Prediction of radial artery diameter in candidates for transradial coronary angiography: is occupation a factor?

Transradial yaklaşımla koroner anjiyografi yapılması planlanan hastalarda radial arter çaplarının tahmin edilmesi: Meslek farklılık yaratır mı?

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ABSTRACT

Objective: Transradial approach (TRA) for coronary angiography is a popular alternative approach to transfemoral coronary angiography due to the infrequent occurrence of access site complications such as bleeding, hematoma and pseudoaneursym formation. However, not all patients are suitable for TRA. This study aimed to determine the predictors of radial artery diameter in patients who are candidates for TRA.

Methods: The study included 222 consecutive patients who underwent TRA due to suspected stable coronary artery disease. Radial artery diameter was evaluated prior to the procedure using B-mode ultrasonography.

Results: Radial artery diameter was correlated with wrist circumference (r=0.539, p<0.001), height (r=0.258, p<0.001), weight (r=0.237, p<0.001), body mass index (r=0.167, p=0.013), shoe size (r=0.559, p<0.001), and pulse pressure (r=-0.161, p=0.016). The right radial artery was larger in men than in women (2.73±0.39 mm *vs.* 2.15±0.35 mm, p<0.001), and smaller in patients with sedentary office work than in physically active outdoor workers (2.42±0.45 mm *vs.* 2.81±0.37 mm, p<0.001). Wrist circumference (b=0.044, p<0.001, confidence interval (CI) 95%= 0.025–0.062), shoe size (b=0.075, p=<0.001, CI 95%=0.039–0.112) and occupation (b=0.228, p<0.001, CI 95%=0.138–0.318) were the independent predictors of radial artery diameter in regression analysis.

Conclusion: In addition to shoe size and wrist circumference, occupation may be an important predictor of radial artery diameter, and it should be evaluated with other clinical parameters in the prediction of radial artery diameter.

ÖZET

Amaç: Transradial yaklaşımla (TRY) koroner anjiyografi femoral yoldan anjiyografinin popüler bir alternatifidir. Kanama, hematom, psödoanevrizma oluşması gibi giriş yeri komplikasyonları TRY'da dahi nadirdir. Ancak bütün hastalar TRY'ya uygun değildir. Bu çalışmanın amacı TRY planlanan hastalarda radial arter çapının öngördürücülerinin belirlenmesidir.

Yöntemler: Bu çalışmaya kararlı koroner arter hastalığı şüphesi nedeniyle TRY planlanan 222 hasta alındı. Radial arter çapları işlemden önce B-mod ultrasonografi ile ölçüldü.

Bulgular: Radial arter çapı, el bileği çapı (r=0.539, p<0.001), boy (r=0.258, p<0.001), ağırlık (r=0.237, p<0.001), beden kütle indeksi (r=0.167, p=0.013), ayakkabı numarası (r=0.559, p<0.001) ve nabız basıncı (r=-0.161, p=0.016) ile ilişkili bulundu. Sağ radial arter çapı erkeklerde kadınlardan daha kalındı (2.73±0.39 mm ve 2.15±0.35 mm, p<0.001) ve sedanter ofis çalışanlarında aktif dışarıda çalışan işçilere göre daha inceydi (2.42±0.45 mm ve 2.81±0.37 mm, p<0.001). Regresyon analizinde el bileği çapı (b=0.044, p<0.001, Güven aralığı [GA] %95=0.025–0.062), ayakkabı numarası (b=0.075, p=<0.001, GA %95=0.039–0.112) ve meslek (b=0.228, p<0.001, GA %95=0.138–0.318) radial arter çapının bağımsız öngördürücüleri olarak bulundu.

Sonuç: Ayakkabı numarası ve el bileği çapının yanında yapılan meslek de radial arter çapının önemli bir öngördürücüsü olabilir. Bu nedenle radial arter çapının tahmininde yapılan meslek de diğer parametrelerle beraber değerlendirilmelidir.

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Transradial approach (TRA) for coronary angiography is a popular alternative approach to transfemoral coronary angiography, with infrequent occurrence of access site complications including bleeding, hematoma and pseudoaneursym formation.[1–3] Patients prefer the transradial approach because of its comfort, resulting shorter hospital stay, lack of necessity to be in the supine position during the procedure, and better and earlier physical and social functioning post-procedure.[1–5] Blood supply to the hand is provided by a double arterial system consisting of the radial and ulnar arteries. In the event of adequate ulnar circulation, the transradial route may be tried for coronary angiography. However, TRA may not possible for all patients with good ulnar collateral circulation. Small radial artery size is an important obstacle, and therefore estimating radial artery diameters may be valuable for clinicians and patients who are candidates for TRA in selecting the most appropriate approach route and instrument, and in saving time.

The aim of this study is to determine the predictors of radial artery diameters in candidates for TRA. To our knowledge, this is the first study to evaluate the role of occupation in predicting radial artery size in candidates for TRA.

METHODS

Study population

This cross-sectional study included 222 consecutive patients (178 male) who underwent TRA due to suspected stable coronary artery disease between August and October 2013. The study protocol was approved by the Ethics Committee and confirms with the principles of the Declaration of Helsinki. Patients with previous transradial coronary revascularization, acute coronary syndrome, abnormal oximeter/plethysmography test, hemodynamic impairment, uncontrolled hypertension, heart rhythm other than sinus rhythm and height <150 cm were excluded from the study.

Patients' occupations were noted and then categorized as either office work or outdoor work. Weights of the patients, in light clothes and without shoes, were measured in kilograms, and their heights were also measured. Body mass index (BMI) was calculated by dividing body weight in kilograms by the square of body height in meters.

Blood pressure was measured, in compliance with World Health Organization guidelines, using a mercury sphygmomanometer (ERKA, Germany) with a cuff appropriate to the arm circumference, in patients at rest for 20 minutes (Korotkoff phase I for systolic blood pressure [SBP] and V for diastolic blood pressure [DBP]) at least 3 times and the average of the measurements calculated. Hypertension was defined as a previous diagnosis of hypertension or the presence of SBP ≥140 mmHg or DBP ≥90 mmHg (the mean of two consecutive measurements). Diabetes was defined as fasting plasma glucose ≥126 mg/dl, or plasma glucose level ≥200 mg/dl 2 hours after the 75 mg oral glucose tolerance test, or symptoms of hyperglycemia accompanied by casual plasma glucose ≥200 mg/dl or HbA1C ≥6.5% or patients using antidiabetic medications. None of the patients received oral nitrates or calcium canal blockers.

Abbreviations:

BMI	*Body mass index*
DBP	*Diastolic blood pressure*
LV	*Left ventricular*
LVMI	*LV mass index*
SBP	*Systolic blood pressure*
TRA	*Transradial approach*

Patients who self-reported as having smoked during the previous six months were classified as smokers. Venous blood samples were drawn after a 12-hour overnight fast. Serum glucose, total cholesterol and triglycerides were determined using standard automatic enzymatic methods. High-density lipoprotein (HDL) cholesterol was determined after specific precipitation and low-density lipoprotein (LDL) cholesterol was determined by the Friedewald formula.

Echocardiographic examinations were performed in the left lateral decubitus position according to guidelines of the American Society of Echocardiography.

Left ventricular mass was calculated according to the Devereux formula:

LV mass: $0.8 \times 1.04 \times ([LVEDD+IVS+PW]^3 - LVEDD^3) + 0.6$

LV mass index (LVMI): LV mass/body surface area

Evaluation of radial artery diameter

The radial artery was evaluated using B mode ultrasonography (Mindray M7 ultrasound system, Mindray, Inc, Shenzen, PRC, 7L4S linear probe [5–10 mHz]) before the procedure. The radial artery was localized, and radial diameters measured 3 cm proximal to the styloid process at the R peak of the electrocardiogram. For each image, the mean of 5 measurements was obtained.

Transradial coronary angiography

After palmar arch permeability assessment by oximeter/plethysmography test, sterile preparation and local anesthesia with 1 ml of 2% prilocaine was performed. The radial artery was cannulated with 5 and 6Fr hydrophilic 10-cm-long sheaths (Terrumo radifocus introducer II, Terumo, Leuven, Belgium). After sheath insertion, a radial cocktail containing 2 mg diltiazem, 200 mcg nitroglycerin and heparin 5000 IU diluted in a 10-ml syringe was injected gradually through the sheath side arm into the radial artery. Coronary angiography was performed using 5 and 6Fr catheters (Boston Scientific). On completion of the diagnostic procedure, the radial sheaths were removed, and an inflatable hemostatic device was applied to the access site. After transfer to the recovery room, initial compression was reduced to maintain radial artery patency. Radial artery patent hemostasis was verified, first by placing a pulse oximeter on the thumb, and then by observing the continuous plethysmographic signal on the monitor during manual compression of the ulnar artery just proximal to the pisiform bone. Great care was taken to obtain radial artery hemostasis while maintaining minimal pressure with the band. The band was left in place until hemostasis was completed, usually within 2 hours. All coronary angiograms were performed by 2 interventional car-

Table 1. Baseline characteristics of the patients

Variables	n	%	Mean±SD
Male	178	80.2	
Age (Years)			62.43±9.10
Wrist circumference (cm)			17.17±2.61
Radial artery diameter (mm)			2.62±0.45
Height (cm)			170.26±6.88
Weight (cm)			82.34±9.83
Body mass index (kg/m^2)			28.42±3.13
Shoe size (EU)	42	2	
High density lipoprotein cholesterol (mg/dl)			41.36±10.54
Low density lipoprotein cholesterol (mg/dl)			147.81±40.59
Triglyceride (mg/dl)			184.49±103.43
Glucose (mg/dl)			103.26±12.22
Hemoglobin (gr/dl)			14.03±1.53
Creatinine (mg/dl)			0.86±0.22
Systolic blood pressure (mmHg)			144.32±12.08
Diastolic blood pressure (mmHg)			88.07±9.65
Pulse pressure (mmHg)			56.10±9.28
Diabetes	63	28.4	
Hypertension	124	55.9	
Dyslipidemia	143	64.4	
Smoking	90	40.5	
Left ventricle ejection fraction			61.79±7.97
Relative wall thickness			0.47±0.09
Left ventricle mass index (gr/m^2)			100.95±32.54
Glomerular filtration rate (ml/min)			96.78±23.58
Occupation			
Outdoor	113	50.9	
Office	109	49.1	

diologists blinded to ultrasonography evaluation and experienced in radial access.

Statistical analysis

SPSS 17.0 statistical software (SPSS Inc., Chicago, Ill., USA) was used for statistical analysis. The Kolmogorov-Smirnov test was used to test the normality of distribution of continuous variables. Continuous variables were expressed as means ± SD or median (interquartile range), and categorical variables were expressed as percentages as appropriate. Pearson or Spearman correlation analysis was used for assessing the correlates of radial artery diameter depending on Gaussian distribution. Continuous variables were compared using independent sample T-test. To avoid collinearity in assessing the multivariate model, independent variables were tested for intercorrelation. Variables showing a significant relationship with radial artery diameter, including shoe size, BMI, occupation, pulse pressure, wrist circumference and gender, were entered into the multivariate linear regression analysis to find independent predictors of radial artery diameter.

RESULTS

The study included 222 patients (178 male). Mean patient age was 62.43±9.10 years. Baseline patient characteristics are shown in Table 1. Mean diameter of the right radial artery was 2.62±0.45 mm. All procedures were performed using the right radial approach. This was unsuccessful in 4 patients due to difficulty in advancing catheters and operators adopted the transfemoral approach.

Radial artery diameter was correlated with wrist circumference (r=0.539, p<0.001), height (r=0.258, p<0.001), weight (r=0.237, p<0.001), BMI (r=0.167, p=0.013), shoe size (r=0.559, p<0.001) and pulse pressure (r=-0.161, p=0.016) (Figure 1). The results of correlation analysis are shown in Table 2.

The right radial artery was larger in men than in women (2.73±0.39 mm *vs*. 2.15±0.35 mm, p<0.001) and smaller in patients with sedentary office work than in those engaged in active outdoor work (2.42±0.45 mm *vs*. 2.81±0.37 mm, p<0.001). Of the 222 patients, 116 (52.3%) were active outdoor workers. There was a significantly higher frequency of outdoor jobs among men compared to women (29.5% *vs*. 57.9% respectively, p=0.001).

Variables showing significant association with radial artery diameters were entered into the multivariate linear regression analysis. Wrist circumference (b=0.044, p<0.001, CI 95%= 0.025–0.062), shoe size (b=0.075, p<0.001, CI 95%=0.039–0.112) and occupation (b=0.228, p<0.001, CI 95%=0.138–0.318) were the independent predictors of radial artery diameter in the regression analysis (Table 3).

DISCUSSION

In univariate analysis, radial artery diameter was

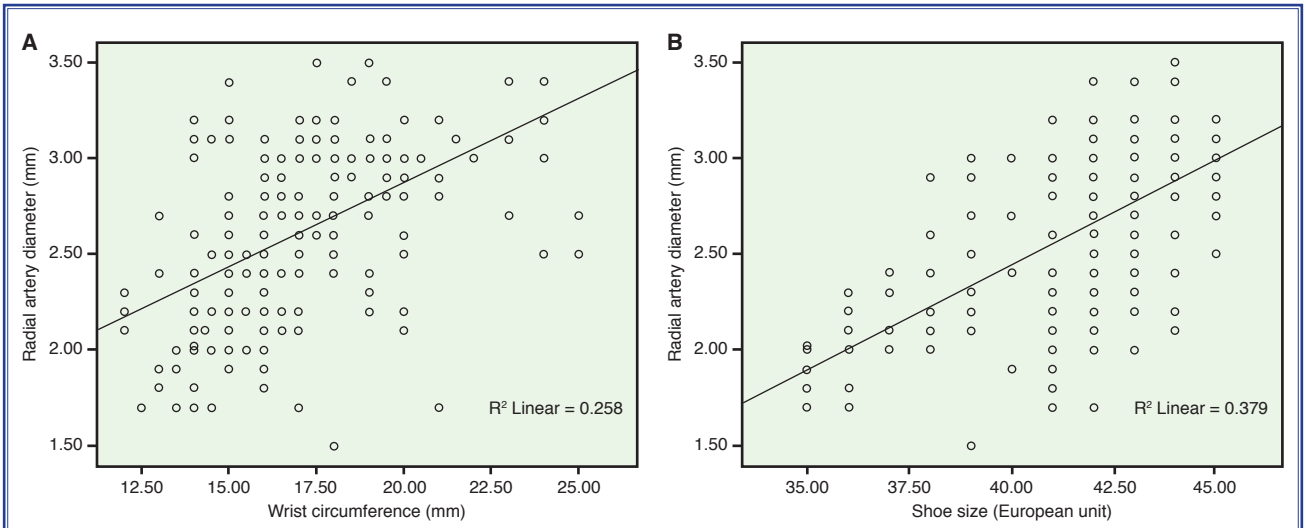

Figure 1. **(A)** Correlation of wrist circumference with radial artery diameter is shown. **(B)** Correlation of shoe size with radial artery diameter is shown.

Table 2. Correlates of radial artery diameter

Variables	r	*p*
Age	0.048	0.481
Wrist circumference	0.539	**<0.001**
Height	0.258	**<0.001**
Weight	0.237	**<0.001**
Body mass index	0.167	0.013
Shoe size	0.559	**<0.001**
High density lipoprotein cholesterol	-0.032	0.639
Low density lipoprotein cholesterol	-0.023	0.739
Triglyceride	0.005	0.940
Glucose	0.063	0.351
Hemoglobin	0.109	0.104
Creatinine	0.105	0.118
Systolic blood pressure	-0.076	0.257
Diastolic blood pressure	0.036	0.595
Left ventricle ejection fraction	-0.046	0.491
Relative wall thickness	-0.016	0.085
Left ventricle mass index	-0.110	0.101
Estimated glomerular filtration rate	0.100	0.139
Pulse pressure	-0.161	0.016

Table 3. The independent predictors of Radial artery diameter

Variable	B	Standardized B	*p*	CI 95%	VIF
Wrist circumference	0.044	0.253	**<0.001**	0.025–0.062	1.327
Body mass index	0.013	0.088	0.071	-0.001–0.026	1.030
Pulse pressure	-0.002	-0.050	0.299	-0.007–0.002	1.030
Shoe size	0.075	0.422	**<0.001**	0.039–0.112	4.727
Occupation	0.228	0.252	**<0.001**	0.138–0.318	1.123
Sex	-0.007	-0.007	0.946	-0.224–0.209	4.124

*The observed R2 of the model was 0.510.

found to be related to gender, height, weight, BMI, pulse pressure, shoe size, occupation and wrist circumference, and in multivariate regression analysis, shoe size, occupation and wrist circumference were the independent predictors of radial artery diameter.

Coronary angiography is the gold standard test for evaluating coronary artery disease. The transfemoral approach is commonly preferred over TRA. However, the former is associated with poorer patient comfort, longer hospital stay and increased complication rates including bleeding, hematoma, pseudoaneurysm and death,[1] and therefore the latter is becoming more popular. In its use, however, the smaller diameter of the radial artery poses a great challenge. In addition, TRA may cause vasomotor dysfunction of radial and brachial arteries.[6] Hence, estimating radial artery size before coronary angiography and intervention may be helpful. Larger catheters enable complex coronary and non-coronary interventions. A high dose of heparin administration is associated with lower rates of radial artery occlusion without any increase

in vascular complications.[7] Many complex cardiac procedures can be performed using 6Fr systems, and therefore practical predictors of radial artery diameter are of importance to radial operators. We used Radifocus introducer sheaths, one of the thinnest, as the 6fr Radifocus introducer sheath has an outer diameter of 2.1 cm. Of our study population, 86.5% was suitable for this 6fr sheath. We found that shoe size and wrist circumference were the major determinants of radial artery diameter, with height and occupation as other important independent predictors.

Similarly to the literature, we found larger radial artery diameter in men than in women,[1,8] this was not an independent predictor in multivariate regression analysis. This finding may be attributable to the shorter stature of women.

In patients with a low BMI (<50 kg, <150 cm), a small radial artery diameter poses a problem in radial artery interventions.[1] No patients in this study were lower than this limit.

Racial variations may be present in among different populations. There are a few studies in the literature reporting radial artery diameter in the Turkish population, with mean radial artery diameter being reported as 2.3–2.8 mm.[9,10] This study's findings were similar: radial artery diameter was 2.62±0.45 mm.

Nitrates and calcium canal blockers have vasodilatory properties, but patients in this study were neither in receipt of oral nitrate or calcium canal blocker therapy at baseline, nor were these drugs were administered before measurement.

Okuyan et al. reported that there was no independent predictor of radial artery diameter, and that left radial artery diameter was smaller than right.[10] They measured radial artery diameter angiographically in 93 patients, who may have been affected by radial artery spasm and thus have shown diminished radial artery diameter. Additionally, the influence of occupation was not evaluated. Recently, Kotowycz et al. measured radial artery diameters after TRA in 130 patients, and reported wrist circumference, male sex and non-South Asian ancestry as independent predictors of radial artery diameter.[8] Similarly, the present study found wrist circumference, in addition to shoe size, height and occupation, to be an independent predictor of radial artery diameter. Furthermore, Kotowycz et al. measured radial artery diameter after TRA, which may be associated with measurements of small radial artery calipers. Our study population was also larger. Aktürk et al. reported small wrist circumference to be associated with more pronounced wrist pain.[11] This finding was probably due to induction of vasospasm in small radial arteries, as we found that wrist circumference was an independent factor of radial artery diameter.

Occupation has several impacts on the human body as it adapts to the occupation. Blood flow may increase to more functioning organs and muscular hypertrophy may ensue. Therefore, increased blood supply to the extremities may be expected in outdoor workers. There are several ways to increase blood supply, including development of collaterals and increasing vessel diameters. These adaptive responses may be associated with increased vessel diameters in outdoor workers in this study. Okuyan et al. reported right radial artery as larger than left, which may be related to the same adaptive response with more usage.[10] Although the left radial artery is smaller than the right, procedural success rates are not affected.[12]

Study limitations

Our study has several limitations. Firstly, the study population was relatively small. Secondly, this single center study was performed in the Turkish population only, and racial variation may be present in radial artery diameters. Therefore, further studies with larger populations are needed to verify our findings.

Conclusion

Besides shoe size and wrist circumference, occupation may be an important predictor of radial artery diameter. Therefore, it should be evaluated along with other clinical parameters in prediction of radial artery diameter.

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Key words: Angioplasty, balloon, coronary/methods; coronary angiography/methods; heart catheterization/methods; radial artery.

Anahtar sözcükler: Anjiyoplasti, balon, koroner/yöntem; koroner anjiyografi/yöntem; kalp kateterizasyonu/yöntem; radial arter.