Published in final edited form as:

Am J Cardiol. 2015 August 1; 116(3): 379–383. doi:10.1016/j.amjcard.2015.04.051.

Predictors of Access Site Crossover in Patients Undergoing Transradial Coronary Angiography

Jeffrey Le, BA^a, Sripal Bangalore, MD, MHA^a, Yu Guo, MA^b, Sohah N. Iqbal, MD^a, Jinfeng Xu, PhD^b, Louis H. Miller, MD^a, John Coppola, MD^a, and Binita Shah, MD, MS^a

^aDivision of Cardiology, Department of Medicine, Division of Cardiology, New York University School of Medicine, New York, NY

^bDivision of Biostatistics, Department of Population Health, New York University School of Medicine, New York, NY

Abstract

Despite increasing use of the transradial approach (TRA) for coronary angiography, TRA failure and subsequent access site crossover remain a barrier to TRA adoption. The aim of this study was to elucidate patient and procedural characteristics associated with TRA to transfemoral approach (TFA) crossover, as well as examine TRA to TFA crossover by operator experience over time.

This retrospective analysis identified 1600 patients undergoing coronary angiography with possible PCI via TRA by operators with varied TRA experience in an urban tertiary care center from October 2010 to August 2013. Univariate and multivariable logistic regression were used to identify independent predictors of access site crossover, from TRA to TFA, and strength of association is presented as odds ratio (OR) [95% confidence interval]. Access site crossover was noted in 166 patients (10.4%). Multivariable predictors of access site crossover included age >75 years (OR 1.90 [1.23–2.91], $p=0.004$) and operator experience (OR 2.98 [1.96–4.52], $p<0.0001$). Less experienced operators (<5 years TRA experience) had a decrease in access site crossover over time (Quartile 1: 8.9%, Quartile 2: 18.8%, Quartile 3: 16.4%, Quartile 4: 8.6%; $p<0.001$), which paralleled an increase in the proportion of procedures using initial TRA over time (Quartile 1: 38.0%, Quartile 2: 53.7%, Quartile 3: 54.8%, Quartile 4: 70.3%; $p<0.001$). Experienced operators (>5 years TRA experience) had no significant change in proportion of access site crossover over time (Quartile 1: 2.8%, Quartile 2: 6.4%, Quartile 3: 5.6%, Quartile 4: 5.8%; $p=0.54$). In conclusion, rate of access site crossover in the contemporary era is relatively low and can be mitigated with operator experience.

Corresponding Author: Binita Shah, 227 E 30th Street, Office 835, New York, NY 10016, Telephone: 212-263-4235, Fax: 212-263-8534, binita.shah@nyumc.org.

Disclosures

Dr. Coppola is a consultant for Terumo and speaker for Medtronic. The authors have no conflicts of interest in relation to this manuscript.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Keywords

transradial; transfemoral; coronary angiography; crossover

A transradial approach (TRA) to coronary angiography and percutaneous coronary intervention (PCI) is associated with decreased bleeding and access site complications, shorter hospital stays, early ambulation, and improved patient comfort when compared to the transfemoral approach (TFA) (1–4). TRA is also associated with decreased mortality in patients presenting with ST-segment elevation myocardial infarction (5–6). Although utilization of TRA is increasing in the United States, the overall prevalence still remains <20% of all procedures (7–8). Anatomical factors that decrease operator adoption and increase the learning curve associated with TRA include access site failure, radial artery spasm, radial and brachial loops, and tortuosity of the innominate trunk. These factors may also lead to increased rate of access site crossover. Access site crossovers can be potentially problematic as it increases procedure duration, radiation exposure, and risk of vascular complications related to multiple sites of access in patients on antiplatelet and antithrombotic therapy. This study aims to detail patient and procedural characteristics associated with access site crossover, from TRA to TFA. This study also aims to examine TRA to TFA crossover by operator experience as utilization of TRA increases over time.

Methods

This is a retrospective study of consecutive patients who underwent a diagnostic coronary angiography with or without PCI using TRA at a tertiary care center from October 2010 to August 2013. Patients who underwent a planned PCI without a diagnostic component were not included. For patients that had more than one procedure using TRA during the study period, only the first chronological procedure was selected. During this study period, transition to the opposite radial or ulnar artery was not routinely performed (n=5) and, therefore, excluded from the study. This study was approved by the institutional review board at New York University School of Medicine and Bellevue Hospital Center.

Approach to coronary angiography and PCI, including access site and type of catheters used, were per individual operator practice. However, during the study period, standard practice was as follows. Conscious sedation was administered prior to local anesthesia with subcutaneous 1% lidocaine. Arterial access was obtained at least 2 cm proximal to the radial styloid process using the Seldinger technique. Once arterial access was obtained, a 5/6 Fr hydrophilic sheath was inserted and a cocktail of 100 µg nitroglycerin, 2.5 mg verapamil, and 2500 U of unfractionated heparin was administered. 5 Fr diagnostic catheters were used to cannulate the coronary arteries, and radial artery angiography was not performed unless the initial wire or catheter could not be passed to the ascending aorta.

Baseline demographic, clinical, and procedural characteristics were abstracted from a review of electronic patient medical records, including cardiac catheterization reports. Operator experience was categorized as those with less (< 5 years) or more (>5 years) TRA experience. The primary outcome of interest was access site crossover defined as crossover

from TRA to TFA for any reason (access failure or failure to engage the coronary arteries or perform PCI).

Continuous variables were examined for normality using the Shapiro Wilkes test. Differences in baseline characteristics between patients who did versus those who did not undergo access site crossover were evaluated by independent two sample t-tests for normally distributed continuous variables, Mann-Whitney U test for skewed continuous variables, and test of proportions for categorical variables. Logistic regression was used to determine multivariable predictors of access site crossover, and strength of association is presented as odds ratio (OR) [95% confidence interval]. Proportion of access site crossover was evaluated over the study period by quartiles of time in days (total cohort: quartile 1, day 1 to 202; quartile 2, day 203 to 434; quartile 3, day 435 to 702; quartile 4, day 703 to 1025). Statistical analysis was conducted using the IBM Statistical Package for Social Sciences software version 20 (IBM Corporation, Armonk, NY) and SAS version 9.3 (SAS Institute Inc., Cary, NC). Statistical significance was tested using a 2-sided α level of 0.05.

Results

Of the 1600 patients who met inclusion and exclusion criteria, 166 patients (10.4%) experienced access site crossover. Baseline characteristics of the group that did versus those that did not undergo access site crossover are shown in Table 1. The proportion of female patients >75 years of age did not differ between the crossover versus no crossover groups (7.2% vs. 5.6%, $p=0.383$).

Procedural characteristics of access site crossover versus no crossover groups are shown in Table 2. Timing of access site crossover in the total cohort and by operator experience is shown in Table 3. Of the patients who did undergo access site crossover, 23 (13.9%) were primarily due to radial artery spasm.

Univariate predictors of access site crossover included age >75 years (OR 1.63 [1.07–2.48], $p=0.0228$) and operator transradial experience ≤ 5 years (OR 2.80 [1.85–4.24], $p<0.0001$). While the rate of access site crossover in operators with >5 years of transradial experience ($n=563$) was 5.2%, the rate of access site crossover in operators with ≤ 5 years of transradial experience ($n=1037$) was 13.2%. The proportions of procedures that underwent access site crossover over time, stratified by operator transradial experience, are shown in Figure 1.

After adjustment for operator experience, the association between age >75 years and access site crossover was strengthened (OR 1.90 [1.23–2.91], $p=0.004$). Similarly, after adjustment for age, the association between operator transradial experience and access site crossover strengthened (OR 2.98 [1.96–4.52], $p<0.0001$).

Discussion

This is one of the larger contemporary studies to examine access site crossover (from TRA to TFA) in an all comers population undergoing coronary angiography with possible PCI by operators with varied TRA experience in a U.S. center. In this study, the proportion of access site crossover appears to be largely driven by patient age and operator experience.

Rate of access site crossover in those with less TRA experience decreases over time as operator utilization of TRA increases, suggesting that operator experience is a modifiable factor.

The 10.4% rate of access site crossover in this study compares to those reported by other centers, which ranges anywhere between 0.7% and 13.8% (9–11). One of the largest studies to date, the multicenter international Radial versus Femoral Access for Coronary Angiography and Intervention in Patients with Acute Coronary Syndromes (RIVAL) trial, reported a 7.0% TRA failure rate, while the multicenter international Radial Versus Femoral Randomized Investigation in ST-Elevation Acute Coronary Syndrome (RIFLE-STEACS) trial reported a 9.6% crossover rate in TRA procedures performed by high-volume operators (1,5). In the current study, the more experienced operators had a crossover rate of 5.2%. This is comparable to a recent meta-analysis by Bertrand et al that reported a mean access site crossover rate of 4.5% in patients undergoing PCI but higher than the 3.8% crossover rate reported by Vink et al in a large observational study of patients from a high-volume center in the Netherlands presenting with ST-segment elevation myocardial infarction (12–13). Although Ball et al also noted a low 4% TRA-PCI failure rate, only non urgent, single vessel TRA-PCI procedures were selected for evaluation, whereas the current study included a more diverse population (14).

In the current study, the only patient characteristic found to correlate with access site crossover was age >75 years. This is consistent with a subgroup analysis from the prospective randomized Transradial Approach (Left vs Right) and Procedural Times During Percutaneous Coronary Procedures (TALENT) study, which demonstrated age >70 years as an independent predictor of subclavian tortuosity (15). A large retrospective analysis by Cha et al reported additional patient characteristics associated with severe right subclavian tortuosity, including female gender, short stature, presence of hypertension, and higher body mass index (16). Although the majority of cases in the current study utilized a right radial approach, more than one third of patients were female, and more than a quarter of patients were < 64 inches, TRA to TFA crossover rate was not associated with these other patient characteristics. Another large retrospective study by Dehghani et al reported only age >75 years, prior coronary artery bypass graft surgery, and short stature as independent predictors of TRA failure (17). Given the rate of patients with prior coronary artery bypass graft surgery was very low in the current study, it is likely that patient selection for TRA versus TFA access played a role in the current results. A multicenter prospective study of 1540 patients in the United Kingdom demonstrated anomalous radial artery anatomy to be associated with TRA failure, and age to be the only independent predictor of a radial artery anomaly (18).

Operator experience was the only procedural characteristic to influence rate of access site crossover. The TALENT study highlighted the potential benefit of a left radial artery approach with less experienced operators (15). Furthermore, subgroup analyses of the TALENT study demonstrated a higher prevalence of subclavian artery tortuosity with right versus left TRA, and age > 70 years was an independent predictor of subclavian artery tortuosity. However, left radial artery access is not routinely performed due to operator physical discomfort when working from the traditional right side of the patient. In the

current study, there was no systematic selection protocol for right versus left TRA, and the majority of patients underwent a right radial artery approach. Although multiple studies have shown that operator experience is associated with lower TRA crossover rate and procedural time, few have evaluated the change in crossover rate with time as operator experience increases (11,13,19–22). In the current study, more experienced operators had low and steady rates of crossover over time, while less experienced operators were associated with an overall decrease in rate of crossover over time. Interestingly, less experienced operators had a low crossover rate early in the observational period. This is likely due to patient selection given that these operators' rate of initial TRA approach was also very low at the start of the study and increased over time.

There are several limitations with the present study, including those inherent to a retrospective single center analysis such as the possibility of unmeasured confounders. This analysis represents procedures performed at a high volume center with a combination of experienced and less experienced operators. Centers with lower volume or without experienced TRA operators to teach radial techniques may not necessarily observe the same data.

Acknowledgments

Funding Sources: Dr. Shah was partially funded by a NIH grant (UL1 TR000038). Part of the data analysis and statistical support was provided by New York University School of Medicine Cardiovascular Outcomes Group.

References

1. Jolly SS, Yusuf S, Cairns J, Niemelä K, Xavier D, Widimsky P, Budaj A, Niemelä M, Valentin V, Lewis BS, Avezum A, Steg PG, Rao SV, Gao P, Afzal R, Joyner CD, Chrolavicius S, Mehta SR. RIVAL trial group. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomized, parallel group, a multicenter trial. *Lancet*. 2011; 377:1409–1420. [PubMed: 21470671]
2. Pristipino C, Trani C, Nazzaro MS, Berni A, Patti G, Patrizi R, Pironi B, Mazzarotto P, Giofrè G, Biondi-Zoccai GG, Richichi G. Prospective REgistry of Vascular Access in Interventions in Lazio Region Study Group. Major improvement of percutaneous cardiovascular procedure outcomes with radial artery catheterization: results from the PREVAIL study. *Heart*. 2009; 95:476–482. [PubMed: 19036757]
3. Rao S, Cohen MG, Kandzari DE, Bertrand OF, Gilchrist IC. The transradial approach to percutaneous coronary intervention: historical perspective, current concepts, and future directions. *J Am Coll Cardiol*. 2010; 55:2187–2195. [PubMed: 20466199]
4. Joyal D, Bertrand OF, Rinfret S, Shimony A, Eisenberg MJ. Meta-analysis of ten trials on the effectiveness of the radial versus the femoral approach in primary percutaneous coronary intervention. *Am J Cardiol*. 2012; 109:813–818. [PubMed: 22196787]
5. Romagnoli E, Biondi-Zoccai G, Sciahbasi A, Politi L, Rigattieri S, Pendenza G, Summari F, Patrizi R, Borghi A, Di Russo C, Moretti C, Agostoni P, Loschiavo P, Liyo E, Sheiban I, Sangiorgi G. 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; 60:2481–2489. [PubMed: 22858390]
6. Valgimigli M, Saia F, Guastaroba P, Menozzi A, Magnavacchi P, Santarelli A, Passerini F, Sangiorgi P, Manari A, Tarantino F, Margheri M, Benassi A, Sangiorgi MG, Tondi S, Marzocchi A. REAL Registry Investigators. Transradial versus transfemoral intervention for acute myocardial infarction: a propensity score-adjusted and -matched analysis from the REAL (REGistro regionale AngiopLastiche dell'Emilia-Romagna) multicenter registry. *JACC Cardiovasc Interv*. 2012; 5:23–35. [PubMed: 22230147]

7. Gutierrez A, Tsai TT, Stanislawski MA, Vidovich M, Bryson CL, Bhatt DL, Grunwald GK, Rumsfeld J, Rao SV. Adoption of transradial percutaneous coronary intervention and outcomes according to center radial volume in the Veterans Affairs Healthcare system: insights from the Veterans Affairs clinical assessment, reporting, and tracking (CART) program. *Circ Cardiovasc Interv.* 2013; 6:336–346. [PubMed: 23941860]
8. Feldman DN, Swaminathan RV, Kaltenbach LA, Baklanov DV, Kim LK, Wong SC, Minutello RM, Messenger JC, Moussa I, Garratt KN, Piana RN, Hillegass WB, Cohen MG, Gilchrist IC, Rao SV. Adoption of radial access and comparison of outcomes to femoral access in percutaneous coronary intervention: an updated report from the national cardiovascular data registry (2007–2012). *Circulation.* 2013; 127:2295–2306. [PubMed: 23753843]
9. Louvard Y, Lefevre T, Allain A, Morice MC. Coronary angiography through the radial or the femoral approach: the CARAFE study. *Catheter Cardiovasc Interv.* 2001; 52:181–187. [PubMed: 11170325]
10. Mann JT, Cubeddu G, Bowen J, Schneider JE, Arrowood M, Newman WN, Zellinger MJ, Rose GC. Stenting in acute coronary syndromes: a comparison of radial versus femoral access sites. *J Am Coll Cardiol.* 1998; 32:572–576. [PubMed: 9741495]
11. Agostoni P, Biondi-Zoccai GG, de Benedictis ML, Rigattieri S, Turri M, Anselmi M, Vassanelli C, Zardini P, Louvard Y, Hamon M. Radial versus femoral approach for percutaneous coronary diagnostic and interventional procedures; Systematic overview and meta-analysis of randomized trials. *J Am Coll Cardiol.* 2004; 44:349–356. [PubMed: 15261930]
12. Bertrand OF, Bélisle P, Joyal D, Costerousse O, Rao SV, Jolly SS, Meerkink D, Joseph L. Comparison of transradial and femoral approaches for percutaneous coronary interventions: a systematic review and hierarchical Bayesian meta-analysis. *Am Heart J.* 2012; 163:632–648. [PubMed: 22520530]
13. Vink MA, Amoroso G, Dirksen MT, van der Schaaf RJ, Patterson MS, Tijssen JG, Kiemeneij F, Slagboom T. Routine use of the transradial approach in primary percutaneous coronary intervention: procedural aspects and outcomes in 2209 patients treated in a single high-volume centre. *Heart.* 2011; 97:1938–1942. [PubMed: 21880651]
14. Ball WT, Sharieff W, Jolly SS, Hong T, Kutryk MJB, Graham JJ, Fam NP, Chisholm RJ, Cheema AN. Characterization of operator learning curve for transradial coronary interventions. *Circ Cardiovasc Interv.* 2011; 4:336–341. [PubMed: 21813402]
15. Sciahbasi A, Romagnoli E, Burzotta F, Trani C, Sarandrea A, Summaria F, Pendenza G, Tommasino A, Patrizi R, Mazzari M, Mongiardo R, Lioy E. Transradial approach (left vs right) and procedural times during percutaneous coronary procedures: TALENT study. *Am Heart J.* 2011; 161:172–179. [PubMed: 21167351]
16. Cha KS, Kim MH, Kim HK. Prevalence and clinical predictors of severe tortuosity of right subclavian artery in patients undergoing transradial coronary angiography. *Am J Cardiol.* 2003; 92:1220–1222. [PubMed: 14609604]
17. Dehghani P, Mohammad A, Bajaj R, Hong T, Suen CM, Sharieff W, Chisholm RJ, Kutryk MJ, Fam NP, Cheema AN. Mechanism and Predictors of Failed Transradial Approach for Percutaneous Coronary Interventions. *JACC Cardiovasc Interv.* 2009; 2:1057–1064. [PubMed: 19926044]
18. Lo TS, Nolan J, Fountzopoulos E, Behan M, Butler R, Hetherington SL, Vijayalakshmi K, Rajagopal R, Fraser D, Zaman A, Hildick-Smith D. Radial artery anomaly and its influence on transradial coronary procedural outcome. *Heart.* 2009; 95:410–415. [PubMed: 18977799]
19. Jolly SS, Cairns J, Yusuf S, Niemela K, Steg PG, Worthley M, Ferrari E, Cantor WJ, Fung A, Valettas N, Rokoss M, Olivecrona GK, Widimsky P, Cheema AN, Gao P, Mehta SR. Procedural volume and outcomes with radial or femoral access for coronary angiography and intervention. *J Am Coll Cardiol.* 2014; 63:954–963. [PubMed: 24269362]
20. Jolly SS, Amlani S, Hamon M, Yusuf S, Mehta SR. Radial versus femoral access for coronary angiography or intervention and the impact on major bleeding and ischemic events: a systematic review and meta-analysis of randomized trials. *Am Heart J.* 2009; 157:132–140. [PubMed: 19081409]

21. Lo TS, Ratib K, Chong AY, Bhatia G, Gunning M, Nolan J. Impact of access site selection and operator expertise on radiation exposure; a controlled prospective study. *Am Heart J.* 2012; 164:455–461. [PubMed: 23067901]
22. Hess CN, Peterson ED, Neely ML, Dai D, Hillegass WB, Krucoff MW, Kutcher MA, Messenger JC, Pancholy S, Piana RN, Rao SV. The learning curve for transradial percutaneous coronary intervention among operators in the United States. A study from the national cardiovascular data registry. *Circulation.* 2014; 129:2277–2286. [PubMed: 24756064]

Figure 1.

A) Proportion of transradial (TRA) to transfemoral (TFA) approach crossover over quartiles of time (days) stratified by operator experience. **B)** Proportion of procedures performed by less experienced operators using initial TRA approach with reference to the proportion of access site crossover in this group over quartiles of time (days). **C)** Proportion of TRA to

TFA crossover over quartiles of time (days) in the less experienced operator group stratified by operator (data are shown for top 3 operators that comprise 86% of the procedures). **D)** Timing of TRA to TFA crossover in the less experienced operator group stratified by operator (data are shown for top 3 operators that comprise 86% of the procedures).

Table 1

Baseline characteristics of patients who did versus those who did not undergo access site crossover during transradial coronary angiography.

Variable	Access Site Crossover		p-value
	Yes (n=166)	No (n=1434)	
Age (years)	61.6 ± 12.4	59.7 ± 11.8	0.085
Age >75 years	31 (18.7%)	177 (12.3%)	0.028
Women	57 (34.3%)	515 (35.9%)	0.733
White	48 (28.9%)	421 (29.4%)	0.658
Black	52 (31.3%)	489 (34.1%)	
Hispanic	30 (18.1%)	219 (15.3%)	
Asian	24 (14.5%)	230 (16.0%)	
Other	12 (7.2%)	75 (5.2%)	
Height (cm)	167.0 ± 11.3	167.5 ± 10.4	0.784
Weight (kg)	80.6 ± 17.4	83.1 ± 22.0	0.416
Body mass index (kg/m ²)	28.9 ± 5.9	29.6 ± 7.4	0.589
Hypertension *	130 (78.3%)	1081 (75.4%)	0.445
Hyperlipidemia [†]	108 (65.1%)	869 (60.6%)	0.276
Diabetes mellitus	67 (40.4%)	544 (37.9%)	0.555
Prior percutaneous coronary intervention	26 (15.7%)	284 (19.8%)	0.215
Prior coronary artery bypass graft surgery	9 (5.4%)	64 (4.5%)	0.555
Peripheral artery disease/aortic aneurysm	9 (5.4%)	61 (4.3%)	0.428
Tobacco use			0.161
Never	120 (72.3%)	1116 (77.8%)	
Prior use	13 (7.8%)	70 (4.9%)	
Current use	33 (19.9%)	248 (17.3%)	

Continuous variables are presented as mean ± standard deviation and categorical variables are presented as n (%)

* Hypertension was defined as a clinical diagnosis of hypertension (blood pressure >140/90 or on antihypertensive medications)

[†] Hyperlipidemia was defined as a clinical diagnosis of hyperlipidemia or on lipid-lowering agents

Table 2

Procedural characteristics of patients who did versus those who did not undergo access site crossover during transradial coronary angiography.

Variable	Access Site Crossover		p-value
	Yes (n=166)	No (n=1434)	
Right-sided access	160 (96.4%)	1358 (94.7%)	0.457
Attending operators with ≥ 5 years of transradial experience	137 (82.5%)	900 (62.8%)	<0.001
Mean number of catheters used to cannulate right coronary artery	1.57 $\pm$ 0.76	1.12 $\pm$ 0.40	<0.001
Mean number of catheters used to cannulate left coronary artery	1.85 $\pm$ 1.24	1.16 $\pm$ 0.52	<0.001
Mean number of guide catheters used (PCI patients)	1.40 $\pm$ 0.67	1.19 $\pm$ 0.52	0.003
Contrast used during diagnostic angiography (mL)	96 $\pm$ 48	73 $\pm$ 54	<0.001
Contrast used during entire procedure (PCI patients)	245 $\pm$ 112	195 $\pm$ 81	0.001

PCI = percutaneous coronary intervention

Continuous variables are presented as mean $\pm$ standard deviation and categorical variables are presented as n (%)

Table 3

Timing of access site crossover

Variable	Total (n=166)	Operators with 5 years TRA experience (n=137)	Operators with >5 years TRA experience (n=29)	p-value
Inability to cannulate the radial artery	47 (28.3%)	32 (23.4%)	15 (51.7%)	0.003
Inability to cannulate any coronary artery (pre-angiography)	51 (30.7%)	47 (34.3%)	4 (13.8%)	0.021
Inability to complete diagnostic angiography (mid-angiography)	54 (32.5%)	46 (33.6%)	8 (27.6%)	0.347
For PCI procedure (between diagnostic angiography and percutaneous coronary intervention)	9 (5.4%)	8 (5.8%)	1 (3.4%)	0.512
After an initial attempt to cannulate the coronary artery with a guide catheter (during percutaneous coronary intervention)	5 (3.0%)	4 (2.9%)	1 (3.4%)	0.622