemoral group experiences a catheter-induced right aortic-cusp tear that retrogradely progressed to the ascending aorta. The right coronary artery was treated with drug-eluting stents covering up to its ostium, and the ascending aorta hematoma was medically managed. A 6-month computed-tomography follow-up showed no further progression and the patient was completely asymptomatic.

Patients in the transradial group received a significantly smaller amount of contrast (177±47 versus 216±75 mL, P<0.001). Prior to discharge, the patency of the radial artery was assessed by plethysmography compressing the ulnar artery, and plethysmographic waveform restoration was present in all patients confirming its patency. Outpatients presenting with stable angina who underwent uncomplicated transradial procedures were more likely to be discharged-home, from the PCI-centre, the same day (53% versus 1.3%, P<0.001).

**DISCUSSION**

The study shows that inter-facility transfer for same-day PCI after diagnostic angiogram appears feasible and safe. The transradial access was associated with substantially less access-related and bleeding complication and significantly lower amount of contrast dye. Notably, outpatients were more likely to be discharged-home the same day after transradial procedures.

The wide adoption and conversion from transfemoral to transradial approach is based on a large body of evidence supporting its superiority in reducing the risk of bleeding and vascular complications, reduced mortality, reduced length of stay and improved cost-effectiveness associated with the transradial access site.8,15-23 Our analysis builds upon this evidence basis; we show that access site bleeding complications occurred in 2.8% of cases undertaken through the femoral approach with no complications recorded in procedures conducted radially. This finding should be seen in the context of higher prevalence of peripheral vascular disease in the transradial group. It might suggest that the radial approach was favored by the operators for those patients with vascular disease, presumably due to concern about the safety of the femoral access Notably, the fact that patients undergoing femoral access for diagnostic angiography did not systematically receive IV heparin, and thus, receiving about half of the total dose, puts our results at a higher relevance. Furthermore, we show that in diagnostic cases undertaken through the radial approach, transfer with the sheath in situ to the interventional centre allowed the successful completion of the PCI procedures through the same radial arterial access site in all cases, and without any complication.

The slow adoption (or not at all) of radial access at the referring centre was related to invasive cardiologists who had received their training in cardiac catheterization when the femoral access was the gold standard. As such, the conversion to a radial-first access strategy should also be encouraged for cardiologists, without interventional-training, but are performing diagnostic procedures at referring centers. Certainly, the choice for initial access site directly influences the future interventional procedure in cases of same-day transfer for PCI. Importantly, although not explored in our series, the decision of removing the femoral sheath after completing coronary angiogram and latter obtaining radial access for PCI, it does not preclude the risk of initial access-site complication and/or further bleeding during PCI.

The practice of same-day discharge was applied for outpatients (stable patients) only. Hence, those patients transferred for PCI, they stayed either in the recovery room or short-stay unit at the University Hospital (where PCI was completed), then discharged-home without going back to the referring facility. This strategy may be particularly important for health-care systems with similar models of service delivery to ours.

**Study Limitations**

The present study has several limitations. The main limitation lies in the retrospective nature of the study. Additionally, the unbalanced sample size between procedures undertaken radially and femorally limits our results. Moreover, it was difficult to assess the outcomes of one intervention which was composed by two parts (initial vascular access for coronary angiography and PCI), each performed by a different physician. Another significant limitation of the study is its single-center nature involving just one referring hospital. This significantly limits the external validity of the findings. However, our overall findings are in accordance with the large body of evidence. Hence, we believe that the superiority of the transradial approach in reducing vascular and bleeding complications opens a new avenue for centers without on-site PCI capabilities, by allowing an easier and safe same-day transfer for further treatment and thus, avoiding costs of prolonged hospitalizations. These results should indeed be validated and supported by future, larger-scale studies.

**CONCLUSION**

The present study shows that transradial access for same-day inter-facility transfer for PCI after diagnostic angiogram appears safe and feasible without increasing the risk for ischemic hand complications. Radial access was associated with fewer bleeding and vascular access-site complications, and with a higher likelihood of a same-day discharge in outpatients.

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**References:**

1. Bagur R, Bertrand OF, Rodes-Cabau J, et al. Comparison of outcomes in patients > or =70 years versus <70 years after transradial coronary stenting with maximal antiplatelet therapy for acute coronary syndrome. *Am J Cardiol.* 2009;104(5):624-629.

2. Tizon-Marcos H, Bertrand OF, Rodes-Cabau J, et al. Impact of female gender and transradial coronary stenting with maximal antiplatelet therapy on bleeding and ischemic outcomes. *Am Heart J.* 2009;157(4):740-745.

3. Bertrand OF, Rodes-Cabau J, Rinfret S, et al. Impact of final activated clotting time after transradial coronary stenting with maximal antiplatelet therapy. *Am J Cardiol.* 2009;104(9):1235-1240.

4. Bagur R, Bertrand OF, Rodes-Cabau J, et al. Long term efficacy of abciximab bolus-only compared to abciximab bolus and infusion after transradial coronary stenting. *Catheter Cardiovasc Interv.* 2009;74(7):1010-1016.

5. Romagnoli E, Biondi-Zoccai G, Sciahbasi A, et al. Radial versus femoral randomized investigation in ST-segment elevation acute coronary syndrome: the RIFLE-STEACS (Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome) study. *J Am Coll Cardiol.* 2012;60(24):2481-2489.

6. Bernat I, Horak D, Stasek J, et al. ST-segment elevation myocardial infarction treated by radial or femoral approach in a multicenter randomized clinical trial: the STEMI-RADIAL trial. *J Am Coll Cardiol.* 2014;63(10):964-972.

7. Bagur R, Bertrand OF, Beliveau P, et al. Feasibility of using a sheathless guiding catheter for left ventricular endomyocardial biopsy performed by transradial approach. *J Invasive Cardiol.* 2014;26(12):E161-163.

8. Ando G, Capodanno D. Radial Access Reduces Mortality in Patients With Acute Coronary Syndromes: Results From an Updated Trial Sequential Analysis of Randomized Trials. *JACC Cardiovasc Interv.* 2016;9(7):660-670.

9. Roe MT, Chen AY, Delong ER, et al. Patterns of transfer for patients with non-ST-segment elevation acute coronary syndrome from community to tertiary care hospitals. *Am Heart J.* 2008;156(1):185-192.

10. Shen L, Shah BR, Li S, et al. The Association of Transfer Rate From Hospitals Without Revascularization Capabilities and Mortality Risk for Older Non-ST-Segment Elevation Myocardial Infarction Patients. *Clin Cardiol.* 2015;38(12):733-739.

11. Barbeau GR, Arsenault F, Dugas L, Simard S, Lariviere MM. Evaluation of the ulnopalmar arterial arches with pulse oximetry and plethysmography: comparison with the Allen's test in 1010 patients. *Am Heart J.* 2004;147(3):489-493.

12. Lavi S, Cheema A, Yadegari A, et al. Randomized Trial of Compression Duration After Transradial Cardiac Catheterization and Intervention. *J Am Heart Assoc.* 2017;6(2):pii: e005029. doi: 005010.001161/JAHA.005116.005029.

13. Mehran R, Rao SV, Bhatt DL, et al. Standardized bleeding definitions for cardiovascular clinical trials: a consensus report from the Bleeding Academic Research Consortium. *Circulation.* 2011;123(23):2736-2747.

14. Bertrand OF. Acute forearm muscle swelling post transradial catheterization and compartment syndrome: prevention is better than treatment! *Catheter Cardiovasc Interv.* 2010;75(3):366-368.

15. Karrowni W, Vyas A, Giacomino B, et al. Radial versus femoral access for primary percutaneous interventions in ST-segment elevation myocardial infarction patients: a meta-analysis of randomized controlled trials. *JACC Cardiovasc Interv.* 2013;6(8):814-823.

16. Jin C, Li W, Qiao SB, et al. Costs and Benefits Associated With Transradial Versus Transfemoral Percutaneous Coronary Intervention in China. *J Am Heart Assoc.* 2016;5(4).

17. Kwok CS, Sherwood MW, Watson SM, et al. Blood transfusion after percutaneous coronary intervention and risk of subsequent adverse outcomes: a systematic review and meta-analysis. *JACC Cardiovasc Interv.* 2015;8(3):436-446.

18. Rao SV, Dai D, Subherwal S, et al. Association between periprocedural bleeding and long-term outcomes following percutaneous coronary intervention in older patients. *JACC Cardiovasc Interv.* 2012;5(9):958-965.

19. Doyle BJ, Rihal CS, Gastineau DA, Holmes DR, Jr. Bleeding, blood transfusion, and increased mortality after percutaneous coronary intervention: implications for contemporary practice. *J Am Coll Cardiol.* 2009;53(22):2019-2027.

20. Kinnaird TD, Stabile E, Mintz GS, et al. Incidence, predictors, and prognostic implications of bleeding and blood transfusion following percutaneous coronary interventions. *Am J Cardiol.* 2003;92(8):930-935.

21. Ayhan E, Isik T, Uyarel H, et al. Femoral pseudoaneurysm in patients undergoing primary percutaneous coronary intervention for ST-elevation myocardial infarction: incidence, clinical course and risk factors. *Int Angiol.* 2012;31(6):579-585.

22. Nathan S, Rao SV. Radial versus femoral access for percutaneous coronary intervention: implications for vascular complications and bleeding. *Curr Cardiol Rep.* 2012;14(4):502-509.

23. Schussler JM, Vasudevan A, von Bose LJ, Won JI, McCullough PA. Comparative Efficacy of Transradial Versus Transfemoral Approach for Coronary Angiography and Percutaneous Coronary Intervention. *Am J Cardiol.* 2016;118(4):482-488.

**Figure legend**

**Figure 1.** Right radial access set-up for inter-facility transfer.