Chapter 1

Radial Access in Primary PCI for Acute Myocardial Infarction

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Abstract

Transradial approach (TRA) is now considered the standard of care in many centers for elective and primary percutaneous coronary intervention (PCI). The use of the radial approach in ST-segment elevation myocardial infarction (STEMI) patients has been associated with a significant reduction in major adverse cardiac events. However, it is still unclear if the side of radial access (right vs. left) has impact on safety and effectiveness of TRA in primary PCI. So this chapter was conducted to summarize the benefits of transradial access over transfemoral access based on the most recent studies and to compare between using either right radial or left radial as an access for transradial procedure.

Keywords: primary PCI, left radial access, right radial approach, AMI

1. Introduction

Primary percutaneous coronary intervention (PPCI) angioplasty saves life and improves outcomes in patients with acute ST-segment elevation myocardial infarction (STEMI). The vascular access in this life-threatening situation has an impact on mortality and morbidity. In this chapter, we will discuss the preferred vascular access in PPCI; radial vs. femoral and review the studies that compared right radial vs. left radial in acute myocardial infarction.

2. Vascular access in acute myocardial infarction; radial or femoral

There is ongoing debate about which of the two commonly used primary percutaneous coronary intervention (PCI) methods, the traditional femoral artery access, or the radial artery access should physicians use. Some physicians support use of the femoral artery method because of concerns on the adequacy of support with the radial route. The claim is that femoral approach can provide stronger support for more complex procedures that require bulkier hardware; kissing balloons, crush techniques, and rotablation. However, most PPCI procedures do not entail densely calcific lesions or complex bifurcations. Most of the trials show that using radial access is feasible in the PPCI procedure and compared with femoral access; can provide a bleeding and mortality advantage.

ST-segment elevation myocardial infarction (STEMI) patients treated with primary percutaneous coronary intervention (PPCI) are likely to benefit from the bleeding reduction by using the radial approach as these patients have more risk for access site bleeding and bleeding-related complications as in primary percutaneous intervention we use aggressive antiplatelet and antithrombotic therapies [1]. Using the radial approach may allow higher doses of anticoagulants to be used for further ischemic reduction with minimal bleeding incidence in comparison with using the femoral approach [2]. In addition, the use of the radial approach in STEMI patients has been associated with a significant reduction in major adverse cardiac events (MACE) during follow-up [3].

3. Trials that compared radial and femoral access in primary PCI

We summarize the most important trials that compared radial and femoral access in primary PCI (**Table 1**).

These trials strongly suggest benefits from the radial approach in terms of reduction of bleeding and possible mortality. There still remain some concerns on the longer door to balloon times with the radial approach.

Study name	Year	Study design	No. of patients (TRI vs. TFI)	Endpoints Results (TRI vs. TFI) P value	Comments (other outcomes)
TEMPURA [4]	2003	Prospective randomized study	77 vs. 72	MACE 5.2 vs. 8.4% *P* = 0.444	Characteristics of coronary intervention were similar in both groups except total procedure time, which was significantly shorter in the TRI group.
RADIAL-AMI [5]	2005	Multicenter pilot trial	25 vs. 25	Procedure time 32 vs. 28 min *P* = 0.04	Despite longer procedure time, Contrast use or fluoroscopy time shows no significant difference.

Study name	Year	Study design	No. of patients (TRI vs. TFI)	Endpoints Results (TRI vs. TFI) P value	Comments (other outcomes)
FARMI [6]	2007	Prospective randomized study	57 vs. 57	Bleeding complications 2 vs. 11 *P* value significant	Coronary angiography duration shorter in TRI than TFI group, but PCI duration was the same.
Li et al. [7]	2007	Prospective randomized study	184 vs. 186	Significantly less Bleeding complications with TRI 2 vs.7	Time procedure is same in TRI and TFI group.
Yan et al. [8]	2008	Prospective randomized study	57 vs. 46	Local complications 1.8 vs. 13.1% $P < 0.05$	All procedure data and MACE show no significant difference between the two groups.
RADIAMI [9]	2009	Prospective randomized study	50 vs. 50	Different procedure data $P > 0.05$ insignificant.	Time to ambulation in TRI group was significantly shorter then in TFI group ($p = 0.003$).
Gan et al. [10]	2009	Prospective randomized study	90 vs. 105	Different procedure data were similar.	Puncture-related complications were lower in the TRI group than the TFI group ($P < 0.05$).
Hou et al. [11]	2010	Prospective randomized study	100 vs. 100	Different procedure data $P > 0.05$ insignificant.	Vascular complications and total hospital stay were lower in TRI group than TFI group ($p < 0.01$).
RADIAMI II [12]	2011	Prospective randomized study	49 vs. 59	Different procedure data using star closure device.	D2B is longer in TRI group than TFA group ($p = 0.009$), but MACE and bleeding complications were the same.
RIFLE-STEACS [13]	2012	Multicenter randomized parallel group study	500 vs. 501	30-day NACEs 13.6 vs. 21% $P = 0.003$.	Lower cardiac mortality ($p = 0.020$), bleeding ($p = 0.026$), and hospital stay ($p = 0.03$) in TRI group.
RIVAL [14]	2012	Multicenter randomized parallel group study	3507 vs. 3514	Complications at 30 days.	Large hematoma and Pseudo aneurysm needing closure in TFI group more than TRI ($p < 0.0001$, $p = 0.006$).
STEMI-RADIAL [15]	2012	Prospective randomized study	348 vs. 359	Complications at 30 days, 1.4 vs. 7.2%, $P = 0.0001$.	Contrast utilization were significantly reduced in TRI than TFI ($p = 0.01$). Mortality shows no difference between two groups.
Ocean race [16]	2014	Prospective randomized study	52 vs. 51	Quality of life.	Radial access is associated with significantly fewer problems with mobility and self-care and better psychological outcome after PCI.

Study name	Year	Study design	No. of patients (TRI vs. TFI)	Endpoints Results (TRI vs. TFI) P value	Comments (other outcomes)
Kasem et al [17]	2014	Retrospective study	150 vs. 63	D2B and contrast volume.	TRI is not associated with prolonged door to balloon time or excess contrast utilization. Also TRI is associated with lower mortality, less need for invasive hemodynamic support and fewer local complications.
ALKK PCI registry [18]	2015	Prospective observational study	2530 vs. 15,270	Complications, bleeding and mortality 1.8 vs. 5.1% $P < 0.001$.	TRI group show higher procedural success rate and lower vascular access complications and mortality.
Warren J. c. et al. [19]	2015	Multicenter prospectively collected study	2947 patients	Door to balloon time 30 vs. 27 min. $P < 0.001$.	Time to first balloon longer with TRI group than with TFI, but no difference mortality and reinfarction rates between TRI and TFI.
Haq et al. [20]	2015	Retrospective data	45 vs. 47	Demographic and procedure data insignificant except D2B.	D2B is longer in TRI group than TFA group ($p = 0.021$).
MATRIX [21]	2015	A Randomized, multicenter study	4197 vs. 4207	MACE at 30 days 8.8 vs. 10.3% $P = 0.0307$	NARC and BARC higher in TFI than TRI group ($p = 0.0092$, $p = 0.013$) and all-cause mortality ($p = 0.045$).
Graham et al. [22]	2016	Prospective randomized study	338 vs. 1553	30-day major bleeding 3.7 vs. 1.2% $P = 0.18$ insignificant.	30-day death and reinfarction show no significant statistically difference between two groups ($p = 0.11$, $p = 0.56$).
Kołtowski et al [23]	2016	Prospective randomized study	52 vs. 51	The cost between the two access points 3060 vs. 3374 EUR was insignificant.	The indirect costs were lower in the radial group. Introduction of radial access as the default approach in all centers may significantly reduce the overall financial burden from a social perspective.
Lee et al. [24]	2016	Prospective randomized study	336 vs. 1609	procedural success, complications, mortality and MACE TRI < TFI. significant better in TRI group	In octogenarians, TRI was more effective than the TFI approach in PPCI.

Study name	Year	Study design	No. of patients (TRI vs. TFI)	Endpoints Results (TRI vs. TFI) P value	Comments (other outcomes)
Kilic et al. [25]	2017	Prospective registry	1310 vs. 2270	30-day all-cause mortality 1.7 vs. 4.6% $p < 0.001$.	Radial access is associated with improved outcome in patients with an acute coronary syndrome.

TRI, transradial intervention; TFI, transfemoral intervention; D2B, door to balloon; MACE, major adverse cardiac events; NARC, net adverse clinical events; BARC, Bleeding Academic Research Consortium.

Table 1. Trials of (TRI) vs. (TFI) in acute myocardial infarction.

4. Right vs. left radial artery access

Transradial cardiac catheterization can be performed either by using right or left radial access. But the catheterization laboratory setup, patient preparation, and overall techniques are different from using right radial access to left radial access. The transradial operator should be proficient with both right and left radial accesses. The modern cardiac catheterization laboratory and its support staff should also be proficient to handle these differences efficiently in order to maximize the advantages gained by using either right or left radial in transradial procedures.

5. Historical aspects

Transradial catheterization was started by using the left radial artery as an access for the procedure. The original description of transradial catheterization was introduced by Lucien Campeau in 1989. Campeau successfully completed a coronary angiography by utilization of left radial artery as an access for the transradial procedure. Campeau prepared the left wrist in hyperextension position to facilitate the puncturing of the radial artery. Campeau completed the procedure by using 18-gage needle, 5-Fr sheath, and 5-Fr catheters [26]. The right radial approach was utilized by Ferdinand Kiemeneij in the first description of transradial PCI in 1993. Ferdinand Kiemeneij successfully completed a percutaneous coronary intervention by the utilization of right radial artery as an access for the transradial procedure. Kiemeneij completed the procedure by using 22-gage access needles, 6-Fr sheath, and 6-Fr guiding catheters [27].

Since 1993, the right radial approach became the preferable vascular access by the majority of transradial operators. The disruption of the traditional laboratory setup and the relocation of the operator in the left radial approach to the left side of the patient, on the contrary, the right radial approach is more familiar as the femoral approach in the catheter and equipment manipulation from the right side by both the operator and the support staff. However, the left radial artery access has advantages over the right radial approach in lower incidence of vascular anomalies less than right radial and using the left radial approach mimetic the femoral approach regarding the manipulation of the catheters and support of guiding catheters. **Table 2** summarizes the differences and similarities between right and left transradial accesses based on the most recent studies [28].

	Right radial access	Left radial access
Acceptability	More popular	Less popular (if indicated only)
Preparation and setup	More standardized	Less standardized (disrupt traditional setup)
Comfort for the operator	More comfortable	Less comfortable
Learning curve	Longer	Shorter
Catheter manipulation	More challenging (similar with experts)	Better control
Radiation dose	Similar (longer with trainees)	Similar (shorter with trainees)
Efficacy and safety	Similar	Similar

Table 2. Comparison between right and left radial access [28].

6. Preprocedural assessment

The choice of right radial vs. left radial is decided by the transradial operator and patient-related factors. Transradial operator may choose the left radial in special conditions as in requiring cannulation of the LIMA or in a presence of a contraindication for using the right radial access. The left radial approach may be preferred in specific patients who have a higher risk for right radial artery (RRA) touristy like in female gender, short stature, low body weights, and elderly.

6.1. Right radial access

The patient is positioned supine on the table in the same manner as the transfemoral route. An arm board extension is attached to the right-hand side of the table. Arm boards are available in different shapes and designs. Perhaps best suited for this purpose may be the trapezoid-shaped fiberglass board, with the narrow end tucked under the mattress at shoulder level and the broad area at the wrist.

The patient should be prepared with the wrist exposed, the forearm placed in the supine position and the hand gently taped in position, with the wrist hyper extended and supinated. A pulse oximetry probe is placed on the right index finger or thumb to allow for continuous monitoring of the circulation to the hand throughout the procedure. After the wrist has been appropriately prepared, it will be examined for the radial artery. Infiltrate local anesthetic subcutaneously at least 2 cm proximal to the radial styloid process (in the region where the radial artery pulse is best appreciated) to form a small wheal. The skin is sterilized with an alcohol-based skin preparation. The groin should also be prepared for access in the event of a failed radial artery insertion. The angiography drape is applied so as to expose the wrist in an area where the radial artery pulse will be palpable.

Radial artery puncture can be done using open needle technique (anterior wall puncture) or trans-fixation technique (posterior wall puncture). After the artery has been successfully punctured, introduce the guide wire through the cannula. Once the guide wire has been smoothly advanced through the device, remove the cannula while leaving the guide wire in place. Introduce the sheath (with the dilator inserted) over the guide wire into the radial artery. A small superficial skin incision may be made where the guide wire enters through the skin to facilitate smooth passage of the sheath and to prevent radial artery spasm.

After the sheath is fully advanced, the guide wire and the dilator assembly may be removed. After the removal of the dilator, the sidearm may be used for administration of compatible medications as antispasmodic agents (e.g., verapamil 2.5–5 mg diluted in blood, nitrates 100–200 mic) through the sheath via the sidearm. And anticoagulants (e.g., heparin 5000 U) may be administered either via the sheath or IV, depending on the procedure performed.

6.2. Left radial access

There are more variations in catheterization laboratory setup, patient preparation, and equipment setup with the left radial compared to the right radial approach. Some operators prefer to perform the left radial procedure from the left side of the patient. In this case, the patient is positioned, prepped, and draped in a similar fashion as that of right radial access, only the arm board is attached to the left side of the table, and the equipment is arranged as a mirror image of the right-sided approach.

The patient is positioned supine on the table in the typical manner as the transfemoral route. A pulse oximeter probe is placed on the left index finger or thumb to allow continuous monitoring throughout the procedure. The operator achieves vascular access either from left side of the patient or from the right side of the patient, as if performing a left femoral artery puncture. After needle puncture and sheath insertion in a typical manner as right radial approach, the left forearm is pronated and adducted, such that the left wrist rests close to the right inguinal area. The operator then performs the catheterization procedure on the right side of the patient with a general setup that closely resembles the transfemoral approach.

7. Trials of right vs. left radial elective PCI

In previously published studies, comparing RRA with left radial artery (LRA) in elective PCI, it has been shown that both approaches are safe, have similar success rates, volume of contrast agent, and similar rate of crossover to different approach [29–32]. On the other hand, controversy between these researches regarding number of catheters used, Fluoroscopy time, and radiation exposure in LRA compared to RRA was obvious. Dominici et al. [29] and Kado et al. [32]

have shown a reduction in fluoroscopy time and number of catheters used in LRA compared to RRA, while Freixa et al. [31] and the "transradial approach (left vs. right) and procedural times during percutaneous coronary procedures (TALENT) study" demonstrated similar procedure and fluoroscopy time between both approaches when performed by well-trained operators [30]. Moreover, decreased radiation exposure with LRA was detected by Kado et al. [32] which is not concordant with the results of sub-study of the "TALENT" trial, which demonstrated no differences in radiation dose between the two approaches [33]. Recently, several studies have shown that the LRA might be associated with shorter procedural time and lower cerebrovascular complications when compared with the RRA in elective PCI [29, 34, 35].

8. Right vs. left radial access in acute myocardial infarction

Data from published studies addressing the best transradial approach (TRA) (right vs. left) in the setting of primary PCI are scarce, while data in the setting of elective PCI are controversial. Although the right radial artery (RRA) approach is usually the first point of access, tortuosity within the brachial and subclavian arteries may result in more radiation exposure, lengthy procedure, or even procedural failure [34, 36, 37]. Alternatively, the left radial artery (LRA) approach, although unflavored and less extensively studied, may offer an advantage from the point-of-view of vascular anatomy [29, 33].

Since delay in the reperfusion, time is considered the main cause of mortality in STEMI patients [38, 39], it is essential to decrease the reperfusion time when undergoing primary PCI. As the choice of transradial access site over the femoral approach is preferred in patients with STEMI because of less bleeding complications, it remains undetermined whether RRA or LRA provides a shorter procedural time in STEMI patients undergoing primary PCI. Up to date, only a few researches have compared the access side (right vs. left) during primary PCI [40–42].

We did a retrospective study on 400 consecutive patients presenting to our hospital with STEMI. Primary PCIs were performed for 202 patients using the right radial approach and 198 using the left radial approach. Results show that there was no significant difference in demographics and clinical characteristics for patients included in both groups with mean age 57 ± 12.8 years, with male predominance (77.2%). There was no significant difference between the right radial and left radial regarding success rate (97.5 for RRA vs. 98.4% for LRA; $P = 0.77$), contrast amount used (151.2 ± 12.4 ml for the RRA vs. 150.8 ± 19.6 ml for the LRA; $P = 0.41$), fluoroscopy time (FT) (13.2 ± 4.3 min for the RRA vs. 12.8 ± 3.5 min for the LRA), needle-to-balloon time (18.2 ± 2.8 min vs. 17.8 ± 6.5 min for RRA & LRA respectively, $P = 0.12$), number of catheters, postprocedure vascular complications, in-hospital reinfarction, and stroke/transient ischemic attack (TIA) or death. We concluded that both right radial access and left radial access are safe and effective in primary PCI, as both approaches have a high success rate and comparable needle-to-balloon time [40].

A recent retrospective study done on 135 patients compared LRA vs. RRA in STEMI patients. Primary PCIs were performed for 85 patients using the right radial approach and 50 using the left radial approach. Results show that there was no significant difference in room procedural times, success rates, and comparable safety. But the authors attributed these results to the choice of LRA in patients known to be at risk for RRA failure (old age, female gender, lower body weight, and lower BMI). As in the patients of the LRA group, there were more females (40 vs. 20%, $P = 0.02$), significantly older (69.7 ± 14.8 vs. 60.0 ± 12.5 years, $P < 0.0001$), lower body weights (78.0 ± 16.3 vs. 95.1 ± 26.8 kg, $P \leq 0.0158$), shorter stature (169.3 ± 10.8 vs. 173.9 ± 10.3 cm, $P = 0.02$), and lower BMI (27.2 ± 5.1 vs. 31.2 ± 7.7 kg m^{-2}, $P \leq 0.01$) [41].

A recent prospective study on 200 STEMI Chinese patients compared LRA vs. RRA. Primary PCIs were performed for 100 patients using the right radial approach and 100 using the left radial approach. Results show that there were no significant differences in the demographics and clinical characteristics for patients included in both groups. There was no significant difference between the right radial and left radial regarding procedural success rate (98 for left vs. 94% for right; $P = 0.28$). But there was significant difference between the right radial and left radial regarding needle-to-balloon time (16.0 ± 4.8 LRA vs. 18.0 ± 6.5 min RRA; $P = 0.02$), fluoroscopy time (7.4 ± 3.4 LRA vs. 8.8 ± 3.5 min RRA; $P = 0.01$), and CAK dose area product (51.9 ± 30.4 vs. 65.3 ± 49.1 Gy cm^2; $P = 0.04$). Fu and colleagues attributed these results to the anatomical advantage of LRA, which allows for quicker and easier delivery of a PCI device, such as a balloon or aspiration catheter. They also mentioned that all operators participating in this study had been well trained to perform the left radial PCI procedure before the study [42].

Another recent prospective study on 206 patients with acute myocardial infarctions who required emergency percutaneous coronary intervention and were divided into the following two groups: a group that underwent percutaneous coronary intervention through the left radial artery and other group that underwent percutaneous coronary intervention through the femoral artery. The times required for angiographic catheter and guiding catheter placements, the success rate of the procedure, and the incidence of vascular complications in the two groups were observed. Results show that there was no significant difference in catheter placement time or the ultimate success rate of the procedure between the two groups. However, the left radial artery group showed a significantly lower incidence of vascular complications than the femoral artery group ($P < 0.05$) [43].

9. Conclusion

The choice of TRA access site (right vs. left) in primary PCI depends on the experience of performing operator and demographics of treated population. With well-trained operators in both approaches, no significant difference in safety or effectiveness of either approach can be detected, as demonstrated in our study and by the “TALENT” study (senior group) in elective PCI and Larsen et al. in primary PCI [30, 41]. On the other hand, LRA shows better outcomes (compared to RRA) with less trained operators or those trained mainly on LRA, as demonstrated by the results of “TALENT” study (the fellow group) and by Fu et al. [30, 42].

Populations characterized by short stature or low BMI (e.g., Chinese population in Fu et al.) [42] showed better outcomes with LRA in primary PCI. On the other hand, Saito et al. [44] revealed lower success rates via LRA in Japanese patients, which were due to a higher reported frequency of left subclavian arteries originating too distally and/or tortuosity not permitting catheter advancement to the aortic root.

Similarity between RRA and LRA in safety and effectiveness gives more space for TRA in primary PCI, as more patients can achieve rapid and successful revascularization (similar to TFA) but with the added safety margin that TRA provides.

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