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## ORIGINAL ARTICLE

# Ultrasound-Guided Distal Radial Versus Traditional Radial Approach for Coronary Catheterization

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## Abstract

**Background:** Proximal trans-radial approach (pTRA) has become the default choice for coronary catheterization. Recently, distal trans-radial approach (dTRA) has gained sound acceptance as an alternative access to overcome undeniable pTRA pitfalls. Nonetheless, dTRA is technically challenging because of smaller size.

**Aim:** The aim was to assess safety and feasibility of dTRA compared with pTRA using ultrasound guidance.

**Patients and methods:** A prospective observational study enrolled 100 patients eligible for coronary catheterization. The patients were divided into group I (pTRA = 50 patients) and group II (dTRA = 50 patients), which in turn subdivided into group A (blind dTRA = 25 patients) and group B (ultrasound-guided dTRA = 25 patients). The demographic and preprocedural/postprocedural data were collected. The primary end points were radial puncture and procedure success, and the secondary end points were number of puncture attempts, total puncture, procedure and radiation times, and local vascular complications.

**Results:** Percutaneous coronary intervention was accomplished in 23 and 21% in pTRA and dTRA groups, respectively. Successful radial cannulation (94 vs. 90%) and procedure completion (92 vs. 90%) were not different between both groups ( $P = 0.71$  and  $1.0$ , respectively). Number of puncture attempts and cannulation time were significantly less in the pTRA group ( $P = 0.017$  and  $0.001$ , respectively). In the dTRA group, the ultrasound-guidance recompletion led to significantly lower vascular puncture attempts ( $P = 0.001$ ). Despite the incidence of complications were recognized more frequently in the pTRA group, it did not reach statistical significance.

**Conclusion:** Distal radial approach is a safe and feasible alternative route for coronary catheterization. Ultrasound guidance helped to overcome the puncture challenges of this relatively new technique.

**Keywords:** Distal radial, Traditional radial, US-Guided distal radial

## 1. Introduction

Transradial access (TRA) for coronary catheterization was reported for the first time by Campaue in 1989 and then in 1993 by Kiemeneij.<sup>1</sup>

Nowadays, TRA has become the access of choice for coronary catheterization as a result of the decreased access site drawbacks, increased patient satisfaction, early hospital discharge, and improved outcomes, especially in the setting of acute coronary syndrome.<sup>2</sup>

In comparison with the femoral approach, the radial artery approach has a similar success rate and

is associated with a significantly lower risk of mortality and major cardiovascular complications.<sup>3</sup>

By the year of 2018, radial access was approved by the ESC myocardial revascularization guidelines “Radial access is recommended as the standard approach, Unless there are overriding procedural considerations” class I, level of evidence A.<sup>4</sup>

More recently, the distal trans-radial approach (dTRA) has gradually become more habitual to operators, and a large number of studies have talked about the feasibility and safety of the dTRA access.<sup>5</sup>

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The dTRA has many advantages such as reduction of access site bleeding, numbness, pain, radial artery occlusion (RAO), and other complications.<sup>6</sup>

However, the distal radial artery approach can be more technically challenging than the standard (proximal) radial artery (pTRA) puncture, as the former has a smaller diameter.<sup>7</sup>

Hadjivassiliou et al.<sup>8</sup> established the use of ultrasound-guided distal trans-radial approach, which is expected to be effective in reduction of failure rate and complications.

This study aimed at evaluation of the dTRA approach feasibility and safety for coronary catheterization in comparison with the pTRA approach, and to assess the added value of ultrasound guidance to the dTRA route.

## 2. Patients and methods

This was a prospective interventional study that enrolled 100 consecutive patients who were scheduled for coronary catheterization either for diagnostic angiography (CA) and/or percutaneous coronary interventions (PCIs) for different indications at Cardiology Department catheterization laboratories at our institutes from September 2021 to May 2022. Based on the site of vascular access, the patients divided into two groups: group I, the vascular access puncture was performed via traditional or proximal radial artery (group I, pTRA, 50 patients), and group II, the puncture site performed via anatomical snuffbox or distal transradial access (dTRA, 50 patients). The choice of the puncture site was left to the preference of the operator. Based on ultrasound guidance during access puncture, group II was subdivided into two groups: group A, in which the puncture was performed blindly, and group B, in which the puncture was performed with ultrasound guidance. Ethical approval was obtained from ethical committee at the pertained institutes.

Inclusion criteria were as follows: all patients who were older than 20 years of both sexes, eligible for undergoing CA and/or PCI for different indications.

Exclusion criteria were as follows: patients with nonpalpable radial pulsation, previous TRA diagnostic CA or PCI, patients with chronic renal failure with arteriovenous fistula, patients who presented with acute coronary syndromes with or without cardiogenic shock, and those who were not willing to participate in the study.

### 2.1. Tools

All participating patients were subjected to full history taking and clinical examination to assess

presence or absence of any contraindication to CA and or PCI as well as suitability of the vascular access.

### 2.2. Procedure

Before puncturing the artery, a local anesthesia agent was given subcutaneously using 2 mL of 2% lidocaine mixed with 500 µg of nitroglycerin in the pTRA and at least 3 mL of 2% lidocaine mixed with 500 µg of nitroglycerin in the dTRA to completely fill the anatomic snuffbox.<sup>9</sup>

#### 2.2.1. Puncture and cannulation

In group I (TRA), traditional radial access via fingertip palpatory method was performed. The arm was positioned comfortably beside patient's trunk with slight hyperextension of the hand at time of the puncture can facilitate access. Under a sterile condition, the radial artery puncture was done by a 20-gauge open needle to obtain a pulsatile blood flow about 2–3 cm away from styloid process at the site of strongest pulsations, followed by insertion of a 6-F dedicated hydrophilic sheath into the artery over a wire using the Seldinger technique.

In group IIA (blind dTRA), distal transradial access via fingertip palpatory method was performed. The distal radial artery puncture was done by a 20-gauge open needle to obtain a pulsatile blood flow proximal in the anatomical snuffbox at the site of strongest pulsations at angle of 45–60°, followed by insertion of 6-F sheath into the artery over a wire using the Seldinger technique. The patients were asked to grip his thumb against the other four fingers, with slight abduction of the hand to make the artery more superficial. The left arm was pulled over to the right inguinal area.

In group IIB, dTRA was performed under ultrasound guidance. As distal radial artery is a superficial structure, a linear transducer was used after putting a sterile cover over it (as well as using sterile gel), with the selection of a device setting for arterial visualization, together with activation of needle mood. Optimization of the depth, gain, and focus on the artery were important parameters to obtain clear view for the vessel and facilitate the access. Tissue harmony mood should be stopped for better needle visualization. Two-dimensional imaging was used to show short and long axis of the vessel, and also color and pulsed wave Doppler were used to confirm view of the artery. A 20-gauge open needle was held in the right hand, whereas the US probe was held in the left hand of the operator, and the transducer operator's fingers rested on the patient to avoid the transducer from unneeded movement as

unsupported hand positions will predispose to easy fatigability and unrequired transducer movement. In the short axis, the artery appeared round, whereas in the long access, it appeared tubular, and this was confirmed by color and pulsed wave Doppler as mentioned before. There are three ways for needle insertion under ultrasound guidance. In our study, we used the long-axis technique, where the needle was inserted at an angle 45° below the edge of the probe with simultaneous observation of the screen and needle orifice by the operator to see penetration of the needle to the artery and blood back flow from the needle at same time, followed by insertion of 6 F sheath into the artery over a wire using the Seldinger technique.

All procedures were done by operators with an accepted experience in traditional radial and distal radial approaches where everyone had reported at least one hundred or more procedures through radial and distal radial accesses before the starting of the study.

### 2.3. Primary end points

The primary end points were defined as successful vascular access and procedure accomplishment (diagnostic coronary angiography plus or minus intervention).

### 2.4. Secondary end points

We projected many secondary end points for our study such as the number of puncture attempts, puncture time, procedural time, fluoroscopic time, radiation dose, contrast volume, and complications (radial artery spasm, radial artery perforation, bleeding, hematoma, and RAO).

Successful vascular access was defined as successful sheath cannulation. Procedural success was defined as the ability to complete procedure through the primary access site and no need to cross over to another access site to complete the procedure.<sup>10</sup>

Puncture time was defined as the time interval from giving local anesthesia to successful sheath cannulation. The total procedure time was referred to the time interval between the administration of the local anesthetic and the completion of the procedure. Major bleeding was defined as Bleeding Academic Research Consortium (BARC) type 3 or 5 bleeding.<sup>11</sup>

Hematoma was defined as subcutaneous swelling of more than 2 cm.<sup>12</sup>

RAO was assessed clinically by radial palpation before patient discharge; , if there was significant

decrease in pulse in comparison with the other hand, color Doppler ultrasound was done.<sup>10</sup>

For hemostasis, the puncture site was compressed with a hemostasis device. Transradial band or the gauze was folded to form a cylinder to stop the bleeding. The hemostasis was continued for 3 h.

Clinical outcomes were assessed postoperatively, and all the following data were collected during each procedure, either CA or PCI: puncture success, number of attempts, puncture time, and failure of puncture. Procedure success and satisfaction were assessed postoperatively.

### 2.5. Statistical analysis

Data management and statistical analysis were done using SPSS version 28 (IBM, Armonk, New York, USA). Quantitative data were assessed for normality using the Kolmogorov–Smirnov test, Shapiro–Wilk test, and direct data visualization methods. According to normality testing, numerical data were summarized as means and SDs or medians and ranges. Categorical data were summarized as numbers and percentages. Quantitative data were compared between the study groups using independent *t*-test or Mann–Whitney *U* test for normally and non-normally distributed quantitative variables, respectively. Categorical data were compared using the  $\chi^2$  or Fisher's exact tests. All statistical tests were two sided. *P* values less than 0.05 were considered significant.

## 3. Results

Baseline demographic characteristics are presented in Table 1. Most patients were men in all groups, with no statistically significant differences noted regarding other demographic parameters. No significant variations were noted between both groups regarding general characteristics and risk factors in the form of age ( $P = 0.167$ ), sex ( $P = 0.190$ ), height ( $P = 0.481$ ), weight ( $P = 0.460$ ), hypertension

Table 1. Baseline demographic characteristics of the studied groups.

Parameter	Group I (n = 50)	Group II (n = 50)	<i>P</i> value
Age (years)			
Mean $\pm$ SD	54 $\pm$ 8	56 $\pm$ 8	0.167
Male sex [ <i>n</i> (%)]	32 (64.0)	38 (76.0)	0.19
Height (m) (mean $\pm$ SD)	1.7 $\pm$ 0.1	1.7 $\pm$ 0.1	0.481
Weight (kg) (mean $\pm$ SD)	83.6 $\pm$ 10.9	81.9 $\pm$ 11.7	0.46
Hypertension [ <i>n</i> (%)]	25 (50.0)	28 (56.0)	0.548
Diabetes [ <i>n</i> (%)]	26 (52.0)	33 (66.0)	0.155
Smoking [ <i>n</i> (%)]	17 (34.0)	25 (50.0)	0.105
Dyslipidemia [ <i>n</i> (%)]	36 (72.0)	32 (64.0)	0.391

Table 2. Procedural characteristics as regard puncture success, number of attempts, and puncture time in the studied groups.

	Group I (n = 50) [n (%)]	Group II (n = 50) [n (%)]	P value
Puncture success	47 (94.0)	45 (90.0)	0.715
Number of attempts			
One	40 (80.0)	27 (54.0)	0.017*
Two	6 (12.0)	17 (34.0)	
Three	4 (8.0)	6 (12.0)	
Puncture time (s) (mean ± SD)	88.1 ± 34.4	150.3 ± 49.1	<0.001*

( $P = 0.548$ ), diabetes ( $P = 0.155$ ), smoking ( $P = 0.105$ ), and dyslipidemia ( $P = 0.391$ ) (Table 1).

PCI was accomplished in 23 and 21% in pTRA and dTRA groups, respectively.

Table 2 displays statistically significant fewer number of attempts to get vascular access ( $P = 0.017$ ) in pTRA group I; the vast majority of successful cannulations were achieved on the first attempt in group I (80%) compared with group II (54%). Conversely, instances with two or three attempts were higher in group II (34 and 12%, respectively) than in group I (12 and 8%, respectively). Because of fewer attempts, it was not surprising that the total puncture time was shorter in the pTRA group compared with group II ( $88.1 \pm 34.4$  versus  $150.3 \pm 49.1$  s,  $P < 0.001$ ). Despite the extra-attempts and time to get vascular access in group II, the final successful cannulation was not statistically

significant between the two groups (94 vs. 90%,  $P = 0.71$ ) (Table 2).

Table 3 demonstrates nonsignificant procedural characteristics between the two groups regarding procedural time ( $P = 0.392$ ), procedural success ( $P = 1.0$ ), fluoroscopic time ( $P = 0.682$ ), radiation dose ( $P = 0.312$ ), and contrast volume ( $P = 0.056$ ). Table 3 shows no significant differences between both groups regarding all complications, including RAO ( $P = 0.495$ ), radial artery spasm ( $P = 0.715$ ), radial artery perforation, major bleeding, and hematoma ( $P = 0.678$ ). No significant variations were observed between both groups regarding postprocedural discharge time ( $P = 0.584$ ) and patient satisfaction ( $P = 0.790$ ).

Group II was divided into two subgroups: group A (25 patients who underwent blind distal radial technique) and group B (25 patients who underwent ultrasound-guided distal radial cannulation).

Table 3. Procedural characteristics as regard secondary end points complications, patient satisfaction, and discharge time in the studied groups.

	Group I (n = 50) [n (%)]	Group II (n = 50) [n (%)]	P value
Procedural time (m) [median (range)]	20 (0–95)	20 (0–70)	0.392
Procedural success	46 (92.0)	45 (90.0)	1.0
Fluoroscopic time (m) (range)	(3.1–39.5)	(2.3–35.4)	0.682
Irradiation dose (MGY) (range)	(337–5764)	(298–5345)	0.312
Contrast volume (ml) (range)	(50–550)	(40–100)	0.056
Radial artery occlusion (RAO)	2 (4.0)	0	0.495
RA spasm	5 (10.0)	3 (6.0)	0.715
RA perforation	0	0	–
Major bleeding	0	0	–
Hematoma	4 (8.0)	2 (4.0)	0.678
Persistent pain	8 (16.0)	6 (12.0)	0.564
Discharge (H) (range)	4 (2–7)	4 (2–8)	0.584
Patient satisfaction	41 (82.0)	42 (84.0)	0.790

Table 4. Procedural characteristics in distal radial subgroups.

	Group A (n = 25) [n (%)]	Group B (n = 25) [n (%)]	P value
Puncture success	21 (84.0)	24 (96.0)	0.349
Number of attempts	4 (16.0)	23 (92.0)	<0.001*
One			
Two	15 (60.0)	2 (8.0)	
Three	6 (24.0)	0	
Puncture time (s) (mean ± SD)	138.7 ± 44.3	161.9 ± 51.7	0.096
Procedural time (min) (range)	0–67	9–70	0.115
Procedural success	21 (84.0)	24 (96.0)	0.349
Fluoroscopic time (min) (range)	2.3–35.4	2.7–35	0.594
Irradiation dose (MGY) (range)	322–5345	298–5224	0.153
Contrast volume (ml) (range)	40–300	40–300	0.422

Table 5. Complications in distal radial subgroups.

	Group A (n = 25) [n (%)]	Group B (n = 25) [n (%)]	P value
RAO	25 (100.0)	25 (100.0)	–
RA spasm	1 (4.0)	2 (8.0)	1.0
RA perforation	0	0	–
Major bleeding	0	0	–
Hematoma	1 (4.0)	1 (4.0)	1.0
Persistent pain	2 (8.0)	4 (16.0)	0.667

RA, radial artery; RAO, radial artery occlusion.

Table 4 justifies a significant statistical difference in the form of fewer number of attempts in group B (ultrasound-guided) than in group A (blind). Vast majority of attempts were successful on the first attempt in the ultrasound-guided patients (92%) versus only 16% in the subgroup A ( $P = 0.001$ ). No significant variations were observed regarding puncture success ( $P = 0.34$ ), puncture time ( $P = 0.096$ ), procedural time ( $P = 0.115$ ), procedural success ( $P = 0.349$ ), fluoroscopic time ( $P = 0.594$ ), radiation dose ( $P = 0.153$ ), and contrast volume ( $P = 0.422$ ).

Table 5 presents no significant differences between both groups regarding all complications, including RAO, radial artery spasm, radial artery perforation, major bleeding, hematoma, and persistent pain.

#### 4. Discussion

Despite the numerous advantages of the conventional/proximal trans-radial approach (pTRA) over the femoral access, there are many pitfalls for pTRA. The most important is the occurrence of RAO, radial artery spasm, and hematoma. Therefore, we implemented this prospective interventional study to compare feasibility and safety of the dTRA (from snuffbox) as opposed to pTRA.

The most important findings of our study are that dTRA is a feasible and safe alternative to pTRA, with the downside of higher number of puncture attempts and longer puncture time, without a net prolongation of the total procedure time or irradiation dose. The downside of higher number of puncture attempts can be improved by US-guided puncture. Although US-guided dTRA significantly improved the number of puncture attempts, it was not associated with a significant reduction of total puncture time in our pilot experience.

##### 4.1. pTRA and dTRA cannulation

As the size of radial artery is getting smaller distally, it is anticipated that cannulation success would be less. In our study, we observed high success rate in both groups (94 vs. 90% in pTRA and

dTRA, respectively;  $P = 0.71$ ). Puncture failure was due to failure of either artery puncture or wire-advancement because of intense spasm. The success rate to get vascular cannulation in our study is less than what had been reported by Rania et al., who reported success rate of 98 and 95.2% in pTRA and dTRA, respectively ( $P < 0.0008$ ).<sup>10,13</sup>

Moreover, Marcos et al. reported very high success rate of dTRA cannulation (97.5%).<sup>14</sup>

Michael et al. reported a high rate of dTRA failure with crossing over to another route, as seen in 30%, in contrast to only 2% in the pTRA group ( $P < 0.001$ ).<sup>15</sup>

The authors suggested many explanations of this high failure rate, such as smaller size of the distal radial artery with increased risk of spasm, artery at this level was more tortuous, which in turn interfered with advancing of the wire, and ultimately the operator's learning curve.

Default ultrasound-guided technique and rising of the learning curve may improve the success rate throughout the time and help to decrease the risk of puncture-mediated arterial spasm. Our study clearly showed that ultrasound guidance was associated with a smaller number of attempts to get the vascular entry in the anatomical snuffbox with very high success rate (23 of 25 patients). Although this study represents our initial experience with ultrasound guidance, it was a helpful consignment and easy to adopt; however, there was no significant difference in utilization of ultrasound guidance or blind puncture in the final procedure's outcome.

##### 4.2. pTRA versus dTRA: safety concerns

In the current analysis, we observed relatively low minor complication rate in both groups with no major bleeding or perforation. The incidence of documented radial artery spasm periprocedurally was 10 versus 6% in pTRA and dTRA, respectively, and minor local hematoma less than 5 cm in diameter was reported in 8 and 4% in pTRA and dTRA, respectively; both did not reach statistical significance. RAO acknowledged by ultrasound duplex scan was documented in two patients (4%) in the pTRA group but none in dTRA. Our results are well matched with previous studies that recorded no major complications such as major bleeding in patients who underwent coronary angiography and/or intervention through proximal or distal radial routes.<sup>16</sup>

Failure of our study to show superiority of dTRA over pTRA in terms of safety is likely due to a small sample size. However, previous studies have shown superior safety profile of dTRA versus pTRA in terms of reduction of access site drawbacks in the

form of bleeding, hematoma, numbness, persistent pain, and RAO.<sup>6</sup>

Moreover, recent optical coherence tomographic studies showed a lower incidence of radial artery complications after coronary catheterization done through distal radial artery in comparison with traditional radial access.<sup>17</sup>

Moreover, another important advantage of distal radial access includes an effective compression during hemostasis owing to the nature of surrounding structures of the anatomical snuffbox in the form of bony floor, muscles surrounding the intermetacarpal space, and absence of venous stasis as a result of mild venous compression. In addition, the superficial course of DRA plays an important role in hemostasis as well as early observation and follow-up of hematoma.<sup>7</sup>

Taken together with previous data, our data can be seen as a confirmation of the safety of dTRA as compared with pTRA approach.

#### 4.3. Limitations

Our study has some limitations: first, the small number of patients included in the study limits its statistical power, and thus, further large-scale studies are needed to validate the findings of this study. Second, the current study represented our initial experience in ultrasound-guided dTRA puncture; however, the learning curve is very fast and easy to grasp.

#### 4.4. Conclusion

Distal radial approach is a feasible, safe, and effective alternative to proximal/conventional transradial approach for diagnostic coronary angiography and intervention. Ultrasound guidance could overcome the challenge of difficult cannulation of the relatively smaller distal radial artery by reducing the number of vascular punctures in comparison with blind puncture.

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