ORIGINAL ARTICLE

Evaluation of the Distal Radial Artery Diameter at the Anatomical Snuffbox in Thai Patients by Ultrasound Study: Single Center Experienced

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Background: The distal radial artery approach at the anatomical snuffbox is another efficacy and safety route for coronary intervention. The procedural success rate depends on the diameter of the distal radial artery.

Objective: To use ultrasound to study the distal radial artery reference diameter and the relationship between the diameter of the distal radial artery and various factors in Thai patients.

Materials and Methods: A non-randomized prospective study was performed between June 2023 and July 2024. Six hundred forty-seven consecutive patients were assessed using a linear ultrasound probe, which was performed by two technicians experienced in right and left distal radial artery measurement.

Results: The mean vessel diameter of the distal radial artery in the anatomical snuffbox, at 2.48±0.28 mm was significantly smaller than that of the radial artery at the traditional puncture site at 2.89±0.29 mm. The distal radial artery was smaller in females than in males at 2.32±0.26 mm versus 2.58±0.24 mm ($p<0.001$). The right distal radial artery differs from the right radial artery, which was 0.41±0.26 mm and approximately 20% smaller than the radial artery diameter. The proportion of patients with a distal radial artery of less than 2.5 mm was 48.5%. The vessel diameter of the distal radial artery was positively correlated with that of the radial artery diameter ($r=0.622$, $p<0.001$), body weight ($r=0.273$, $p<0.001$), height ($r=0.336$, $p<0.001$), and BMI ($r=0.124$, $p=0.002$). On the other hand, the vessel diameter of the distal radial artery is not correlated to age.

Conclusion: The study demonstrated that measuring the distal radial artery at the anatomical snuffbox provided valuable clinical information for vascular access planning. The strong correlation with the conventional radial artery diameter supported its use as a reliable reference, aiding in safer and more effective procedural decisions.

Keywords: Distal transradial artery diameter; Anatomical snuffbox

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In 2017, Kiemeneij developed an anatomical snuffbox, or distal radial artery, approach as an alternative access to coronary intervention, which is considered safe and effective for catheterization(1). The advantages of such a position included preserving the radial artery, reducing radial artery occlusion, and shortening the hemostasis time(2-5). According to the 2021 Korean-European consensus opinion, the benefits of distal radial access offer similar advantages to those of traditional transradial access at the wrist level, along with additional advantages including effective potential for lower rates of radial artery occlusion and vascular complications, rapid hemostasis, and favorable ergonomics, both for the patients and for the operator, especially in the case of left radial artery access(6).

In Thailand, distal radial artery access has become increasingly popular in coronary interventional procedures. However, considering the distal radial artery is a distal site of the radial artery at the wrist, it may be of smaller caliber, tortuosity, and have more of a learning experience for puncture technique, lower success rate, and is characterized by various anatomical anomalies and branching. In the previous study, ultrasound guidance can increase the cannulation success rate, decrease complications, and evaluate the diameter to prepare before the procedure(7-9).

In general, an approach with a sheath that is

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larger than the radial artery itself may result in more frequent long-term vascular complications, including diffuse stenosis, loss of forward flow, and increased risk for radial artery occlusion. A previous study demonstrated that a radial artery diameter/sheath diameter ratio of less than 1 is associated with a reduction in distal flow, indicating a high risk of vessel injury, and if the ratio is equal to or greater than 1.0, the incidence of flow reduction is significantly lower[10]. However, there are no large-scale clinical reports in Thai patients, and it is unclear whether the distal radial artery is large enough to withstand the insertion of a conventional sheath of the same size as the traditional radial approach. The present study aimed to study the distal radial artery reference diameter and the relationship between the diameter of the distal radial artery and the various factors by using ultrasound in Thai patients.

Material and Methods

The present study was a prospective non-randomized, single-centered study conducted at the Central Chest Institute of Thailand (CCIT), a tertiary care hospital with 350 in-hospital beds specializing in cardiopulmonary disease. Written informed consent was obtained from each patient before performing coronary angiography, fractional flow reserve (FFR), percutaneous coronary intervention (PCI) procedures, and recruitment to the study. The Human Research Ethics Committee of the Central Chest Institute, Department of Medical Services, Ministry of Public Health of Thailand approved the study protocol (COA REC 045/2566). Before commencing the present study, the study protocol was registered with the Thai Clinical Trials Registry (TCTR20231114001). The present study was conducted in compliance with the ethical standards of the responsible institution on human subjects as well as with the Helsinki Declaration.

After the Ethical Committee's approval, a non-randomized prospective study was performed between June 2023 and July 2024. Six hundred forty-seven consecutive patients were recruited for the current study. The ultrasound procedure was performed by two technicians with five years of experience in the cardiac catheterization laboratory (cath lab), who had undergone at least 20 cases of distal radial artery diameter before the study. The patient will have their distal radial artery diameter measured during echocardiography and will have it measured again during the cath lab by a different technician. Subjects were included in the study if they

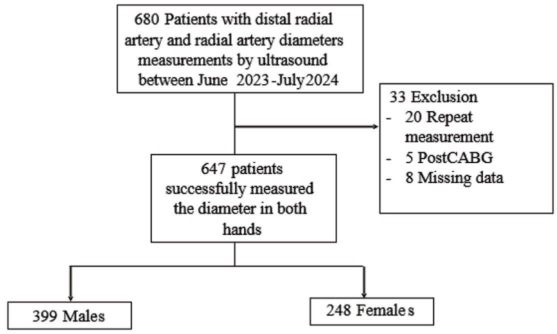

Figure 1. Study flowchart.

were at least 18 years of age and diagnosed with acute coronary syndrome, chronic coronary syndrome, or valvular heart disease. The patients were treated with elective or urgent coronary artery angiography (CAG)/PCI catheterization. Patient exclusion criteria included patients diagnosed with ST-elevation myocardial infarction (STEMI) who underwent primary PCI strategy, patients with peripheral arterial disease, post-coronary artery bypass grafting (CABG), cardiogenic shock, and patients who had undergone repeated diameter measurements, had missing data, or incomplete measurements (Figure 1).

An ultrasound transducer (Philips Lumify L12-4 Transducer, linear array transducer high frequency) was applied for ultrasound technique, identifying the radial artery and distal radial artery with short axis, out-of-plane needle puncture, and long axis. The radial artery and distal radial artery were measured at the distance from the lower edge of the adventitial of the vessel proximal wall to the upper edge of the adventitial of the vessel distal wall[11]. The radial artery and distal radial artery were measured at an anatomical landmark two centimeters proximal to the styloid process of the radius and the anatomical snuffbox, respectively. Both arteries' diameters were measured on two perpendicular axes, at the "9 o'clock to 3 o'clock" and the "6 o'clock to 12 o'clock" positions. The average of the two diameters was then reported as the patient's radial and distal radial artery diameters[11].

The patient's preparation position is shown in Figure 2. Right distal transradial access was performed by placing the right arm on the armrest along with the patient's body in a neutral position, with the lateral side of the forearm facing superiorly (Figure 2A-D).

Sample size

From a previous study by Deora et al., the sample

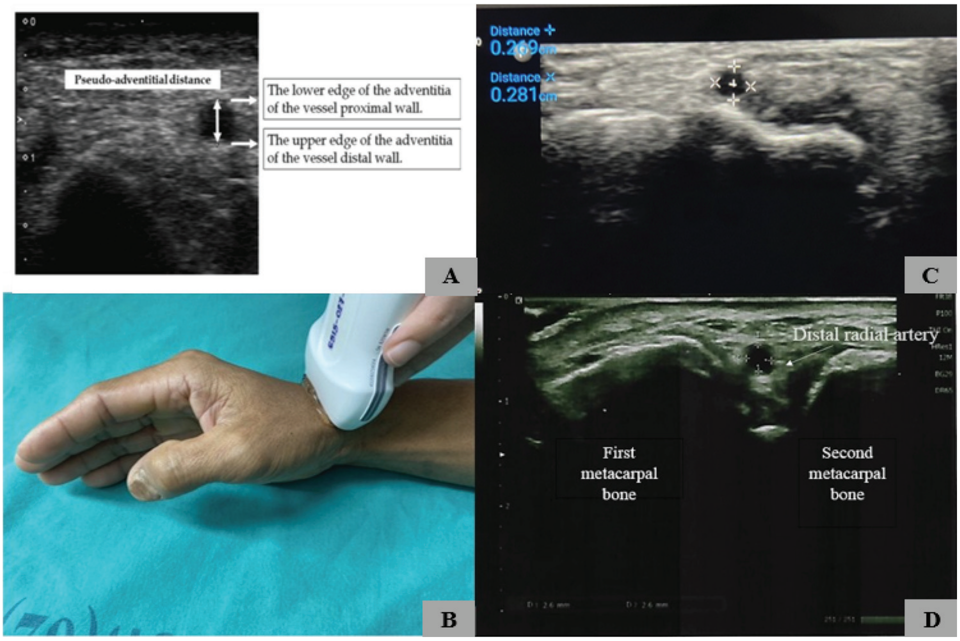

Figure 2. The measurement of the distal radial artery at the anatomical snuffbox, The pseudo-adventitial distance was used as the vessel diameter; i.e., the distance from the lower edge of the adventitia of the vessel proximal wall to the upper edge of the adventitia of the vessel distal wall (A), positioning of the ultrasound probe at the distal radial artery on the right hand (B), and the longitudinal and short-axis plane measurements of the distal radial artery between the first and second metacarpal bones (C-D).

size for the present study was calculated based on the average distal radial artery diameter in the right anatomical snuffbox position, which is 2.23 mm, with a standard deviation of 0.39, and the average distal radial artery diameter in the left anatomical snuffbox position, which was 2.17 mm(12), also with a standard deviation of 0.39. When calculating the sample size, the formula for estimating the mean of one group was used, with a standard value from the Z table set at 1.96 for a 95% confidence level. Consequently, the acceptable error was established at 2% of the average distal radial artery diameter in the anatomical snuffbox position for both the right and left hands. Initially, the researcher selected a sample of 370 individuals from the left hand, then increased it by 30% (111 individuals) to account for potential data loss. This adjustment resulted in a total of 481 individuals. Therefore, the final sample size for this study was determined to be at least 500 patients.

Statistical analysis

The clinical characteristics of patients were analyzed using descriptive statistics. Continuous variables were summarized as means and standard deviations for those with a normal distribution, while non-normally distributed variables were reported as medians along with the twenty-fifth and seventy-fifth percentiles, which represent the interquartile range (IQR). Categorical variables were represented as frequencies and percentages. The student t-test and Mann-Whitney test were used to compare continuous variables, whereas chi-square and Fisher's exact test were tested for categorical variables. Pearson correlation coefficient was applied to demonstrate the correlation between age, body weight, height, body mass index (BMI), and diameter of the distal radial artery. The following variables were analyzed to determine the factors associated with the size of the distal radial artery. A two-tailed p-value of less than 0.05 was considered statistically significant for all tests performed. PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA) was used to perform all statistical analyses.

Results

During the study period, six hundred forty-seven patients underwent distal radial evaluation. Patients' mean age was 62.78±11.87 years, and 399 (61.6%) were male. The female patients were older and had a similar BMI compared to male patients, although the difference was not statistically significant. However, females had significantly lower body weights, heights, and body surface areas than their male counterparts. The clinical presentation with reduced

Table 1. Baseline demographics and clinical presentation of the patients between males and females (n=647)

Baseline demographics	Total (n=647)	Male (n=399)	Female (n=248)	p-value
Age (years); mean±SD	62.71±11.87	62.00±11.68	63.85±12.10	0.053
Body weight (kg); mean±SD	65.12±13.47	68.00±12.88	60.48±13.14	<0.001
Height (cm); mean±SD	162.23±8.49	166.56±6.75	155.26±6.03	<0.001
BMI (kg/m^2); mean±SD	24.69±4.49	24.48±4.23	25.02±4.88	0.155
BSA (m^2); mean±SD	1.71±0.20	1.77±0.18	1.61±0.19	<0.001
Systolic BP (mm/Hg); mean±SD	128.09±21.16	127.63±20.54	128.84±22.16	0.478
Diastolic BP (mm/Hg); mean±SD	74.01±11.39	74.19±11.35	73.72±11.47	0.612
HR (beat/minute); mean±SD	71.66±13.30	70.83±12.55	73.01±14.35	0.042
LVEF (%); mean±SD	55.98±16.02	53.83±16.37	59.43±14.83	<0.001
Clinical presentation; n (%)				
Previous PCI	177 (27.4)	132 (33.1)	45 (18.1)	<0.001
Previous radial access	91 (14.1)	74 (18.5)	17 (6.9)	<0.001
Previous distal radial access	17 (2.6)	13 (3.3)	4 (1.6)	0.203
Dyslipidemia	601 (92.9)	380 (95.2)	221 (89.1)	0.003
Cerebrovascular disease	30 (4.6)	19 (4.8)	11 (4.4)	0.848
Family history of CAD	224 (34.6)	142 (35.6)	82 (33.1)	0.512
COPD	3 (0.5)	3 (0.8)	0 (0.0)	0.290
Current/recent smoking (<3 months)	79 (12.2)	74 (18.5)	5 (2.0)	<0.001
Hypertension	562 (86.9)	346 (86.7)	216 (87.1)	0.889
DM type II	198 (30.6)	109 (27.3)	89 (35.9)	0.021
CKD (eGFR <60 mL/minute)	111 (17.2)	64 (16.0)	47 (19.0)	0.340
Atrial fibrillation	110 (17.0)	61 (15.3)	49 (19.8)	0.141

SD=standard deviation; BMI=body mass index; BSA=body surface area; BP=blood pressure; HR=heart rate; LVEF=left ventricular ejection fraction; PCI=percutaneous coronary intervention; CAD=coronary artery disease; COPD=chronic obstructive pulmonary disease; DM=diabetes mellitus; CKD=chronic kidney disease; eGFR=estimated glomerular filtration rate

left ventricular (LV) function, previous PCI, previous radial artery access, and smoking were significantly higher in males than in females. Baseline patient characteristics are summarized in Table 1.

The diameter of the distal radial and radial artery in males and females are listed in Table 2. The mean vessel diameter of the distal radial artery in the anatomical snuffbox, at 2.48±0.28 mm, was significantly smaller than that of the radial artery at the traditional puncture site at 2.89±0.29 mm, in all patients. The results showed a similar vessel diameter in both men and women. The mean difference between the right radial artery and the right distal radial artery was 0.41±0.26 mm, and the ratio of artery size was 0.86±0.90. The mean diameter of the distal radial artery in females, at 2.32±0.26 mm, was smaller than in males, at 2.58±0.24 mm (p<0.001). The proportion of patients with distal radial artery of less than 2.5 mm was 48.5%, and women with distal radial artery diameter of less than 2.5 mm were more remarkable than men at 73.4% versus 66.9% (p<0.001).

The vessel diameter of the distal radial artery was positively correlated with that of the radial artery (r=0.622, p<0.001) (Figure 3), body weight, height, and BMI (r=0.273, p<0.001, r=0.336, p<0.001 and r=0.124, p=0.002) (Figure 4). On the other hand, the vessel diameter of the distal radial artery was not correlated to age (Figure 4).

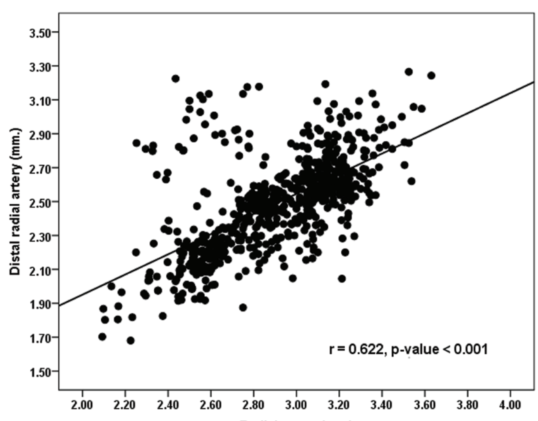

Figure 3. Correlation between the vessel diameters of the distal radial artery and radial artery.

Table 3 demonstrates the relationship between

Table 2. Diameters and characteristics of the distal radial and radial arteries

Characteristics	Total (n=647)	Male (n=399)	Female (n=248)	p-value
Distal radial artery (mm); mean±SD				
Right	2.48±0.29	2.58±0.25	2.32±0.27	<0.001
Left	2.48±0.29	2.59±0.25	2.31±0.27	<0.001
Radial artery (mm); mean±SD				
Right	2.89±0.30	3.00±0.26	2.71±0.27	<0.001
Left	2.89±0.30	3.01±0.26	2.71±0.27	<0.001
Δ Diameter (radial-distal radial) (mm), mean±SD				
Right	0.41±0.26	0.42±0.29	0.39±0.20	0.139
Left	0.41±0.27	0.42±0.29	0.39±0.21	0.240
Diameter index (mm)/BSA; mean±SD				
Right distal radial artery	1.47±0.20	1.47±0.19	1.46±0.21	0.314
Left distal radial artery	1.47±0.20	1.48±0.19	1.46±0.21	0.167
Right Radial artery	1.71±0.22	1.72±0.22	1.71±0.23	0.555
Left Radial artery	1.46±0.20	1.47±0.19	1.44±0.23	0.121
Ratio of arterial size (mm); mean±SD				
Right DRA/RA	0.86±0.09	0.86±0.10	0.85±0.07	0.244
Left DRA/RA	1.01±0.07	1.01±0.06	1.01±0.07	0.436
Distal radial artery (mm); n (%)				<0.001
<2.5	314 (48.5)	267 (66.9)	182 (73.4)	
≥2.5	333 (51.5)	132 (33.1)	66 (26.6)	

SD=standard deviation; BSA=body surface area; DRA=distal radial artery; RA=radial artery

Table 3. Comparison of the outer diameter of various conventional and thin-walled transradial sheaths introduced by various manufacturers

Product name	Company	Outer diameter (mm)		
		5 Fr	6 Fr	7 Fr
Glidesheath Slender®	Terumo Corporation	2.13	2.46	2.79
Prelude Ideal ™	Merit Medical System, Inc.	2.13	2.44	2.77
RAIN Sheath™	Cordis, a Cardinal Health company	2.14	2.47	2.80
Radiofocus Introducer II	Terumo Corporation	2.29	2.62	2.97
Prelude EASE™	Merit Medical System, Inc.	2.38	2.66	
APT Braidin™	APT Medical	2.16	2.49	2.87
Average		2.21	2.52	2.84

the average outer diameter of a conventional and thin-walled sheath using a traditional radial approach produced by six products. The relationship is shown between the outer diameter of a conventional sheath with traditional radial access in the authors' hospital and the diameter of the distal radial artery and radial artery (Figure 5). The proportion of males and females with sheath outer diameter per distal radial artery diameter (SOD/DRA) of 1 or more was 7.8%, 40.7% at 5 Fr sheath (2.21 mm), 41.6%, 76.6% at 6 Fr sheath (2.52 mm), and 84%, 96% at 7 Fr sheath (2.84 mm). While the proportion of males with sheath outer diameter per proximal radial artery diameter (SOD/PRA) greater than 1 was 0%, 2.8% at 5 Fr, 5.5%, 25.4% at 6 Fr, and 25.8%, 74.2% at 7 Fr (Table 4). The proportion of both hands is the same diameter.

Discussion

The present study was the first study of Thai patients from a non-randomized perspective to determine the diameter of the distal radial artery before cannulation and the selection of a sheath or guiding catheter of the appropriate size to perform the procedure safely. The study found that the vessel diameter of the distal radial artery at the anatomical snuffbox was significantly smaller than that of the radial artery. The mean distal radial artery and radial

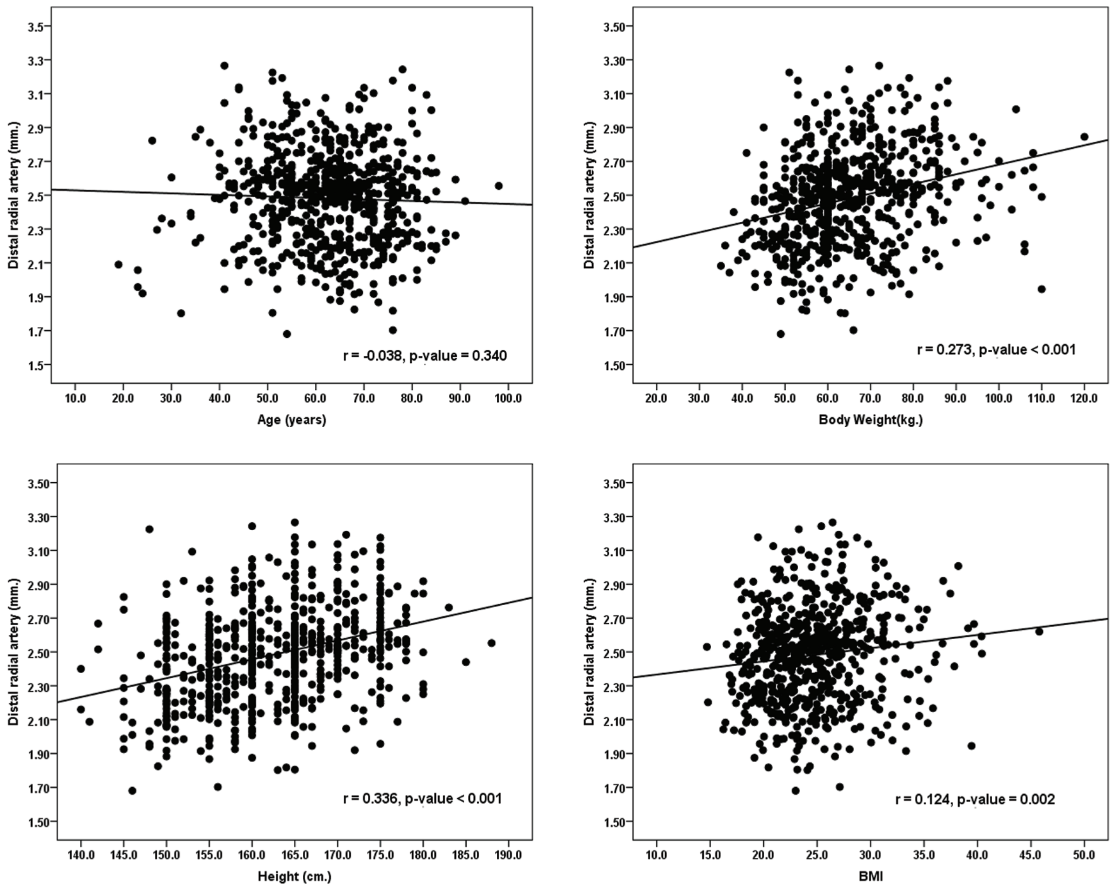

Figure 4. Correlation between the distal radial artery and age, body weight, height, and BMI.

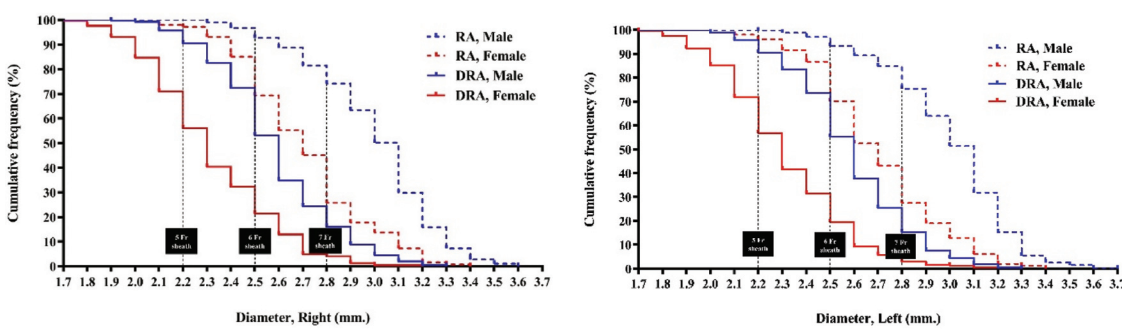

Figure 5. Relationships between the outer diameter of a conventional sheath using traditional radial access and the diameter of the distal radial artery and radial artery in the right and left hands.

artery diameter were 2.48±0.28 mm and 2.89±0.29 mm, respectively. Females had a smaller distal radial and radial artery diameter than males. The results found that the distal radial diameter is associated with weight, height, and BMI, and showed the strongest correlation with the radial artery diameter. The difference between the distal radial artery and radial artery diameters was approximately 0.41±0.26 mm and approximately 20% smaller than the radial artery diameter. Half of the patients (51.1%) had a distal radial artery size larger than 2.5 mm, which is compatible with a conventional 6 Fr sheath used in general practice in the cath lab.

The author's findings are concordant with the previous study of measurement of the diameter of the distal radial artery from a Korean study. Kim

Table 4. Cumulative frequency of conventional sheath outer diameter that is larger than distal radial artery and radial artery diameter

Sheath outer diameter/radial artery diameter	Male (n=399); n (%)		Female (n=248); n (%)	
	Right	Left	Right	Left
DRA				
>5 Fr (2.21 mm)	31 (7.8)	28 (7.0)	101 (40.7)	98 (39.5)
>6 Fr (2.52 mm)	166 (41.6)	159 (39.9)	190 (76.6)	192 (77.4)
>7 Fr (2.84 mm)	335 (84.0)	338 (84.7)	238 (96.0)	241 (97.2)
RA				
>5 Fr (2.21 mm)	0 (0.0)	0 (0.0)	7 (2.8)	8 (3.2)
>6 Fr (2.52 mm)	22 (5.5)	25 (6.3)	63 (25.4)	63 (25.4)
>7 Fr (2.84 mm)	103 (25.8)	98 (24.6)	184 (74.2)	180 (72.6)

DRA=distal radial artery; RA=radial artery

et al. found that the average diameter of the distal radial artery was 2.57±0.5 mm, and females had a significantly smaller diameter of the distal radial artery than men at 2.40 mm versus 2.65 mm[13]. The mean distal radial diameter was larger in the Japanese study by Norimatsu et al. The diameter of the distal radial artery in the anatomical snuffbox, at 2.6±0.5 mm, was significantly smaller than that of the radial artery, at 3.10±0.4 mm, and the difference was seen in both males and females. The study showed that the diameter of distal radial artery was positively correlated with that of the radial artery, both body weight, height, and BMI[11]. However, the methods for measuring the diameter of the vessel were different. In most studies, the definition of vessel diameter was measured from media-to-media distance[14,15], while the present research used the distance from the outer membrane to the outer membrane, which was larger than the results of other studies[11]. On the other hand, in the Indian population, Deora et al. study found the mean diameter of the right radial artery at the conventional access site was 2.56±0.35 mm, and at the distal access site 2.23±0.39 mm was smaller compared with the Thai population. In females, diabetes mellitus, hypertension, height, and weight were significant predictors of distal radial artery diameter[12]. In a Chinese population, Li et al. found that the mean diameter of the distal radial artery of 2.05±0.41 mm, hypertension, and distal radial artery diameter positively correlate with the success rate of distal radial artery access[16].

Ultrasound is an increasingly used tool in cardiovascular intervention via distal radial artery access. The benefits of ultrasound include preoperative vascular assessment, intraoperative guided puncture, and postoperative evaluation of complications. The anatomical snuffbox contains important structures, such as the distal radial artery, the superficial branch of the radial nerve, and the cephalic vein. Preoperative ultrasound guidance can identify important anatomical landmarks near the distal radial artery to avoid injuries and reduce puncture-related complications[17-19]. In addition, the previous study has found that factors that influence the success rate of distal transradial access were positively correlated with the diameter of the distal radial artery and hypertension and negatively correlated with female gender.

The study reported that the artery/sheath ratio greater than 1 was the least damaging to the vessel during coronary intervention. The inappropriate insertion of a conventional sheath using radial access may increase the risk of vascular injury, patient pain, and occlusion of the distal radial artery. The distal radial artery measurement is helpful in selecting the appropriate sheath size during CAG or PCI to reduce the incidence of radial artery occlusion[13,20]. The present study result was that the distal radial artery diameter was smaller than the radial artery diameter at the wrist. Therefore, it is recommended to measure the diameter of the distal radial artery preoperatively in all patients who plan to use distal radial artery access and select the appropriate sheath size or choose the one size smaller sheath or approach site according to the size of each vessel. Various manufacturers of thinner walls or slender sheaths may be beneficial for distal transradial artery access in patients with a small distal radial artery.

Limitation

The present study design was a prospective, non-randomized, single-center study. The first limitation of the study is that the distal radial artery may be underestimating vessel size because of spasm in anxious patients or cold temperatures in the echocardiography room or cath lab room, so the actual size of the distal radial artery may be bigger than the measurement data. Second, the distal radial artery is a small vessel with a superficial, movable, bends, and tortuosity, so it may be difficult to accurately measure the vessel diameter and unintentional compression with the linear transducer. The most appropriately used hockey stick probe type can be easily positioned in the anatomical snuffbox because of its small size and ultra-high frequency at 6 to 18 MHz. Third, technical difficulties in identifying the actual adventitial border may lead to vessel size overestimation and increase the risk for artery occlusion. Fourth, the present study had a small sample size. A further study should be conducted with a larger sample size for multi-center hospitals.

Conclusion

The present study demonstrates that measuring the distal radial artery at the anatomical snuffbox provided valuable clinical information for vascular access planning. The strong correlation with the conventional radial artery diameter supports its use as a reliable reference, aiding in safer and more effective procedural decisions.

What is already known about this topic?

Measuring the distal radial artery diameter in Thai patients provides essential demographic data, improves safety, ensures proper device selection, reduces complications, and establishes population-specific standards that differ from Western references.

What does this study add?

For coronary catheterization by a distal radial approach, physicians should evaluate whether there is sufficient vessel diameter using ultrasound before the procedure. Additionally, this approach can be an effective option from this perspective.

Conflicts of interest

The authors declare no conflicts of interest.

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