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Original Article

Assessment and comparison of distal radial artery diameter in anatomical snuff box with conventional radial artery before coronary catheterization

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ABSTRACT

Background: The distal radial artery (dRA) approach at anatomical snuff box has gained attention of the interventional cardiologist in last few years. The procedural success rate by this novel approach depends on size of the radial artery and therefore the study was planned to study the size of distal radial artery.
Methods: Total of 1004 patients of >18 years of age undergoing coronary catheterization were included in the study. The vessel diameter was measured from media to media in the anatomical snuff box a day prior to coronary catheterization.
Results: The mean diameter of right radial artery at conventional access site was 2.56 ± 0.35 mm and at distal access site 2.23 ± 0.39 mm ($p < 0.001$). Females had significantly smaller radial artery diameter as compared to males at right conventional access site (2.42 ± 0.36 mm vs 2.60 ± 0.34 mm; $p < 0.001$) and distal access site (2.09 ± 0.38 mm vs 2.27 ± 0.39 mm; $p < 0.001$). The diameter of the right dRA was not significantly correlated with age (r^2 linear = 0.002, p = 0.0475) but was positively correlated with height and weight (r^2 linear = 0.076, p = <0.001 and r^2 linear = 0.005, p = <0.001) and negatively correlated with BMI (r^2 linear = 0.076, p = 0.519).
Conclusions: This study has shown the size of right dRA 2.27 + 0.39 mm in males and 2.09 + 0.38 mm in females. Diabetes, hypertension, height and weight are important predictors of dRA diameter.
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1. Introduction

Percutaneous approach for coronary angiography (CAG) and intervention (PCI) has seen many advances in the last two decades. Transradial Approach (TRA) is the default vascular access for these procedures and has many advantages compared to Transfemoral Approach (TFA).[1] It reduces the bleeding complications and associated with significant reduction in major adverse cardiovascular events (MACE). But still there are many challenges with TRA for both patient and operator. The patient has to keep forearm in supine position for long duration during the procedure which is unnatural arm position and is uncomfortable. The left TRA is even more challenging as it needs more forearm and wrist rotation of the patient and is not ergonomic for the operator. Post procedure, the complications are rare with TRA but still the incidence of radial artery occlusion (RAO) ranges from 1% to 9%.[2] The other infrequent complications like radial artery spasm or injury, arteriovenous fistula, nerve damage, complex regional pain syndrome can also occur.[3] Distal Transradial access (dTRA) through distal radial artery (dRA) in anatomical snuff box (ASB) has been explored in recent years for CAG and PCI and proposed as an alternate to conventional TRA (cTRA). The ASB is a triangular depression at the dorsum of the hand and was used to place and snuff tobacco and hence the name was derived. The depression is limited medially with tendon of extensor pollicis longus muscle and laterally by the tendons of abductor pollicis longus and extensor pollicis brevis muscles. The

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base is formed by the distal margin of the retinaculum of extensor muscles and vertex by the tendons of extensor pollicis longus and extensor pollicis brevis muscles. The main advantage of dTRA is greater comfort to patient during the procedure especially with left dRA as the forearm is in more natural and comfortable position. Another advantage as shown in some studies is lower incidence of RAO with dTRA.[4] As the radial artery size is an important predictor of RAO therefore, this study was proposed to measure normal size of the radial artery at conventional puncture site and in anatomical snuff box.

2. Methods

Total of 1004 patients of >18 years of age undergoing coronary catheterization were included in the study from two tertiary cardiac care centres of India. The study was approved by Institutional Ethics Committee and written informed consent was taken from all patients. The vessel diameter was measured from media to media of right and left radial artery at conventional puncture site over the palmar side of the wrist 2 cm proximal to styloid process and in the anatomical snuff box (Fig. 1). The measuring point of dRA was over the scaphoid and trapezium bone where the vessel is superficial and safe to puncture. All measurements were performed a day prior to coronary catheterization using commercially available ultrasound system (EPIC 7C, Philips Medical Systems) with vascular probe (8–11 MHz). Baseline demographic characteristics i.e., age, gender, weight, height, body mass index (BMI), smoking, diabetes, hypertension, eGFR were recorded. Patients with past history of coronary catheterization by either cTRA or dTRA and those with feeble palpable pulse were excluded.

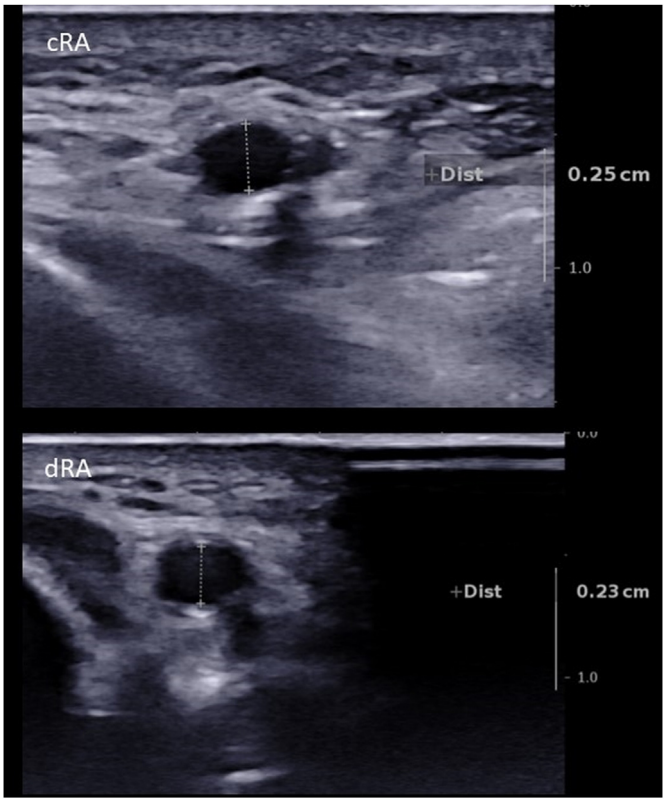

Fig. 1. Measurement of radial artery at conventional access site (cRA) and distal access site in anatomical snuff box (dRA).

Categorical variables are presented as numbers and percentages. Continuous variables are shown as the mean ± standard deviation and were compared between the groups by the unpaired *t* test. The association between the groups was evaluated by Pearson correlation coefficient method. A *p*-value < 0.05 was considered as statistically significant. The statistical analysis was performed with IBM-SPSS-26.0 software package (SPSS Inc., Chicago, Illinois, USA).

3. Results

Table 1 shows the baseline characteristic of total 1004 patients who were enrolled in the study. Out of these 785 (78.2%) were males and 219 (21.8%) were females. The number of hypertensive and diabetic patients were 378 (37.6%) and 285 (28.4%) respectively.

Table 2 shows the mean diameter of right radial artery in all patients undergoing CAG or PCI at conventional access site (cRA) was 2.56 ± 0.35 mm and at distal access site (dRA) was 2.23 ± 0.39 mm ($p < 0.001$) whereas the size of left cRA was 2.50 ± 0.35 mm and dRA was 2.17 ± 0.39 mm ($p < 0.001$). In male patients, the mean diameter on right cRA was 2.60 ± 0.34 mm and dRA was 2.27 ± 0.39 mm ($p < 0.001$). Similarly, on left side the mean diameter of cRA was 2.54 ± 0.34 mm and dRA was 2.21 ± 0.39 mm ($p < 0.001$). In females, the mean diameter on right cRA was 2.42 ± 0.36 mm and dRA 2.09 ± 0.38 mm ($p < 0.001$). Similarly, on left side the mean diameter of cRA was 2.35 ± 0.38 mm and dRA was 2.02 ± 0.37 mm ($p < 0.001$).

Table 3 shows gender difference in radial artery at conventional and distal access site. Females had significantly smaller radial artery diameter as compared to males at right conventional access site (2.42 ± 0.36 mm vs 2.60 ± 0.34 mm; p < 0.001) and distal access site (2.09 ± 0.38 mm vs 2.27 ± 0.39 mm; p < 0.001). Similarly on left side females have smaller radial artery diameter at conventional access site (2.35 ± 0.38 mm vs 2.54 ± 0.34 mm; p < 0.001) and distal access site (2.02 ± 0.37 mm vs 2.21 ± 0.39 mm; p < 0.001).

Table 4 shows the significant difference in radial artery diameter between non-hypertensive and hypertensive patients at both conventional and distal access site on both sides. The mean diameter of right cRA in hypertensive was 2.51 ± 0.37 mm and in non-hypertensive patients was 2.59 ± 0.34 mm and ($p < 0.001$). Simi-

Table 1
Baseline descriptive statistics of study population.

Number of patients	n = 1004
Age (years)	57.75 ± 11.8
Male (n, %)	785 (78.2%)
Height (cm)	165.93 ± 7.3
Weight (kg)	68.99 ± 11.4
BMI (kg/m^2)	25.04 ± 3.8
Diabetes (n, %)	285 (28.4%)
Hypertension (n, %)	378 (37.6%)
Smoking (n, %)	213 (21.2%)

Values are mean ± SD, median [Inter Quartile Range], or n (%).
BMI = Body Mass Index.

Table 2
Size of right and left radial artery at conventional and distal access site.

	Conventional	Distal	*p* value (*t* test used)
Right Radial artery (All patients)	2.56 ± 0.35	2.23 ± 0.39	<0.001
Male	2.60 ± 0.34	2.27 ± 0.39	<0.001
Female	2.42 ± 0.36	2.09 ± 0.38	<0.001
Left Radial artery (All patients)	2.50 ± 0.35	2.17 ± 0.39	<0.001
Male	2.54 ± 0.34	2.21 ± 0.39	<0.001
Female	2.35 ± 0.38	2.02 ± 0.37	<0.001

Values are mean ± SD.

Table 3
Gender difference in radial artery at conventional and distal access site.

	Male	Female	*p*-value
Right cRA	2.60 ± 0.34	2.42 ± 0.36	<0.001
Right dRA	2.27 ± 0.39	2.09 ± 0.38	<0.001
Left cRA	2.54 ± 0.34	2.35 ± 0.38	<0.001
Left dRA	2.21 ± 0.39	2.02 ± 0.37	<0.001

Values are mean ± SD.
cRA = Conventional Radial Artery.
dRA = Distal Radial Artery.

Table 4
Effect of diabetes, hypertension and smoking on size of radial and distal radial arteries.

	Hypertension (n = 378)	Non hypertensive (n = 626)	*p*-value
Right cRA	2.51 ± 0.37	2.59 ± 0.34	<0.001
Right dRA	2.18 ± 0.41	2.26 ± 0.38	0.001
Left cRA	2.44 ± 0.37	2.53 ± 0.34	<0.001
Left dRA	2.11 ± 0.41	2.20 ± 0.38	0.001
	Diabetic (n = 285)	**Non-diabetic (n = 719)**	
Right cRA	2.55 ± 0.36	2.57 ± 0.35	0.351
Right dRA	2.18 ± 0.44	2.26 ± 0.38	0.004
Left cRA	2.46 ± 0.37	2.51 ± 0.35	0.024
Left dRA	2.09 ± 0.41	2.20 ± 0.38	<0.001
	Smoker (n = 213)	**Non-smoker (n = 791)**	
Right cRA	2.59 ± 0.33	2.55 ± 0.36	0.193
Right dRA	2.27 ± 0.38	2.22 ± 0.39	0.082
Left cRA	2.53 ± 0.31	2.49 ± 0.36	0.103
Left dRA	2.23 ± 0.36	2.15 ± 0.40	0.016

Values are mean ± SD.
cRA = Conventional Radial Artery.
dRA = Distal Radial Artery.

larly, the mean diameter of right dRA in hypertensive was 2.18 ± 0.41 mm and in non-hypertensive was 2.26 ± 0.38 mm ($p < 0.001$). Diabetic patients also have smaller radial artery diameter as compared to non-diabetics at distal access site (Right dRA 2.18 ± 0.44 mm vs 2.26 ± 0.38 mm; p = 0.004 and left dRA 2.09 ± 0.41 mm vs 2.20 ± 0.38 mm; p < 0.001). At conventional access site, although the diameter was smaller on right side in diabetic patients but was not statistically significant (2.55 ± 0.36 mm vs 2.57 ± 0.35 mm; p = 0.351) whereas it was statistically significant on left side (2.46 ± 0.37 mm vs 2.51 ± 0.35 mm; p = 0.024).

The association of radial artery diameter with age, height, weight and body mass index was also studied (Fig. 2). The diameter of the right dRA was not significantly correlated with age (r^2 linear = 0.002, p = 0.0475) but was positively correlated with height and weight (r^2 linear = 0.076, p = <0.001 and r^2 linear = 0.005, p = <0.001) and negatively correlated with BMI (r^2 linear = 0.009, p = 0.519).

4. Discussion

The dTRA approach has gained attention of the interventional cardiologist in last few years. The initial feasibility of dTRA for CAG and PCI was reported by Kiemeneij in 70 patients where left dRA was accessed.[5] Then later many studies reported its feasibility in various clinical settings like primary PCI, Left main bifurcations, Chronic total occlusions.[6–8] The dRA in ASB is smaller and tortuous therefore its access is relatively more difficult as compared to cRA. Also, as the size of radial artery is an important predictor of RAO there is still an uncertainty about the incidence of RAO with dTRA approach. Therefore, the size of dRA must be known in the population before using dTRA as default approach for CAG and PCI.

There is paucity of data available for the size of cRA and no data available for dRA in Indian population and therefore the study was planned. The size of the right cRA in our study was 2.60 ± 0.34 mm in males and 2.42 ± 0.36 mm in females. A study by Beniwal et al in 204 patients from southern Rajasthan has shown the diameter of cRA in males 2.37 ± 0.41 mm and females 2.26 ± 0.39 mm which was smaller than what has been observed in our study.[9] Also, in our study the size of dRA was significantly smaller than the size of cRA. There are small studies available from Japan and Korea of the size of dRA. A study by Naito et al in 120 patients from Japan has shown the size of dRA to be 2.04 ± 0.43 mm in males and 1.96 ± 0.44 mm in females.[10] As in our study, the diameter of dRA was significantly smaller than cRA. Similarly, a study by Norimatsu et al in 142 patients from Japan has shown the diameter of dRA (2.60 ± 0.34 mm) to be significantly smaller as compared to cRA (3.10 ± 0.4 mm) and the difference was seen in both males and females.[11] Similar to our results the females in the study had smaller dRA diameter (2.5 ± 0.4 mm) as compared to males (2.60 ± 0.5 mm). A study by Kim et al in 117 patients from Korea has shown average diameter of left dRA of 2.57 ± 0.50 mm and the females had smaller size (2.40 ± 0.53 mm) as compared to males (2.65 ± 0.46 mm).[12] In our study, the size of left dRA was 2.17 ± 0.39 mm with significantly smaller diameter in females (2.02 ± 0.37 mm) as compared to males (2.21 ± 0.39 mm). A study from Canada by Hadjivassiliou in 287 patients undergoing interventional radiology procedures has shown the mean diameter of left cRA 2.55 ± 0.39 mm and dRA 2.34 ± 0.36 mm ($p = 0.001$) and the difference was significant in both genders.[13]

In our study, diabetic and hypertensive patients have smaller radial arteries as compared to non-diabetic and normotensives. This may be because of increased atherosclerosis and poor

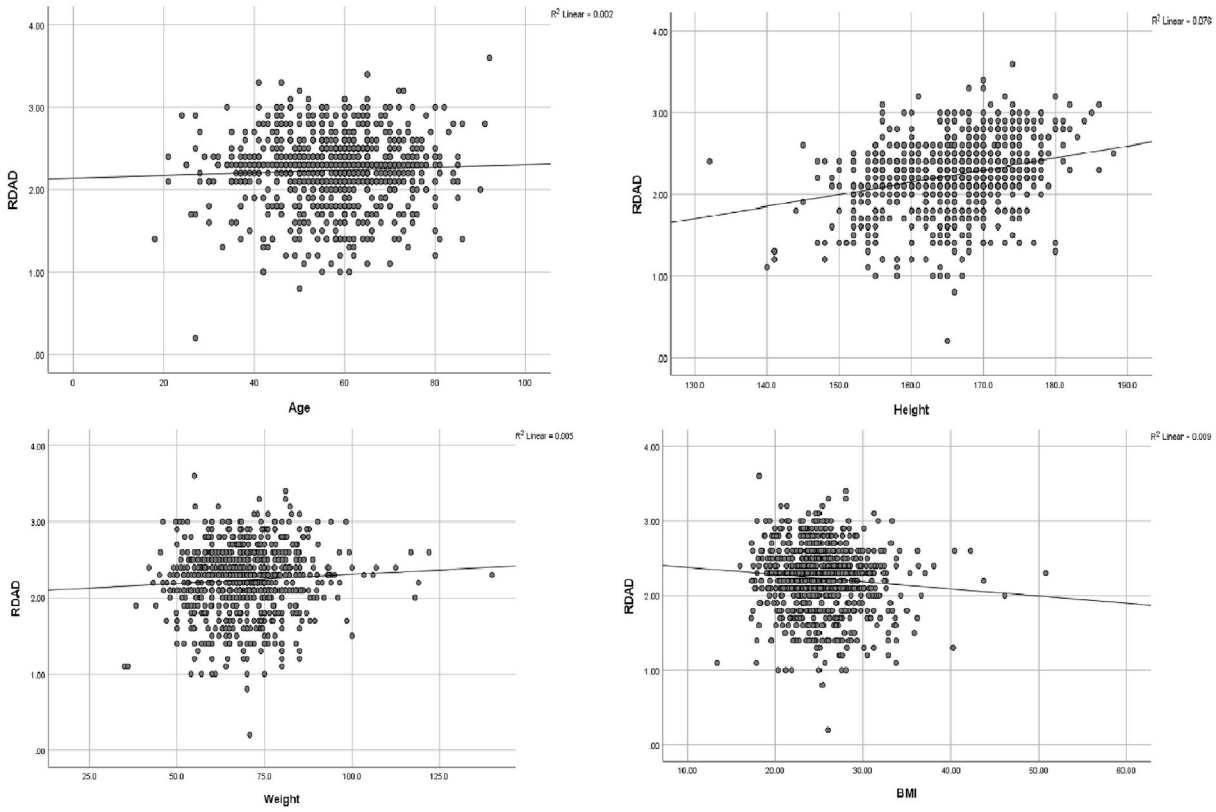

Fig. 2. Association between the right distal radial artery (RDAD) with age, height, weight and body mass index (BMI).

TRANSRADIAL SHEATH INTRODUCER	5F Outer Diameter (mm)	6F Outer Diameter (mm)
RADIFOCUS® INTRODUCER II (TERUMO)	2.31	2.63
GLIDESHEATH SLENDER® (TERUMO)	2.15	2.45
PRELUDE EASE™ (MERIT)	2.36	2.66
PRELUDE IDEAL™ (MERIT)	2.13	2.45
AVANTI® SHEATH INTRODUCER (CORDIS)	2.39	2.68
RAIN SHEATH™ (CORDIS)	2.14	2.47

Fig. 3. Comparison of outer diameter of various conventional and thin walled transradial sheath introducers by various manufacturers.

compliance to medications in these patients. Similar observations were noted by Ruengkularh and colleagues where atherosclerosis and diabetes were independent predictors of small radial arteries.[14] We also found positive correlation between the size of dRA with height, weight and negative corelation with body mass index. In a study by Norimatsu et al, dRA was not correlated with age and height but was positively correlated with both body weight and body mass index.[11]

The smaller size of dRA as compared to cRA makes the vascular access difficult, more chances of spasm or injury and may also have increased RAO. Therefore, the sizing of dRA before the procedure helps in choosing appropriate sheath size during CAG and PCI so that incidence of RAO can be decreased as radial artery diameter is an important predictor of RAO. The other predictors are inadequate anticoagulation and inappropriate radial artery compression post procedure.[15] But with the available data, the dRA has been shown to have lesser RAO rate as compared to cRA. Hamandi et al performed a metanalysis of five studies with 4676 patients (four observational and one randomised trial) and has shown RAO in dRA to be significantly less as compared to cRA (2.30 versus 4.86%; p = 0.004).[16] Similarly, Eid-Lidt et al in a prospective randomised study in 282 patients has shown 30-days RAO to be significantly less in dRA as compared to cRA (6.4% vs 0.6%; $p = 0.007$).[17] Our study of the radial artery diameter has shown significant mean difference of 0.3 mm between cRA and dRA, therefore it is recommended to choose a one size smaller sheath. With the availability of thinner sheaths by various manufacturers, same size sheath may be used for dTRA (Fig. 3). The outer diameter of 6 F conventional radial artery Glidesheath™ (Terumo, Japan) is 2.63 mm and that of 6 F Glidesheath Slender® (Terumo, Japan) is 2.44 mm and therefore preferred for use in dTRA (Fig. 4). The ongoing randomized controlled trials TENDERA (NCT04211584) and DISCO Radial (NCT04171570), comparing conventional vs distal radial access will help us in understanding complications especially late RAO with dTRA approach.

5. Conclusion

The knowledge of the size of dRA is important for clinical and technical success of CAG and PCI from dTRA. This study has shown the size of right dRA 2.27 ± 0.39 mm in males and 2.09 ± 0.38 mm

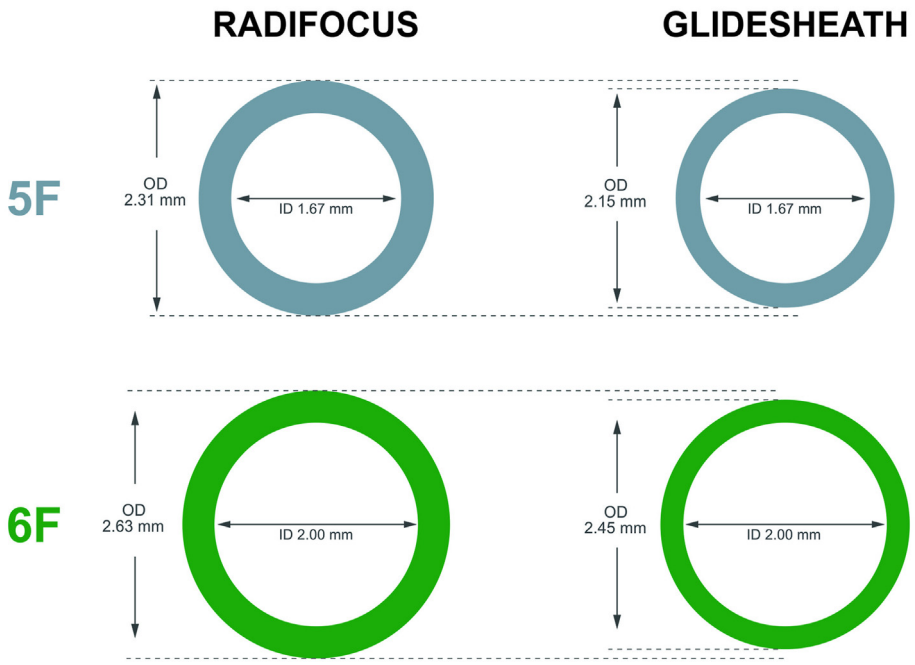

Fig. 4. The comparison of outer diameter (OD) of 5 F and 6 F RADIFOCUS™ and GLIDESHEATH SLENDER™ suggesting compatibility in small size distal radial artery.

in females. Diabetes, hypertension, height and weight are important predictors of dRA diameter.

Declaration of competing interest

None.

Acknowledgments

Nil.

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