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## The effect of coronary angiography and femoral access on femoral artery distensibility and elasticity

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### Keywords

coronary angiography,  
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### Abstract

**Aim of the study:** The aim of this study was to evaluate the long-term effects of access to the femoral artery for the purposes of coronary angiography through the measurement of femoral artery distensibility and elasticity on the accessed and non-accessed sides. **Material and methods:** This cross-sectional study included patients who underwent femoral angiography at least 1 year previously. Those whose femoral artery was accessed once formed Group 1 ( $n = 59$ ), those who were accessed twice formed Group 2 ( $n = 57$ ), those accessed 3 times formed Group 3 ( $n = 55$ ), and those with more than 3 accesses, Group 4 ( $n = 60$ ). The groups were compared in respect of femoral artery elasticity and distensibility in the accessed and non-accessed sides. **Results:** No statistically significant difference was determined in respect of femoral distensibility and elasticity in Group 1 ( $9.40 \pm 0.84$  vs  $9.48 \pm 0.75$ ,  $p = 0.107$  and  $0.23 \pm 0.03$  vs  $0.23 \pm 0.03$ ,  $p = 0.433$ , respectively). However, a significant difference was observed between the two sides in terms of distensibility and elasticity in Group 2 ( $9.02 \pm 0.81$  vs  $9.23 \pm 0.75$ , and  $0.21 \pm 0.02$  vs  $0.22 \pm 0.02$ ), in Group 3 ( $8.49 \pm 0.77$  vs  $9.18 \pm 0.9$  and  $0.19 \pm 0.02$  vs  $0.21 \pm 0.02$ ), and in Group 4 ( $8.14 \pm 0.74$  vs  $9.03 \pm 0.81$  and  $0.16 \pm 0.01$  vs  $0.2 \pm 0.02$ ,  $p < 0.001$ , for all comparisons). **Conclusion:** While a single access in the femoral artery for coronary angiography does not affect femoral artery elasticity and distensibility, multiple accesses may have adverse effects.

## Introduction

Atherosclerotic coronary heart disease has an important place among cardiovascular diseases, which are the most common cause of mortality and morbidity all over the world. Although anamnesis, physical examination, laboratory and non-invasive stress tests are usually sufficient for diagnosis, some patients require coronary angiography, which is the gold standard imaging method<sup>(1)</sup>. The main advantage is that it clearly shows the coronary anatomy and allows treatment with percutaneous coronary intervention to be performed in the same session. As coronary angiography laboratories become more widespread and more easily accessible, they are being used more frequently all over the world. Coronary angiography can be accessed from the femoral, radial, brachial, ulnar or axillary arteries. As atherosclerotic coronary artery disease is a progressive and chronic condition, many patients undergo

repeated coronary angiography interventions and, therefore, have multiple artery access sites<sup>(2-3)</sup>.

Distensibility and elasticity determined by vascular tone are two important parameters that reflect subclinical damage in arteries. There are many publications in the literature demonstrating that a decrease in distensibility and elasticity is associated with undesirable cardiovascular events and directly linked to subclinical atherosclerosis in the arteries. Although both distensibility and elasticity can be evaluated with many different imaging methods, ultrasonography is the most preferred modality, as it is cheap and easily accessible<sup>(4-7)</sup>.

The effect of these interventions on the femoral artery is not clear in patients undergoing femoral artery catheterization for coronary angiography. The aim of this study was to evaluate this effect through measurements of the distensibility

and elasticity of the femoral arteries on the accessed and non-accessed sides in patients who had previously undergone unilateral femoral artery coronary angiography.

## Material and methods

This single-center cross-sectional study included patients who were followed up in the Cardiology Outpatient Clinic of Baskent University, Faculty of Medicine, Adana Hospital after undergoing coronary angiography from the femoral artery at least 1 year prior. The patients were divided into 4 groups according to the number of interventions performed on the femoral artery. Those whose femoral artery was accessed once formed Group 1 ( $n = 59$ ), those who were accessed twice formed Group 2 ( $n = 57$ ), those accessed 3 times formed Group 3 ( $n = 55$ ), and those with more than 3 accesses, Group 4 ( $n = 60$ ). The baseline clinical, laboratory and demographic characteristics of the patients were recorded. The anatomical synergy between percutaneous coronary intervention with taxus and cardiac surgery (SYNTAX) score was calculated and recorded<sup>(8)</sup>. The patients were screened retrospectively, and only those where 6 French sheaths were used were included. Comparisons were then made to determine whether there was a statistically significant difference in terms of distensibility and elasticity values between the sides with and without femoral access.

## Exclusion criteria

Known peripheral arterial disease, atrial fibrillation, patients who were accessed at both femoral arteries (at different times or at the same time), patients with percutaneous coronary intervention, hypertension, patients with lower or larger femoral sheath implantation than 6 Fr, diabetes mellitus, familial hypercholesterolemia, smoking, presence of collagen tissue disease, presence of autoimmune disease, chronic kidney disease, chronic liver disease, steroid use, presence of hypo- or hyperthyroidism, patients who had their last femoral artery accessed less than 1 year prior to the study, patients with ejection fraction (EF) <40%, patients with severe heart valve disease, presence of active infection, patients undergoing previous cardiac surgery, age <18 years or >65 years, all local complications for femoral access (dissections, hematoma, arteriovenous fistula, pseudoaneurysm), as well as patients whose image quality results were insufficient or patients not wanting to participate in the study were excluded.

## Evaluation of femoral artery distensibility and elasticity

All participants were placed in the supine position and then connected to an electrocardiogram and monitored. B-mode duplex ultrasonography revealed a longitudinal visualization of the femoral arteries by visualizing the right and left common femoral arteries. In this image, the lumen diameter (LD) was calculated by measuring the intima-intima distance between the distal and proximal

walls. The media-media distance was measured, and the vessel diameter (VD) was recorded. All measurements were taken separately during the systole and diastole, and the maximum and minimum of these values were calculated ( $VD_{max}$ ,  $VD_{min}$ ,  $LD_{max}$ ,  $LD_{min}$ ). Figure 1 shows the measurement of  $LD_{max}$  and  $VD_{max}$  in systole (A), and  $LD_{min}$  and  $VD_{min}$  in diastole (B). All measurements were performed in 3 consecutive heartbeats, and the mean values of these 3 measurements were recorded. Systole and diastole separation were performed according to the ECG. The formula  $[(VD_{max} - VD_{min}) / VD_{min}] \times 100$  was used for femoral artery distensibility (%)<sup>(9)</sup>. Femoral artery elasticity (% / mmHg) was calculated according to the formula  $[(LD_{max} - LD_{min}) / LD_{min}] / \Delta P \times 100\%$ <sup>(9-10)</sup>. In this formula,  $\Delta P$  = the difference between systolic and diastolic blood pressure. All measurements of both distensibility and elasticity were performed automatically using dedicated software.

The study was carried out in accordance with the criteria of the Helsinki Declaration, and approval was obtained from the local ethics committee. After giving detailed information about the study, written consent forms were obtained from all participants.

## Statistical analysis

Continuous variables were tested for normal distribution by using the Kolmogorov-Smirnov test. The results including normally distributed variables were expressed as mean  $\pm$  standard deviation, while non-normally distributed variables were expressed as medians and interquartile ranges (IQR). Categorical variables were shown as absolute values and percentages. Continuous variables with a normal distribution were analyzed with one-way analysis of variance (ANOVA) or paired samples t-test, as appropriate (paired samples t-test for dependent variables, one-way ANOVA for independent variables). Continuous variables with a non-normal distribution (for independent variables) were analyzed with the Kruskal-Wallis test. Categorical variables of independent samples were compared with the chi-square test. A  $p$  value less than 0.05 was considered statistically significant. Statistical analyses were performed using SPSS, version 20 (SPSS, Chicago, IL, USA).

## Results

The evaluation included a total of 231 patients; 59 in Group 1, 57 in Group 2, 55 in Group 3, and 60 in Group 4. Baseline demographic, clinical and laboratory values of the groups are shown in Tab. 1. There was no statistically significant difference in femoral distensibility and elasticity between the accessed and non-accessed sides in Group 1 ( $p = 0.107$  and  $p = 0.433$ , respectively). In the other groups (Groups 2, 3 and 4), a statistically significant difference was determined in terms of both distensibility and elasticity between the accessed and non-accessed sides ( $p < 0.001$ , for all comparisons). Table 2 summarizes the femoral distensibility and elasticity values, and the comparisons between the groups.

**Tab. 1.** Baseline clinic, demographic and laboratory values of the study population

	Group 1 (n = 59)	Group 2 (n = 57)	Group 3 (n = 55)	Group 4 (n = 60)	p
Age [years]	59.23 ± 5.62	60.7 ± 4.98	58.76 ± 5.66	59.61 ± 5.61	0.282
Female sex [n (%)]	23 (38.98)	28 (49.12)	21 (38.18)	27 (45)	0.598
BMI [kg/m <sup>2</sup> ]	28.68 ± 3.56	28.73 ± 3.49	28.49 ± 3.18	28.71 ± 3.79	0.982
Creatinine [mg/dL]	0.78 ± 0.1	0.77 ± 0.11	0.79 ± 0.12	0.8 ± 0.13	0.577
Hb [gr/dL]	13.67 ± 1.29	13.76 ± 1.49	14.1 ± 1.41	13.57 ± 1.41	0.2
WBC [/mm <sup>3</sup> ]	7510 ± 1659	7212 ± 1923	7123 ± 1738	7309 ± 1887	0.614
Platelets [100/mm <sup>3</sup> ]	280 (172)	274 (56)	245 (45)	238 (81)	0.075
FPG [mg/dL]	101.73 ± 9.87	102.16 ± 8.23	102.85 ± 10.26	102.53 ± 9.63	0.93
HDL [mg/dL]	45.47 ± 7.46	47.66 ± 9.05	47.36 ± 8.75	47.2 ± 6.97	0.457
LDL [mg/dL]	130.81 ± 16.35	135.1 ± 21.37	130.3 ± 16.73	132.21 ± 17.36	0.491
Triglyceride [mg/dL]	145 (88)	134 (67)	128 (79)	147 (69)	0.258
EF [%]	58.61 ± 2.91	58.78 ± 3.29	58.76 ± 2.97	59.08 ± 3.16	0.866
SBP [mmHg]	122.95 ± 6.8	124 ± 6.43	123.87 ± 9.12	122.82 ± 9.34	0.799
DBP [mmHg]	80.97 ± 5.45	81.04 ± 5.31	80.93 ± 5.83	81.60 ± 4.97	0.895
USG time [month]*	28 (16)	29 (13.5)	28 (14)	27 (17.75)	0.918
SYNTAX Score	7 (4)	11 (6)	15 (7)	17 (5.75)	<0.001
ASA [n (%)]	33 (55.93)	47 (82.45)	48 (87.27)	55 (91.66)	<0.001
Beta blocker [n (%)]	6 (10.16)	27 (47.36)	47 (85.45)	55 (91.66)	<0.001
Ca CB [n (%)]	6 (10.16)	6 (10.52)	6 (10.9)	5 (8.3)	0.968
Trimetazidine [n (%)]	0 (0)	0 (0)	0 (0)	12 (20)	NA
Nitrates [n (%)]	0 (0)	0 (0)	11 (21.81)	51 (85)	NA
Ranolazine [n (%)]	0 (0)	0 (0)	6 (10.9)	17 (28.33)	NA

**Tab. 2.** Comparison of femoral distensibility and elasticity between the sides with and without femoral access in different groups

	Group 1 (n = 59)			Group 2 (n = 57)			Group 3 (n = 55)			Group 4 (n = 60)		
	Access side	No access side	p	Access side	No access side	p	Access side	No access side	p	Access side	No access side	p
Distensibility [%]	9.40 ± 0.84	9.48 ± 0.75	0.107	9.02 ± 0.81	9.23 ± 0.75	<0.001	8.49 ± 0.77	9.18 ± 0.9	<0.001	8.14 ± 0.74	9.03 ± 0.81	<0.001
Elasticity [%/mmHg]	0.23 ± 0.03	0.23 ± 0.03	0.433	0.21 ± 0.02	0.22 ± 0.02	<0.001	0.19 ± 0.02	0.21 ± 0.02	<0.001	0.16 ± 0.01	0.2 ± 0.02	<0.001

## Discussion

This is the first study reported in the literature which examines the effects of femoral artery access on femoral artery distensibility and elasticity after coronary angiography. According to the results obtained, femoral artery interventions performed for coronary angiography reduce femoral artery distensibility and elasticity.

Decreased distensibility and elasticity of the elastic arterial system are well-known to be associated with atherosclerosis and cardiovascular complications. It has been shown that distensibility and elasticity are significantly associated with the development and progression of atherosclerotic diseases that lead to cardiovascular events. In addition, researchers have also documented that distensibility and elasticity vary among different vascular segments. Evaluating these differences will be helpful for better understanding of the local changes of atherosclerotic plaques in the arterial system<sup>(11,12)</sup>.

Although some studies have examined the impact of percutaneous coronary interventions on endothelial function, there are few studies evaluating the effect of

coronary angiography alone<sup>(13-15)</sup>. In addition, the majority of studies found in the literature focus on the radial artery, so the femoral artery has not been studied in this respect. In a study by Tak *et al.*, it was shown that transradial coronary angiography decreased endothelial functions, and excessive puncture for sheath entry, use of a thick sheath, long procedure and operator experience were directly related to this deterioration<sup>(16)</sup>. In another study with 136 patients conducted by Aykan *et al.*, it was shown that radial artery diameter and flow-mediated dilatation decreased 1 month after transradial coronary angiography<sup>(17)</sup>. In another study by Madsen *et al.*, no difference was observed in the diameter of the intervened and untreated radial arteries in respect of vasodilator characteristics 1 year after the intervention. However, it was shown that the diameter of the intervened radial artery was smaller than that of the untreated radial artery. Based on the findings of the study, the authors emphasized that even if the vasodilation capacity of the intervened and untreated arteries was similar, there might be structural changes in the intervened vessel<sup>(18)</sup>. In another study, by Okuyan *et al.*, flow-mediated dilatation after radial artery angiography was found to be

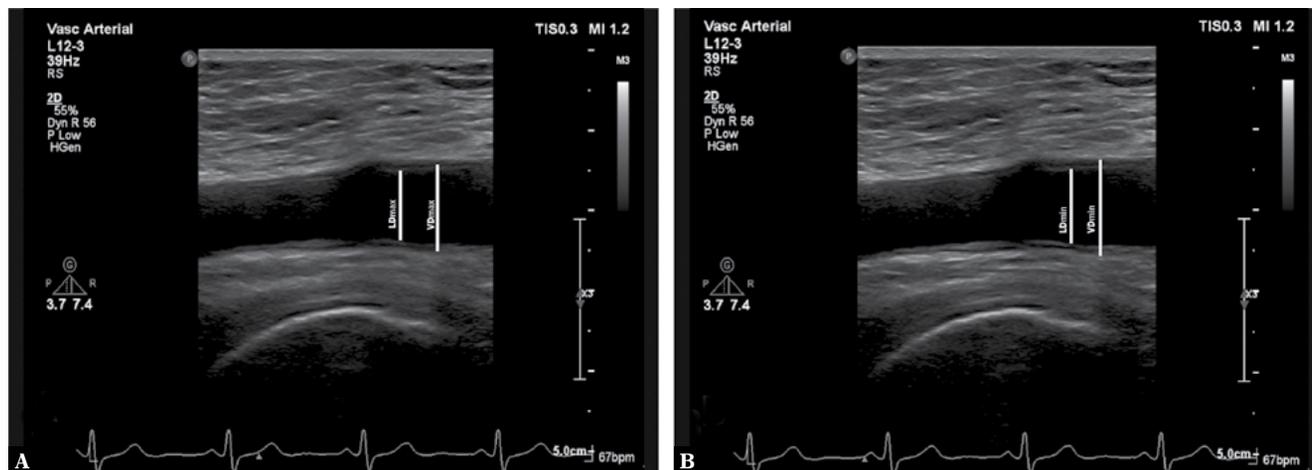


Fig. 1. Measurement of maximum lumen and vessel diameter in systole (A), and minimum lumen and vessel diameter in diastole (B)

lower on the side undergoing angiography, but nitroglycerine-mediated dilation was not different between the two sides<sup>(19)</sup>. In a study of 50 patients by Abe *et al.*, radial artery diameter was investigated on the sides with and without angiography, 3 months after the use of 6 Fr sheath. A slight decrease in vessel diameter was observed on the angiography side, but the decrease was not found to be statistically significant<sup>(20)</sup>. In both coronary angiography and percutaneous coronary procedures, the direct mechanical impact of the sheath may cause adverse effects on the endothelium of the femoral artery. Some studies have shown that intimal hyperplasia, necrosis and inflammation develop in the sheath implanted region for coronary angiography and, furthermore, this is not observed in regions with no sheath implanted. This strong inflammatory response and trauma are known to cause dysfunction of the smooth muscles in the arterial wall in the long term. Endothelial dysfunction and injury due to catheter trauma may be caused by sheath placement in both early and late phases<sup>(21)</sup>. In the current study, inflammatory parameters were not directly measured and evaluated, but according to the results of previous studies, the process may be the cause of the findings in the current study. In most studies reported in the literature, the relationship between the number of punctures and endothelial dysfunction has not been investigated. According to the current study results, a single puncture of the femoral artery does not affect femoral artery distensibility and elasticity in the long term, but multiple punctures may have negative effects on the femoral artery endothelium in the long-term perspective. It is not incorrect to think that recurrent interventions cause recurrent traumas as well as recurrent inflammatory responses in the femoral arteries, and thus further deterioration of endothelial functions is expected.

### Limitations of the study

This study was performed only on patients where 6 French sheaths were used. It is not known how sheaths of other thicknesses would affect the results. The compression time

at the insertion site after coronary angiography was not standard, and it is not known whether this time would affect the findings. The effect of these results on the femoral arteries in the long term, and whether this effect has clinical significance, is also unknown. Since the selection of patients was done retrospectively, and some interventions were performed with outdated machines, we were unable to determine the dose of radiation each subject received, which might affect femoral artery properties. The number of patients in the study was limited, and the findings need to be supported by studies enrolling more patients.

### Conclusions

A single 6-French access on the femoral artery during coronary angiography does not affect femoral artery elasticity and distensibility in the long term, whereas multiple accesses may adversely affect femoral artery distensibility and elasticity.

### Conflict of interest

*The authors declare that they have no conflicts of interest. The authors have indicated they have no financial relationships relevant to this article to disclose*

### Ethical approval

*All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.*

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