

Methods for increasing distal radial artery diameter

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Abstract. – OBJECTIVE: Our study aimed to find the maximum rate of increase in distal radial artery size.

PATIENTS AND METHODS: Diameter measurements were obtained on transverse and sagittal sections of the artery with a high-frequency linear transducer (Philips ClearVue L12-4 Mhz). In the baseline evaluation, radial artery and distal radial artery diameters were measured. The patients were divided into two groups: patients with flow-mediated dilatation in Group I and patients with 30 mg Topical Nitroglycerin in Group II. Group II patients were divided into two groups 30 minutes after topical nitroglycerin; patients with flow-mediated dilatation (FDM) in Group IIa, patients with wrist warming plus FMD in Group IIb.

RESULTS: A significant increase was found between baseline and second measurements in the radial artery (2.64 ± 0.46 and 2.36 ± 0.39 mm; $p=0.02$ in Group I, 2.78 ± 0.38 and 2.39 ± 0.25 mm; $p=0.01$ in Group II) and distal radial artery (2.29 ± 0.49 and 1.93 ± 0.37 mm; $p=0.02$ in Group I, 2.32 ± 0.28 and 1.96 ± 0.44 mm; $p=0.04$ in Group II) diameters. Radial (3.02 ± 0.55 and 2.78 ± 0.38 mm; $p<0.01$) and distal radial artery (2.55 ± 0.32 and 2.32 ± 0.28 mm; $p=0.01$) diameters increased compared to the second measurements in Group IIa. Radial (3.25 ± 0.35 and 2.78 ± 0.38 mm; $p<0.01$) and distal radial artery (2.88 ± 0.12 and 2.32 ± 0.28 mm; $p<0.01$) diameters increased compared to the second measurements in Group IIb. The results of the final evaluations of the two groups were compared, radial (3.02 ± 0.55 and 3.25 ± 0.35 mm; $p=0.04$) and distal radial artery (2.55 ± 0.32 and 2.88 ± 0.12 mm; $p=0.03$) diameters were found to be significantly higher in Group IIb than Group IIa. When comparing baseline and final evaluations, the radial artery diameter was increased by 37%, and the distal radial artery diameter was increased by 49% in Group IIb.

CONCLUSIONS: We increased the radial artery diameter higher proportion than defined in the literature.

Key Words:

Distal radial artery, Nitrate, Warming, Flow-mediated dilation.

Introduction

The distal trans-radial access approach has gained increasing popularity and adoption worldwide¹. One of the biggest challenges of a successful distal trans-radial procedure remains the small size of the distal radial artery. The potential need for larger catheters may be a common reason for intraprocedural switching from the radial artery to the femoral access. For these reasons, a method of increasing the size of the distal radial artery before attempting the access will make trans-radial artery access more convenient. Spasm is common due to the vasoreactivity of the radial artery². Repeated puncture attempts are an independent predictor of radial artery spasms and may contribute to failure^{3,4}. Strategies aimed at maximizing radial artery access with a single puncture may help reduce the risk of spasms.

Important influencing factors of radial artery diameter are medications (e.g. nitrates and their derivatives), room temperature, and flow-mediated vasodilation⁵. In previous literature, various treatments were suggested to increase the diameter of the radial artery. There are many studies⁶⁻⁹ in the literature in which various nitrate derivatives are tested. In a randomized, double-blind clinical trial¹⁰, topical nitroglycerin and lidocaine resulted in an increase in cross-sectional area by 16.5%. In addition to topical nitroglycerin application, flow-mediated dilatation (FDM) is a reasonable method for peripheral arterial expansion. FMD is used to measure endothelial function and shows the ability of the endothelium to produce nitric oxide¹¹⁻¹⁵. The results of a study¹⁶ demonstrate that palmar warming is effective at inducing radial artery vasodilation with a 43.9% increase in the cross-sectional area.

Since the success of distal and radial artery access may depend on operator experience, increasing the vessel diameter alone may be an indirect indicator of radial intervention success. Our study

aimed to find the maximum rate of increase in distal radial artery size. Although there are many studies to increase the diameter of the radial artery, this was the first study to evaluate the distal radial artery to our knowledge.

Patients and Methods

Patients

To reduce confounding factors, patients without coronary artery disease were excluded from the study. Patients older than 18 years of age, previously undergoing coronary angiography, and diagnosed with coronary artery disease (>50% coronary luminal stenosis, coronary stent, or coronary bypass) were included in our study. To decrease the impact of confounding variables, patients taking drugs containing nitrates and their derivatives were excluded. Patients with known contraindications for nitroglycerin (NTG) (hypertrophic obstructive cardiomyopathy, severe aortic valve stenosis, heart rate <50 bpm, systolic blood pressure <100 mm Hg) were excluded from the study.

Procedures

Exercising before the procedure was avoided. Care was taken not to consume caffeinated or alcoholic beverages and not to eat food 12 hours before the procedure. The procedure was started by measuring the systolic and diastolic blood pressure of the patients after a ten-minute rest in an environment at 20/25°C.

The patients were placed in the supine position. Diameter measurements were obtained on transverse and sagittal sections of the artery with a high-frequency linear transducer (Philips ClearVue L12-4 Mhz, Amsterdam, Netherlands). Diameters from intima to intima were measured three times at the end of diastole according to ECG monitoring, and the average of these three measurements was used. After the basal measurements, the probe location was marked with a ballpoint pen and the measurements were made from the same locations. All measurements were made as indicated below;

Radial artery diameter (RAD) measurement: the patient laid in the supine position, with the arm at the patient's side, with the wrist up. RAD was measured 2 cm more proximal to the radial styloid process at the wrist.

Distal radial artery diameter (DRAD) measurement: the presence of open pulsation of the distal ra-

dial artery was confirmed by manual palpation in the anatomical snuffbox. The right hand was positioned and supported with the arm more pronated with the anatomical snuffbox facing upwards. The hand was positioned with the thumb bent underneath the other four fingers and DRAD was measured.

Application of topical nitroglycerin (NTG): NTG was delivered as a commercially available paste. 30 mg of NTG was applied in a linear fashion overlying from the proximal to the distal radial artery. Measurements of diameter and blood pressure were performed 30 minutes after application.

Flow-mediated dilatation (FMD): a sphygmomanometric cuff was first placed into the wrist. Thereafter, arterial occlusion was created by cuff inflation to supra-systolic pressure. The cuff was inflated to at least 50 mmHg above the systolic pressure to occlude arterial inflow for 5 minutes. Images of the artery were recorded one minute after the cuff deflation.

Warming the wrist: the heat bag filled with hot water was kept under the wrist for 5 minutes.

Patients were assigned to Group I and Group II:

- In Group I, FMD was applied first, and the diameters were measured after 1 minute. After FMD, topical NTG was applied, and the diameters were measured 30 minutes after NTG.
- In Group II, topical NTG was applied, and the diameters were measured 30 minutes after NTG. After NTG application, Group II was divided into Group IIa and Group IIb: 5 minutes of FMD was applied in Group IIa. 5 minutes of wrist warming and FMD were applied in Group IIb.

Statistical Analysis

All of the statistical analyses were performed using SPSS statistics for Windows, version 23.0 software package (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was evaluated using histograms, normal Q-Q plots, skewness, kurtosis, and Kolmogorov-Smirnov test. Frequency analysis and descriptive statistics were used to describe data. The independent samples *t*-test was used for normally distributed data and the Mann-Whitney U test for non-normally distributed data. Normally distributed echocardiographic parameters in consecutive diameter measurements were compared with the paired *t*-test. Non-normally distributed data in consecutive diameter measurements were analyzed using a signed Wilcoxon rank-sum test. Values of $p < 0.05$ were considered to indicate statistical significance.

Results

A total of 152 patients diagnosed with coronary artery disease between July 2022 and October 2022 were included in the study. Group I (n=50) and Group II (n=102) were formed with similar basic characteristics including age, gender, height, weight, body mass index, hypertension, diabetes, and smoking (Table I). In baseline measurements, radial (2.36±0.39 and 2.39±0.25 mm; *p*=0.23) and distal radial artery (1.93±0.37 and 1.96±0.44 mm; *p*=0.42) dimensions were similar in each group.

In the second measurement, radial artery diameters were increased in 48 of 50 (96%) patients in Group I after 5 minutes of FMD, and in 98 (97%) of 102 patients in Group II 30 minutes after NTG. A significant increase was found between baseline and second measurements in the radial artery (2.64±0.46 and 2.36±0.39 mm; *p*=0.02 in Group I, 2.78±0.38 and 2.39±0.25 mm; *p*=0.01 in Group II) and distal radial artery (2.29±0.49 and 1.93±0.37 mm; *p*=0.02 in Group I, 2.32±0.28 and 1.96±0.44 mm; *p*=0.04 in Group II) diameters.

In Group II, after the second measurement, FMD was applied to Group IIa and FMD with wrist warming was applied to Group IIb. Radial (3.02±0.55 and 2.78±0.38 mm; *p*<0.01) and distal radial artery (2.55±0.32 and 2.32±0.28 mm; *p*=0.01) diameters increased compared to the second measurements in Group IIa. Radial (3.25±0.35 and 2.78±0.38 mm; *p*<0.01) and distal radial artery (2.88±0.12 and 2.32±0.28 mm; *p*<0.01) diameters increased compared to the second measurements in Group IIb. The results of the

final evaluations of two groups were compared, radial (3.02±0.55 and 3.25±0.35 mm; *p*=0.04) and distal radial artery (2.55±0.32 and 2.88±0.12 mm; *p*=0.03) diameters were found to be significantly higher in Group IIb than Group IIa. When comparing baseline and final evaluations, the radial artery diameter was increased by 37%, and the distal radial artery diameter was increased by 49% in Group IIb (Figure 1). Importantly, there was no difference in blood pressure before and after treatment in both groups, indicating that nitroglycerin had no significant systemic effects (Table II).

Discussion

This study demonstrated that by combining topical NTG, FMD, and warming, the radial and distal radial arteries can be enlarged at rates greater than those defined in the literature. 83.2% increase in cross-sectional area in the radial artery and 117.1% in the distal radial artery were recorded. Administering 30 mg topical NTG, warming the wrist, and applying FMD before trans-radial coronary interventions may be reasonable to increase the success of the radial puncture.

In baseline measurements, the mean radial artery and distal radial artery size of the patients were smaller than the outer diameter of the 6 French sheaths. Only the mean radial artery diameters were larger than the outer diameter of the 5 French sheaths. After topical NTG, FMD, and warming, we can say that patients can receive 8 French sheaths for the radial artery and

Table I. Patient characteristics.

Variable	Group I	Group II	Overall cohort	<i>p</i> -value
Age, years	60.0 ± 13.8	65.4 ± 13.6	62.2 ± 12.9	0.142
Gender, % male	45	47	46	0.682
Height, m	1.75 ± 0.02	1.72 ± 0.12	1.73 ± 0.09	0.831
Weight, kg	80.2 ± 16.2	79.3 ± 11.2	80.8 ± 12.6	0.343
Body mass index	27.3 ± 3.7	27.7 ± 6.2	27.0 ± 4.6	0.394
Diabetes mellitus, %	18	22	19	0.679
Dyslipidemia, %	58	56	57	0.577
Hypertension, %	64	55	61	0.225
Tobacco, %	18	14	15	0.117
Pre-procedural medical therapy				
Beta-blockers, %	72	66	69	0.376
Calcium channel blockers, %	19	11	115	0.321
Aspirin, %	78	80	80	0.741
Clopidogrel, %	32	25	27	0.566

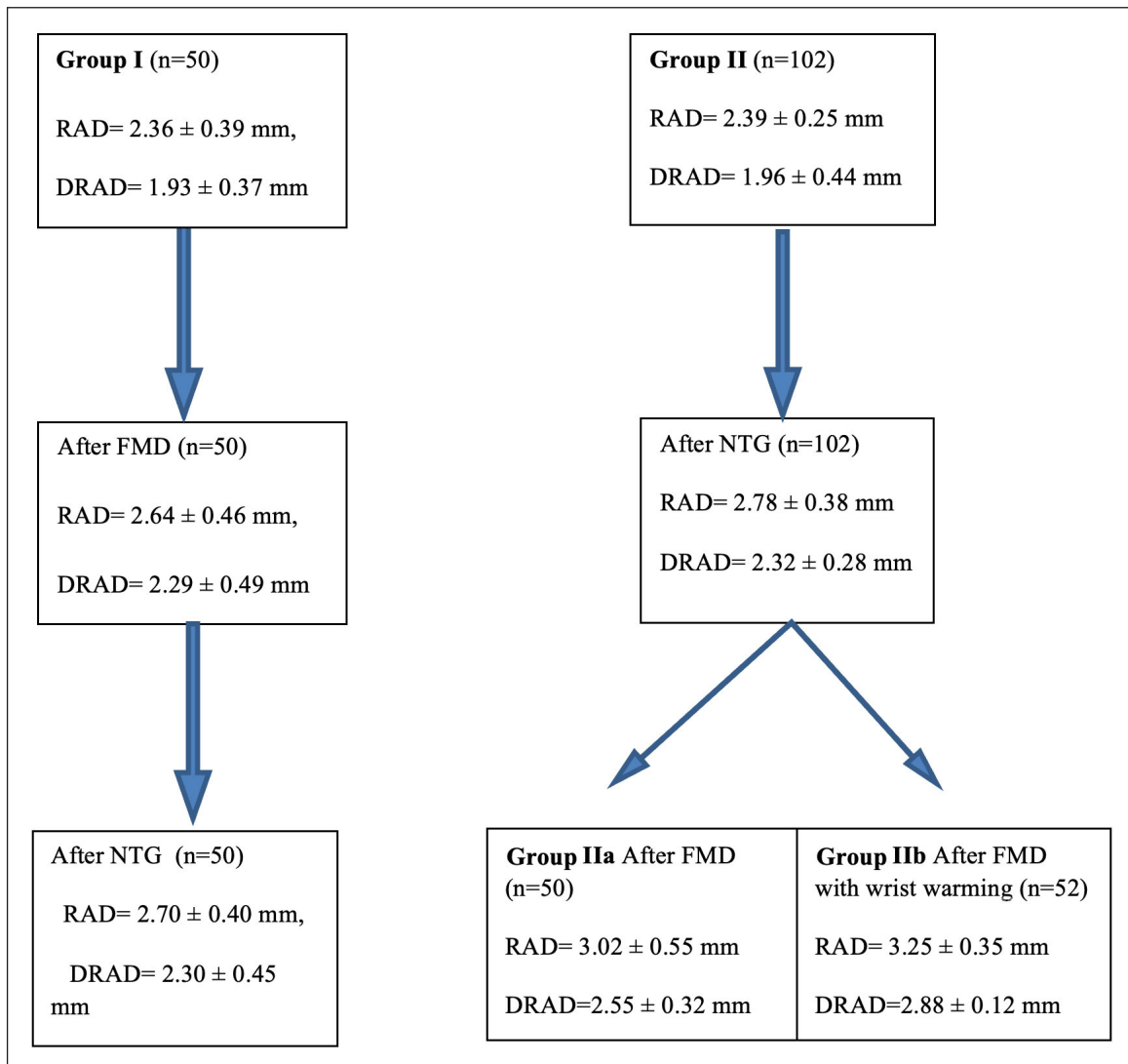


Figure 1. Study design and results. Abbreviations: NTG: nitroglycerin, FMD: flow-mediated vasodilation, RAD: radial artery, DRAD: distal radial artery.

Table II. Results in Group IIb.

Variable	Baseline	Final	p-value
RA diameter (mm)	2.39 ± 0.25	3.25 ± 0.35	0.001
Change in diameter, %	37.4		
Cross-sectional RA area (mm ²)	4.48 ± 0.24	8.24 ± 0.29	0.001
Change in area, %	83.2		
DRA diameter (mm)	1.96 ± 0.44	2.88 ± 0.12	0.001
Change in diameter, %	49.6		
Cross-sectional DRA area (mm ²)	3.01 ± 0.21	6.51 ± 0.8	0.001
Change in area, %	117.1		
Systolic Blood Pressure (mmHG)	136 ± 15	139 ± 21	0.237
Diastolic Blood Pressure (mmHG)	77 ± 11	75 ± 12	0.343

RA: radial artery, DRA: distal radial artery.

7 French sheaths for the distal radial artery. This suggests that sheath insertion stretches the radial artery in most patients in whom we placed a 6 French sheath. In these patients, endothelial damage is likely because the sheath is larger than the arterial lumen. The rate of radial artery occlusion after radial artery access appears to be related to radial sheath diameter. Arterial occlusion is also more common in women, younger patients, and patients with peripheral artery disease^{17,18}. This indicates a significant interaction between artery and sheath size when considering occlusion rates. Therefore, it is recommended to use smaller sheaths for radial artery access. Increasing arterial size to minimize endothelial trauma can reduce the rate of radial artery occlusions¹⁹.

Intra-arterial vasodilators, which we use in our routine practice, are administered after sheathing, however, endothelial damage started with sheath insertion. Although the onset of action with topical nitrates is not as rapid as intra-arterial administration, topical nitrates are locally effective and act for a longer period⁶. Al-Hakim et al¹⁶ demonstrated that palmar warming was effective at inducing radial artery vasodilation with a 43.9% increase in a cross-sectional area. Palmar warming may also be more effective than the application of topical nitroglycerin and lidocaine¹⁰. Garg et al²⁰ found a 16.3% increase in the diameter of the radial artery with FMD. In previous studies^{21,22}, it was observed that performing the puncture under ultrasound guidance, using methods that increase the radial artery diameter, and increasing operator experience shortened the procedure time and increased the success of the procedure. In our study, we obtained a higher increase in radial artery size than the proportion described in the literature. In addition, we found that the distal radial artery could expand more than the radial artery.

Limitations

Ease of radial artery puncture and radial artery pre-cannulation spasm also need to be analyzed during trans-radial coronary angiography. We intend to conduct a subsequent study involving patients undergoing trans-radial percutaneous coronary intervention. We included only patients diagnosed with coronary artery disease in our study. However, we found that our method increased the radial artery diameter in the group of patients who are likely to have vascular dysfunction and impaired vascular reactivity.

Conclusions

We increased the radial artery diameter higher proportion than defined in the literature. We found that the application of combined nitroglycerin-containing cream, FMD, and forearm warming can dilate the radial artery diameter by 37% and the distal radial artery diameter by 49%. It may be recommended to provide three parameters when organizing the catheterization units.

Conflict of Interest

The authors declared no potential conflicts of interest for the research, authorship, and/or publication of this article.

Ethics Approval

The study protocol was approved by Tekirdag Namık Kemal University Ethics Committee (28/06/2022- 2022.124.06.14). The study abided by ethical standards laid down in the Declaration of Helsinki in 1964 and its later amendments.

Informed Consent

All participants provided written informed consent.

Availability of Data and Materials

Data and materials are available and can be sent upon request.

Authors' Contributions

A.D.: conceptualization, methodology, and software.
A.D. and C.A.: data curation, writing, and original draft preparation.
A.D.: visualization, investigation.
A.D. and C.A.: supervision.
A.D. and C.A.: reviewing, editing.

Acknowledgments

The authors would like to thank chief physician professor Şeref Alpsoy for contributing to the study.

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