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Increased intima thickness of the radial artery in individuals with prehypertension and hypertension

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ABSTRACT

Background: We have used a novel ultra high-frequency (55 MHz) ultrasound technique to non-invasively measure the radial arterial vessel wall and separate the intima–media (IMT) complex into measurements of intima and media thickness (IT and MT). Since no previous study has measured IT and MT separately in individuals with prehypertension and hypertension, the aim of the current study was to measure IT and MT thickness of the radial arteries among individuals with prehypertension, hypertension and healthy subjects.

Methods and results: Individuals with prehypertension ($n = 32$), hypertension ($n = 34$) and healthy subjects ($n = 29$) underwent ultra high-resolution ultrasound of the radial artery. Individuals with prehypertension showed a 14% increase in IT compared to healthy subjects (0.083 ± 0.020 mm versus 0.073 ± 0.015 mm; $p < 0.05$), whereas no difference was seen in MT. Individuals with hypertension showed a 12% increase of in IT compared to healthy subjects (0.082 ± 0.018 mm versus 0.073 ± 0.015 mm, $p < 0.05$), whereas no differences were seen regarding MT. Prehypertensive and hypertensive individuals did not differ regarding IT and MT.

Conclusion: Both prehypertension and hypertension are associated with thickening of the intimal layer of the radial artery. The present data indicates that intima thickening appears early during the development of hypertension even when blood pressure is only slightly elevated.

1. Introduction

The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC-VII) [1] suggested that individuals with a systolic blood pressure (SBP) of 120–139 mmHg or a diastolic blood pressure (DBP) of 80–89 mmHg should be considered as prehypertensive. The risk for cardiovascular diseases increases linearly with increasing blood pressures beginning at 115/75 mmHg, thereby providing the rationale for the JNC recommendations [2].

Intima–media thickness (IMT) of the carotid arteries, which comprises both the intima and media layers of the vessel wall, is a marker of atherosclerosis and a predictor of death and cardiovascular events in hypertensive patients with coronary artery disease [3]. The IMT of the carotid artery is increased in prehypertensive subjects [4]. Although clinically relevant atherosclerosis of the upper limb arteries is rarely seen, there are evidence suggesting that intimal hyperplasia of the arteries in the upper limb reflects global atherosclerosis. Firstly, histological studies indicate that intimal hyperplasia prevails in the majority of the radial artery grafts used in patients undergoing coronary artery by-pass grafting (CABG) [5,6]. Secondly, established risk factors for atherosclerotic vascular disease such as age, smoking, peripheral vascular disease, diabetes and hypertension are independent predictors of intima hyperplasia in the radial artery [5,6]. We have recently reported increased intima thickness (IT) of radial artery in patients with coronary heart disease (CHD) (Myredal et al., Vasc Med, in press). Hence, the development of a non-invasive method to measure the radial artery intima thickness (IT) may provide valuable information on the risk of cardiovascular morbidity.

We hypothesized that ultra high-resolution ultrasound of the radial arteries could identify structural changes early in the development of hypertension. Hence, the aim of the current study was to assess the IT and media thickness (MT) of the radial arteries among individuals with prehypertension, hypertension and healthy subjects using ultra high-resolution ultrasound of 55 MHz frequency [7].

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2. Methods

2.1. Study population

Ninety-five healthy subjects without any clinical symptoms who were participating in a health control program were recruited. They did not suffer from any chronic disease and were all non-smokers at present. None of the participants were on antihypertensive medication. All subjects underwent 24 h ambulatory blood pressure recordings using Spacelabs ultralight ambulatory blood pressure monitor 90217. Daytime hours were defined from 06.00 am to 10.00 pm. A dipping blood pressure pattern were defined as >10% reduction of SBP and DBP during night. The subjects were divided into three study groups; healthy subjects ($n = 29$) with average 24 h SBP < 120 mmHg and DBP < 75 mmHg, prehypertensives ($n = 32$) with average SBP between 120 and 130 mmHg or average DBP between 75 and 85 mmHg, hypertensives ($n = 34$) with average SBP > 130 mmHg or average DBP > 85 mmHg. All subjects underwent ultra high-resolution ultrasound measurement of the radial arteries, sphygmomanometer SBP and DBP, and 24-h BPs. Height and weight were measured and BMI calculated as weight in kilograms divided by height in meters squared. Waist circumference was measured at the level of the umbilicus. All participants answered a validated questionnaire regarding physical activity comprehending four categorical questions about leisure-time physical activity during the last 12 months [8] comprising four categories: (1) sedentary leisure-time (<2 h of activity such as walking and biking per week); (2) sporadic leisure-time moderate activity (at least 2 h of moderate-intensity activity such as bicycling, walking and gardening per week); (3) sporadic regular exercise (regular exercise once or twice per week for at least 30 min at each occasion, such as jogging, aerobics, weight training, soccer, etc.); and (4) regular exercise (regular exercise at least three times per week for at least 30 min at each occasion, such as jogging, aerobics, weight training, soccer, etc.). Since very few participants rated themselves in the first category, the first and second categories were lumped together and categorized as sedentary and the results are presented for three groups. Written informed consent was obtained before entry into the study. The study was approved by the local ethics committee of the University in Lund, Sweden.

2.2. Ultrasound measurements

The radial artery was examined with ultra high-resolution ultrasound, using a 55 MHz probe (Visualsonics, Toronto, Canada). Recently this method has been established and validated at our laboratory for studies of human superficial arteries [7,9]. In vitro measurements of IT and MT in human mesenteric arteries by ultra high-resolution ultrasound have demonstrated close correlations to histological measurements. The discrimination capacity was tested with silicon layer phantoms in the range 1–200 μm with excellent results and a 2D discrimination capacity of 20 μm [7]. In the current study, the radial arteries of the right hand were investigated and subjects were examined in a supine position. The radial arteries were measured 1–2 cm proximal to the skinfold separating the palma manus from regio antebrachii anterior. At the position of the thickest part of the far wall (visually judged), four consecutive beats were recorded in real time and saved. Analyses were then made off-line. Three measurements of the IT and IMT were performed in systole when the artery showed its largest diameter. IT was defined as the distance from the leading edge of the lumen–intima interface to the interface between intima and media of the far wall. IMT was defined as the distance from the lumen–intima interface of the far wall to the leading edge of the media–adventitia interface (Fig. 1). The MT was then calculated by subtracting IT from IMT. In one of the subjects with hypertension it was not possible to measure IMT. Lumen diameter was defined by the distance between the leading edges of the intima–lumen interface of the near wall and the lumen–intima interface of the far wall (Fig. 1). All measurements were performed off-line by an investigator blinded as to whether the investigation was performed in a subject with prehypertension, hypertension or in a healthy subject. Reproducibility of IT and IMT measurements in our laboratory has previously been studied and the intra-observer variability, calculated as coefficients of variation, was 7% for IT and 5% for IMT of the radial artery. The intra individual variation (the coefficient of variation of repeated measurements by the same operator) was 8.1% for the IT and 4.0% for IMT of the radial artery and 1.5% for the diameter of the radial artery [9].

2.3. Statistics

The results are presented as mean ± S.D. Analysis of variance (ANOVA) with Fisher's post hoc test were used for unpaired comparisons of data with a normal distribution. For data which showed a non-normal distribution the Kruskal–Wallis and Mann–Whitney tests were used for unpaired analyses. As body mass index (BMI), waist circumference, age and physical activity could have affected the measurements, the results for IT ant MT were adjusted for these covariates, using a multiple linear regression model. Since the numbers of subjects within the study groups were limited, we composed a hypertensive group comprehending both the prehypertensive and hypertensive subjects and compared IT and MT with healthy subjects after adjusting for the covariates and adjusted means were calculated.

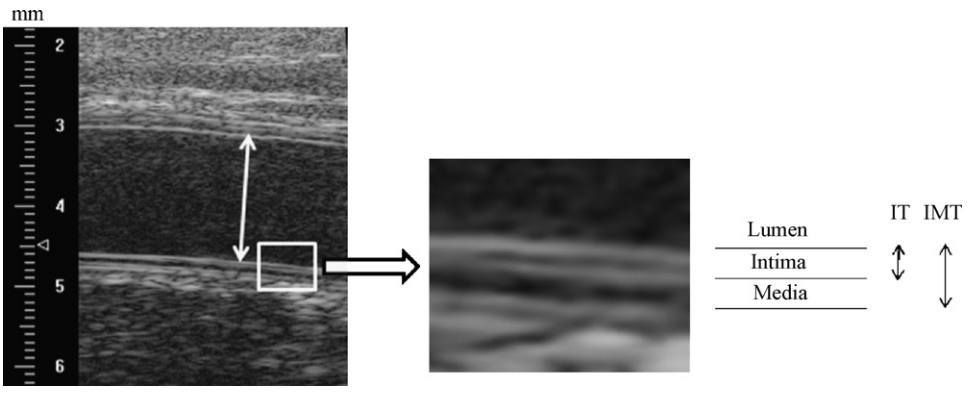

Fig. 1. High-resolution ultrasound image of the radial artery in prehypertensive subject. Lumen diameter (LD), intima thickness (IT) and intima–media thickness (IMT) were measured as shown below (1 mm between numbers on the axis to the left).