Correlation Between Increased Thoracic Aortic Intima-Media Thickness and Renal Doppler Parameters in Hypertensive Patients: A Cross-Sectional Study

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ABSTRACT

Introduction: Increased vascular intima-media thickness is an accepted marker of subclinical atherosclerosis and closely correlates with cardiovascular risk factors. Hypertension is a robust risk factor for increased thoracic aortic intima-media thickness (TA-IMT) and deteriorated renal Doppler measurements. Owing to the lack of information about the correlation between TA-IMT and renal Doppler parameters, this study aims to investigate the same in hypertensive patients.

Patients and Methods: This cross-sectional study examined 112 hypertensive patients who underwent transesophageal echocardiography (TEE) for different diagnostic reasons. The patients were divided into group 1 (56 patients with increased TA-IMT) and group 2 (56 patients without increased TA-IMT). For all patients, transthoracic echocardiography, TEE, renal B-mode and Doppler ultrasound, and laboratory measurements were performed.

Results: Compared with group 2, group 1 had markedly elevated systolic blood pressure (SBP), diastolic blood pressure (DBP), body mass index (BMI), total cholesterol, low-density lipoprotein (LDL) cholesterol, and triglyceride levels. In addition, renal resistive index (RRI), renal pulsatility index (RPI), the presence of RRI > 0.70, and cortical thickness were markedly higher in group 1 than that in group 2. Besides, renal acceleration time (AT) was considerably lower in group 1 patients. In group 1, we observed increased RRI (> 0.70) in 39 (70%) hypertensive patients. Furthermore, linear regression analyses revealed an independent correlation of SBP, BMI, LDL cholesterol, and renal AT with TA-IMT.

Conclusion: This study establishes a correlation between increased TA-IMT values and deteriorated renal Doppler measurements in hypertensive patients. Perhaps, TA-IMT measurements could help to determine the end-stage organ damage in hypertensive patients who undergo TEE.

Key Words: Hypertension; thoracic aortic intima-media thickness; renal ultrasound; Doppler

Hipertansif Hastalarda Torasik Aortik İntima Media Kalınlığı Renal Doppler Parametreleri ile İlişkilidir

ÖZET

Giriş: Artmış intima media kalınlığı subklinik bir ateroskleroz belirteci olarak kabul edilmektedir ve kardiyovasküler risk faktörleri ile yakından ilişkilidir. Hipertansiyon artmış torasik aortik intima media kalınlığı (TA-IMK) ve bozulmuş renal Doppler ölçümleri için bilinen bir risk faktörüdür. Araştırdığımız kadarıyla, TA-IMK ve renal Doppler parametreleri arasındaki ilişkiye dair bir bilgi yoktur. Bu çalışmanın amacı, hipertansif hastalarda böyle bir ilişki olup olmadığını incelemektir.

Hastalar ve Yöntem: Kesitsel çalışmamız çeşitli sebeplerle transözefageal ekokardiyografi yapılan ve hipertansiyonu olan 112 hastayı içermektedir. Grup 1'de TA-IMK artmış 56 hasta yer almıştır. Grup 2'de ise TA-IMK normal olan 56 hasta mevcuttur. Tüm hastalara transtorasik, transözefageal ekokardiyografi, renal B-mod, Doppler ultrason ölçümleri ve standart laboratuvar incelemeleri yapılmıştır.

Bulgular: Grup 1'deki hastalarda belirgin olarak artmış sistolik, diyastolik kan basınçları, beden kütle indeksi (BKİ), total ve LDL kolesterol ve trigliserid değerleri saptanmıştır. RRI, RPI değerleri, RRI > 0.70 olma sıklığı ve renal kortikal kalınlık ölçümleri grup 1'de önemli ölçüde artmıştır. Bu hastalarda renal AT belirgin biçimde azalmıştır. Artmış RRI (RRI > 0.70), grup1'deki 39 (%70) hastada görülmüştür. Lineer regresyon analizinde sistolik kan basıncı, BKİ, LDL kolesterol ve renal AT'nin TA-IMK ile bağımsız olarak ilişkili olduğu görülmüştür.

Sonuç: Çalışmamızda hipertansif hastalarda artmış TA-IMK ve bozulmuş renal Doppler parametreleri arasında bir ilişki olduğu gösterilmiştir. Transözefageal ekokardiyografi yapılması düşünülen hipertansif hastalarda TA-IMK ölçümü yapılması uç organ hasarını saptamak için faydalı olabilecek gibi görünmektedir.

Anahtar Kelimeler: Hipertansiyon; torasik aort; intima media kalınlığı; renal ultrason; Doppler

Cite this article as: *Dönmez Y, Acele A, Bulut A, Kaplan M, Koca H, Koç AS, et al. Correlation between increased thoracic aortic intima-media thickness and renal doppler parameters in hypertensive patients: a cross-sectional study. Koşuyolu Heart J 2020;23(1):1-8.*

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Submitted: 06.09.2019
Accepted: 29.12.2019
Available Online Date: 30.04.2020

INTRODUCTION

Hypertension is an established risk factor for cardiovascular diseases, and its primary target organs are the heart and brain. Reportedly, hypertension increases the vascular intima-media thickness (IMT), which is an accepted marker of subclinical atherosclerosis and closely correlates with cardiovascular risk factors[1,2]. Since being defined for the first time by Pignoli et al., clinicians have been investigating the changes in IMT of different vascular beds. In adults, the carotid and abdominal aorta are usually screened to detect macrovascular problems[3,4]. The aorta is the first vascular bed that displays signs of atherosclerosis at different sections[5]. However, thoracic aortic evaluation is an atypical and relatively challenging method to assess IMT. Transesophageal echocardiography (TEE) can measure thoracic aortic IMT (TA-IMT) clearly and objectively. Harrington et al. reported a positive and significant correlation between TA-IMT and subclinical atherosclerosis, which was better than that with carotid IMT[6].

Reportedly, B-mode and Doppler ultrasound (US) are non-invasive, repeatable, and cost-effective methods for the assessment of the renal structure, vascular functions, diseases, and several renal disorders[7]. Typically, owing to several diseases, morphological changes in the kidneys are detected very late with the B-mode US. Lately, the renal resistive index (RRI), renal pulsatility index (RPI), and renal acceleration time (AT) have become the new Doppler-based US evaluations. The RRI can detect renovascular or parenchymal diseases without morphological changes, especially in young patients with hypertension and diabetes. Besides, the RRI can help in the stratification of renal damage and has been accepted as an indicator for the systemic atherosclerotic status[8,9].

Hypertension is a robust risk factor for increased TA-IMT and deteriorated renal Doppler measurements. To the best of our knowledge, no previous paper has reported about the correlation between TA-IMT and renal Doppler parameters. Hence, this study aims to investigate the correlation between TA-IMT and renal Doppler parameters in hypertensive patients.

PATIENTS and METHODS

Ethics committee approval was received for this study from the Ethics Committee of the Adana City Training and Research Hospital (Decision Number: 450; Decision Date: May 22, 2019).

Study Population

In this cross-sectional study, we enrolled 112 patients with hypertension who underwent TEE for different diagnostic reasons during July-August 2019. All patients were divided into two groups as follows: group 1 [56 patients with increased TA-IMT (mean age: 52.9 ± 4.88 years; male/female: 35/21)] and group 2 [56 patients without increased TA-IMT (mean age: 50.2 ± 10.9 years; male/female: 41/15)]. Of note, patients with known coronary artery disease (CAD) or localized thoracic aortic atheroma (TA-IMT ≥ 2.00 mm) were excluded. In addition, we excluded patients with a history of aortic operations, secondary or malignant hypertension, pulmonary hypertension, aneurysm or dissection of the thoracic aorta, cerebrovascular disease, heart failure, moderate-to-severe valvular heart disease, systemic inflammatory diseases, hematological diseases, thyroid disease, moderate-to-severe liver and kidney diseases, cancer, suspected or real pregnancy, active infectious disease, or those aged < 18 years.

Complete physical examinations of patients were performed, and their detailed medical histories were obtained. We recorded patients' demographic details, resting heart rate, systolic blood pressure (SBP), and diastolic blood pressure (DBP). In addition, the status of smoking, hypertension, hypercholesterolemia, CAD, diabetes mellitus, and obesity were questioned. Furthermore, we evaluated the body mass index (BMI) of all patients and noted all medications related to CAD risk factors.

Laboratory Measurements

Patients' blood samples were collected from the cubital vein 1 h before TEE, and complete blood tests were performed using the Sysmex K-1000 (Block Scientific, Bohemia, NY) auto-analyzer device. Then, we measured serum blood urea nitrogen, creatinine, total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, and triglyceride concentrations with a biochemistry analyzer (Abbott Aeroset; Abbott, Minnesota) using commercially available kits (Abbott).

Echocardiographic Evaluation

Using EPIQ 7 (Philips Healthcare Andover, MA), we performed echocardiography evaluations. Of note, all measurements were performed in accordance with the American Echocardiography Society guidelines. We obtained standard parasternal long- and short-axis views, as well as reviewed apical two-, four-, and five-chamber windows. All views were recorded for three cycles[10]. Then, we noted the standard two-dimensional measurements of the left ventricular (LV) end-diastolic and end-systolic diameters, end-diastolic interventricular septum and posterior wall thickness, and end-diastolic and end-systolic diameters of the aorta. The LV ejection fraction was evaluated using Simpson's echocardiographic method. Using pulsed-wave Doppler, transmitral flow measurements were obtained in the apical four-chamber view. Then, we evaluated the velocities of the E and A waves. Notably, peak systolic (LV-S_m), early diastolic (LV-E_m), and late diastolic (LV-A_m) myo-

cardial velocities were measured using tissue Doppler imaging at the lateral mitral annulus. Next, the isovolumic relaxation time was measured. Furthermore, LV E/A, LV-E_m/A_m, and LV-E/E_m ratios were calculated to assess the LV diastolic functions[11].

Intima-media Thickness Measurement of the Thoracic Aorta

In this study, TEE was performed using EPIQ 7 (Philips Healthcare) after 8-h fasting and when patients were deeply sedated by an anesthesiologist. Of note, the TEE probe was a multiplane transducer. During the procedure, the patients were positioned in the left lateral decubitus position. The probe was engaged at the esophageal and gastric entry levels. Notably, the experienced echocardiographers were blinded to patients' details. All patients well tolerated the procedure with no complication. The TA-IMT was measured from the following six segments of the thoracic aorta: (i) the ascending aorta; (ii) the arcus aorta; (iii) from 0 to 5 cm distal to the arcus; (iv) from 5 to 10 cm distal to the arcus; (v) from 10 to 15 cm distal to the arcus; and (vi) from 15 to 20 cm distal to the arcus. We accepted the mean of the 12 measurements (two for each segment) as the TA-IMT[12]. Furthermore, the distance between the front edge of the lumen-intima intersection and the leading front of the media-adventitia intersection of the posterior wall was defined as the TA-IMT (Figure 1).

Renal B-mode and Doppler Ultrasonography

Renal US was performed using a high-resolution device (EPIQ 7; Philips Healthcare) and a 5-1 MHz convex probe (Philips Healthcare, Bothell, WA) after, at least, 8-h fasting and 20-min rest. The echogenicity of the parenchyma and the size and cortical thicknesses of the kidneys were evaluated in the gray-scale B-mode images. In addition, the renal hilum and capsule distances were measured from the middle pole in the coronal plane. The kidney length was defined as the distance between the upper and lower five poles, whereas the cortical thickness was defined as the distance between the middle renal medulla pyramid base and the renal capsule. The renal Doppler US parameters were obtained after performing B-mode evaluations. Next, we measured the peak systolic velocity (PSV), end-diastolic velocity (EDV), and AT in the intrarenal artery (segmental or interlobar). Of note, the angle of the Doppler beam was 30°-60°. We evaluated the RRI value using the following formula: PSV-EDV/PSV. The spectral waveform was traced manually, and the RPI was calculated on this waveform using the formula as follows: PSV-EDV/mean flow rate. The duration between the onset of increased systole and the first peak point was accepted as the renal AT. Moreover, the mean of these three measurements was evaluated for the RRI, RPI, and AT values of both kidneys (Figures 2 and 3). In this study,

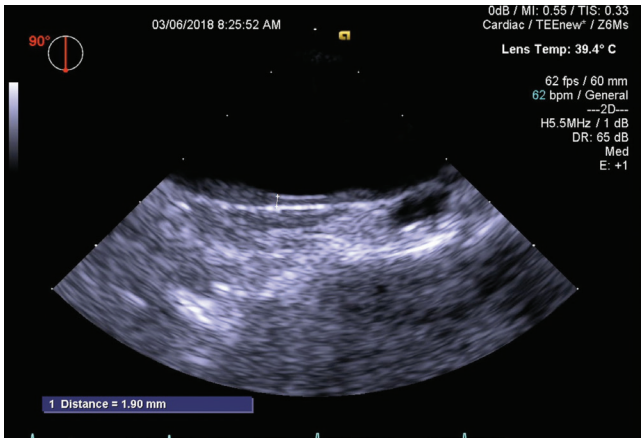

Figure 1. Increased thoracic aortic intima-media thickness in hypertensive patients.

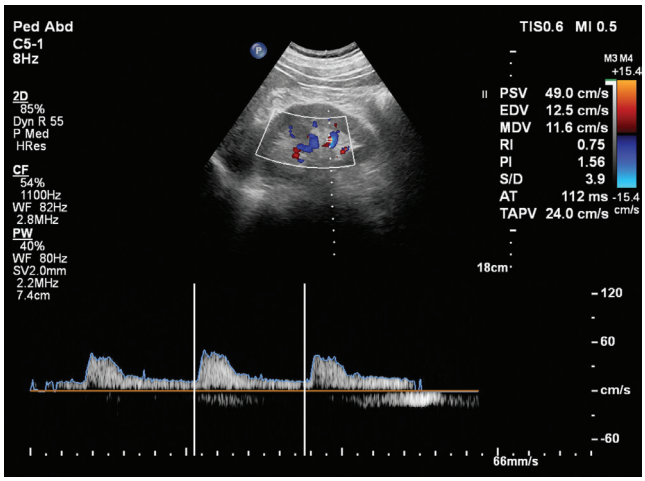

Figure 2. The renal resistive index (RRI) is measured using color Doppler sonography in hypertensive patients with increased thoracic aortic intima-media thickness. The increased RRI measurement was 0.75.

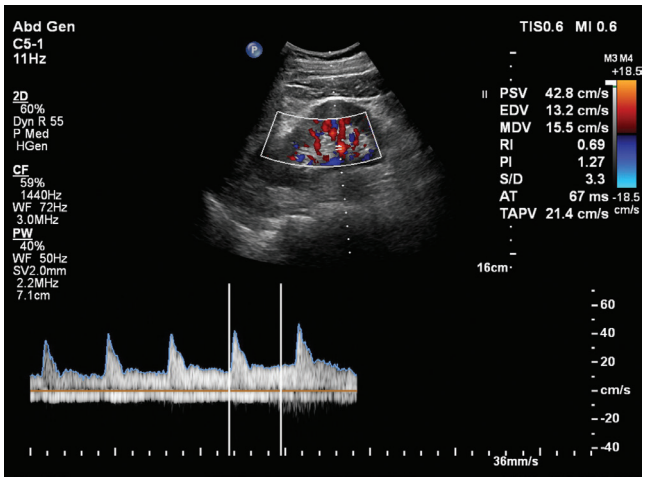

Figure 3. The renal resistive index (RRI) is measured using color Doppler sonography in hypertensive patients without increased thoracic aortic intima-media thickness. The standard RRI measurement was 0.69.

all US examinations were evaluated by two radiologists, each with, at least, 5 years of Doppler experience and had evaluated ≥ 1000 hypertensive patients annually.

Statistical Analysis

The continuous variables are presented as the mean ± standard deviation, whereas the categorical variables are presented as numbers and percentages. We determined the distribution type of each continuous variable using the Kolmogorov-Smirnov test. In addition, the Student's t-test was used for normally distributed variables. However, the variables without normal distribution were tested using the Mann-Whitney U-test.

We analyzed the categorical variables using the chi-square (x^2) test. Then, the k coefficient was used to examine the interobserver variability of all US and TEE measurements. Using Pearson's and Spearman's correlation analyses, we determined the existence of a correlation between the countable parameters. A multivariate linear regression analysis was performed for TA-IMT with the variables that were statistically significant in the univariate analysis. In addition, a logistic regression analysis was performed to detect the parameters that independently determined patients with TA-IMT > 1.6 mm. We also performed the ROC curve analysis. In this study, $p< 0.05$ was accepted as being statistically significant. Furthermore, all statistical analyses were performed using SPSS 22.0 software (SPSS, Chicago, IL).

RESULTS

Renal US and TA-IMT measurements were successfully obtained from the study sample. The Cohen k values that evaluated interobserver and intraobserver variability were > 90% for all US and TA-IMT measurements.

Compared with group 2, group 1 had markedly elevated SBP, DBP, BMI, total cholesterol, LDL cholesterol, and triglyceride levels (Table 1). In addition, mitral E velocity, LV-E/E_m ratio, and LV-deceleration time were significantly higher in group 1 than that in group 2. The RRI, RPI values, presence of RRI > 0.70, and cortical thickness were also significantly higher in group 1 relatively. Of note, the renal AT was considerably lower in group 1 patients. In group 1, we detected an increased RRI (> 0.70) in 39 (70%) hypertensive patients. However, we observed no differences in other echocardiographic and US parameters between both groups (Table 2).

Table 3 presents the correlation between TA-IMT measurements and the clinical and laboratory parameters. A positive correlation was noted between TA-IMT and SBP, DBP, BMI, total cholesterol, LDL cholesterol, triglyceride, RRI, left atrium (LA) dimension, LV-deceleration time, and LV-E/E_m ratio. Of note, only HDL cholesterol and renal AT measurements negatively correlated with TA-IMT. Furthermore, linear regression analyses revealed an independent correlation of the SBP, BMI, LDL cholesterol, and renal AT with TA-IMT. Figure 4 shows the correlation between renal AT and TA-IMT.

Table 1. Comparison of clinical and laboratory parameters

	Group 1 (n= 56)	Group 2 (n= 56)	p
Age (years)	52.9 ± 4.88	50.2 ± 10.9	0.082
Gender (male/female)	35/21	41/15	0.156
Systolic blood pressure (mmHg)	141 ± 16	131 ± 12	**< 0.001**
Diastolic blood pressure (mmHg)	90 ± 10.4	81 ± 8.2	**< 0.001**
Heart rate (beat/min)	76.4 ± 7.1	77.1 ± 5.6	0.583
Body mass index (kg/m^2)	28.3 ± 3.1	26.5 ± 2.9	**0.002**
Total cholesterol (mg/dL)	211 ± 48	178 ± 35	**< 0.001**
Low-density lipoprotein cholesterol (mg/dL)	140 ± 34	117 ± 34	**0.001**
High-density lipoprotein cholesterol (mg/dL)	39 ± 10	41 ± 8.3	0.136
Triglyceride (mg/dL)	201 ± 72	139 ± 42	**< 0.001**
Blood urea nitrogen (mg/dL)	27.7 ± 8.9	29.1 ± 6.8	0.401
Creatinine (mg/dL)	0.80 ± 0.16	0.82 ± 0.25	0.760
White blood cell count ($1000/mm^3$)	7.87 ± 2.23	8.02 ± 1.99	0.462
Hemoglobin (g/dL)	13.3 ± 1.17	13.1 ± 1.28	0.640

Table 2. Comparison of ultrasonography and echocardiography parameters

	Group 1 (n= 56)	Group 2 (n= 56)	p
Renal resistive index, mean ± SD	0.75 ± 0.05	0.70 ± 0.06	**< 0.001**
Renal resistive index, median (min-max)	0.75 (0.67 - 0.84)	0.70 (0.60 - 0.83)	
Renal resistive index > 0.70 (n, %)	39 (70%)	25 (45%)	**0.007**
Renal pulsatility index	1.55 ± 0.43	1.40 ± 0.32	**0.015**
Renal acceleration time (m/s)	94.2 ± 18.4	114 ± 17.8	**< 0.001**
Kidney length (mm)	107 ± 7.7	106 ± 11	0.716
Kidney width (mm)	45.9 ± 6.2	47.5 ± 11	0.370
Cortical thickness (mm)	12.9 ± 1.9	11.9 ± 1.3	0.003
IVS end-diastolic thickness (mm)	11.3 ± 1.35	10.9 ± 1.19	0.075
PW end-diastolic thickness (mm)	10.7 ± 1.53	10.2 ± 1.01	0.097
LV end-diastolic dimension (mm)	48.7 ± 5.21	48.3 ± 4.83	0.768
LV end-systolic dimension (mm)	31.5 ± 4.43	31.8 ± 3.60	0.764
Aorta maximal dimension (mm)	32.5 ± 4.30	31.6 ± 3.13	0.203
LA end-systolic dimension (mm)	35.9 ± 2.72	35.1 ± 4.61	0.234
LV ejection fraction (%)	60.9 ± 5.23	59.7 ± 4.72	0.385
Mitral E velocity (m/sn)	0.83 ± 0.14	0.75 ± 0.19	**0.007**
Mitral A velocity (m/sn)	0.61 ± 0.16	0.56 ± 0.17	0.168
Mitral E/A ratio	1.41 ± 0.23	1.48 ± 0.75	0.485
LV-isovolumic relaxation time (ms)	104 ± 17	102 ± 28	0.632
LV-deceleration time (ms)	210 ± 46	183 ± 35	**0.001**
LV-S_m velocity (cm/s)	0.665 ± 0.093	0.694 ± 0.121	0.153
LV-E_m velocity (cm/s)	0.796 ± 0.295	0.885 ± 0.294	0.113
LV-A_m velocity (cm/s)	0.755 ± 0.153	0.714 ± 0.141	0.148
LV-E_m/A_m ratio	1.11 ± 0.49	1.29 ± 0.54	0.063
LV-E/E_m ratio	11.8 ± 4.31	9.16 ± 2.98	**< 0.001**

A_m: Late diastolic peak velocity, E_m: Early diastolic peak velocity, LV: Left ventricular, IVS: Interventricular septum, PW: Posterior wall, S_m: Systolic peak velocity.

Using the logistic regression analyses, the SBP, renal AT, and LV-E/E_m were independently determined in patients with increased TA-IMT (> 1.6 mm). The analysis revealed that every 1 mmHg increase in the SBP, every 1m/s decrease in the renal AT, and every 1 point increase in the LV-E/E_m ratio increased the likelihood of increased TA-IMT by 27.5%, 5%, and %44.8, respectively (Table 4).

We performed the ROC curve analysis to assess the presence of TA-IMT > 1.6 mm. The area under the curve was 0.832, 0.713, and 0.670 for the SBP, renal AT, and LV-E/E_m, respectively (Table 5). When the SBP, renal AT, and LV-E/E_m cutoff values were taken as 133 mmHg, 100 ms, and 10, they determined the presence of TA-IMT > 1.6 mm with high sensitivity and specificity (Table 5).

DISCUSSION

The major finding of this study was the establishment of the correlation between increased TA-IMT values and deteriorated renal Doppler measurements in hypertensive patients. Based on our literature review and best sources, this is the first study to report the correlation between increased TA-IMT values and deteriorated renal Doppler measurements in hypertensive patients.

Hong et al.[13] reported that the abdominal aorta was one of the first areas in which early atherosclerosis could be noted. In addition, Li et al.[5] explored the first signs of atherosclerosis in the aorta and reported higher intima-media ratio in the distal segments of the aorta. Although all muscular arteries

Table 3. The parameters related to thoracic aortic intima-media thickness and linear regression analysis of parameters significantly correlating with it

Renal resistive index	Univariate analysis		Multivariate analysis	
	p	r	p	β
Systolic blood pressure	< 0.001	0.602	< 0.001	0.371
Diastolic blood pressure	< 0.001	0.549	0.822	0.031
Body mass index	0.001	0.383	< 0.001	0.289
Total cholesterol	0.001	0.322	0.367	0.066
Low-density lipoprotein cholesterol	< 0.001	0.326	0.002	0.360
High-density lipoprotein cholesterol	0.025	-0.211	0.036	-0.134
Triglyceride	< 0.001	0.479	0.187	-0.130
Renal resistive index	< 0.001	0.379	0.296	-0.070
Renal acceleration time	< 0.001	-0.597	< 0.001	-0.430
LA end-systolic dimension	0.002	0.295	0.596	0.040
LV-deceleration time	< 0.001	0.349	0.117	0.114
LV-E/E_m ratio	0.006	0.256	0.344	0.082

LA: Left atrium, LV: Left ventricular.

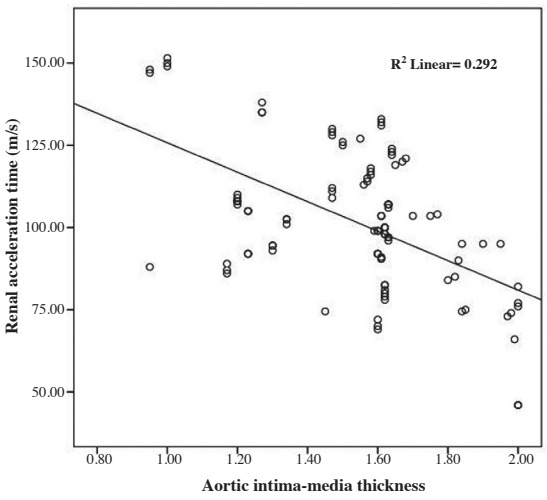

Figure 4. Simple Scatter/Dot diagram for the positive and negative correlation between the renal acceleration time and thoracic aortic intima-media thickness.

are known to be affected by atherosclerosis, it remains unclear which of these is affected the most, and to what extent. Early detection of atherosclerosis is one of the major objectives of several clinicians, and the measurement of IMT is one method to attain this objective. Currently, carotid artery IMT is a routine evaluation method for patients with multiple CAD risk factors[14], as the carotid artery is superficial and easy to visualize. Conversely, abdominal aortic IMT (AA-IMT) measurement is a less frequently used method, especially in adults, primarily because their abdominal fat tissue acts as a restricting factor for imaging quality. The recently introduced high-resolution US devices have made reliable AA-IMT measurement feasible[15]. TA-IMT is another aorta section to be inspected for atherosclerosis, which can be easily and objectively measured by TEE[6]. Moreover, being an aorta portion, IMT of the thoracic aorta could be increased earlier than that of other peripheral arteries, including the carotid or the extremity arteries. Notably, TEE offers an opportunity to view, evaluate, and measure the thoracic aorta in terms of premature atherosclerosis. This study revealed that increased TA-IMT values correlated with deteriorated renal functions, as measured by Doppler methods, which corroborates general literature regarding IMT, hypertension, and renal functions. In this study, we took 1.6 mm as a limit for the increased TA-IMT, as this was our patients' median value. In the literature, no generally accepted cutoff value exists for TA-IMT; perhaps, this could be the case because TA-IMT changes significantly with age and other cardiovascular and metabolic risk factors. The routine evaluation of TA-IMT could help to screen for subclinical target organ damage in TEE of hypertensive patients. Furthermore, patients should be assessed using renal Doppler methods, especially if there is an increase in TA-IMT.

The heart, brain, kidneys, and vascular beds are the main target organs for hypertension[16]. For several years, clinicians have used creatinine clearance, microalbuminuria or macroalbuminuria, and glomerular filtration rate (GFR) to detect hypertension-related damage in the kidneys. Recently, renal Doppler measurements have begun to be used for detecting

Table 4. Independent risk factors for the occurrence of increased thoracic aortic intima-media thickness, based on the multivariate regression analysis

	Odds Ratio	95% CI	p
Systolic blood pressure (1 mmHg)	1.275	1.145-1.420	< 0.001
Renal acceleration time (1 m/s)	0.950	0.912-0.989	0.013
Left ventricular E/E_m ratio (each 1)	1.448	1.184-1.772	< 0.001

CI: Confidence Interval.

Table 5. ROC analysis for the detection of increased thoracic aortic intima-media thickness

Variable	AUROC Curve	p	Cut-off	Sensitivity	Specificity
Systolic blood pressure	0.832 (0.755-0.910)	< 0.001	133 mmHg	78.6%	81.1%
Renal acceleration time	0.713 (0.617-0.809)	< 0.001	100 ms	73.6%	73.2%
Left ventricular E/E_m ratio	0.670 (0.568-0.772)	0.002	10	60.7%	62.3%

hypertension-related damage in the kidneys, especially because it was demonstrated that the RRI is valuable in detecting early deterioration in the kidneys. An RRI > 0.70 correlates with increased albuminuria and decreased GFR in hypertensive patients with normal kidney function. Some studies have reported a correlation between increased RRI, LV mass index, and IMT in hypertensive patients[7,17]. To date, however, most studies exploring the correlation between IMT and RRI were based on the carotid artery measurements; ours is the first study to investigate this correlation in TA-IMT. This study revealed that RRI, RPI values, the presence of RRI > 0.70, and cortical thickness were markedly higher in patients with increased TA-IMT than those without increased TA-IMT. In addition, we reported a positive correlation between TA-IMT, RRI, and RPI in our study sample. Besides, the logistic regression analysis revealed that every 1 mmHg increase in the SBP, every 1 m/s decrease in the renal AT, and every 1 point increase in the LV-E/E_m ratio increased the likelihood of having an increased TA-IMT by 27.5%, 5%, and 44.8%, respectively.

This study established a positive correlation between TA-IMT and the SBP, DBP, BMI, total cholesterol, LDL cholesterol, triglyceride, RRI, LA dimension, LV-deceleration time, and LV-E/E_m ratio, as expected based on the literature. Only HDL cholesterol and renal AT negatively correlated with TA-IMT, which contradicted the literature.

This study has some major limitations. First, the sample size was small and limited to hypertensive patients. Second, only TA-IMT measurements were performed; AA-IMT and carotid IMT measurements would have rendered our study more valuable. Hence, larger, comprehensive, and prospective studies are warranted to support the findings of our study.

CONCLUSION

This study establishes a correlation between increased TA-IMT values and deteriorated renal Doppler measurements in hypertensive patients. Perhaps, TA-IMT measurements could be helpful for hypertensive patients who undergo TEE.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of the Adana City Training and Research Hospital (Decision Number: 450; Decision Date: May 22, 2019).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept/Design - YD, AA, MK; Analysis/Interpretation - AB, MK, YD; Data Collection – HK, MK, ASK, BÇP; Writing - YD; Critical Revision – AA, MK; Final Approval – MK; Statistical Analysis – YD, AB; Obtained Funding – YD; Overall Responsibility - YD

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Ferreira JP, Girerd N, Bozec E, Machu JL, Boivin JM, London GM, et al. Intima-media thickness is linearly and continuously associated with systolic blood pressure in a population-based cohort (STANISLAS Cohort Study). J Am Heart Assoc 2016;5:e003529.
2. Magnussen CG. Carotid artery intima-media thickness and hypertensive heart disease: a short review. Clin Hypertens 2017;23:7.
3. Pignoli P, Tremoli E, Poli A, Oreste P, Paoletti R. Intimal plus medial thickness of the arterial wall: a direct measurement with ultrasound imaging. Circulation 1986;74:1399-406.
4. Koc AS, Sumbul HE. Increased aortic intima-media thickness may be used to detect macrovascular complications in adult type II diabetes mellitus patients. Cardiovasc Ultrasound 2018;16:8.
5. Li W, Luo S, Luo J, Liu Y, Huang W, Chen J. Association between abdominal aortic plaque and coronary artery disease. Clin Interv Aging 2016;11:683-8.

6. Harrington J, Pena AS, Gent R, Hirte C, Couper J. Aortic intima media thickness is an early marker of atherosclerosis in children with type 1 diabetes mellitus. J Pediatr 2010;156:237-41.
7. Viazzi F, Leoncini G, Derchi LE, Pontremoli R. Ultrasound Doppler renal resistive index: a useful tool for the management of the hypertensive patient. J Hypertens 2014;32:149-53.
8. Boddi M. Renal ultrasound (and Doppler sonography) in hypertension: an update. Adv Exp Med Biol 2017;956:191-208.
9. Hanamura K, Tojo A, Kinugasa S, Asaba K, Fujita T. The resistive index is a marker of renal function, pathology, prognosis, and responsiveness to steroid therapy in chronic kidney disease patients. Int J Nephrol 2012;2012:139565.
10. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, et al. Recommendations for chamber quantification. Eur J Echocardiogr 2006;7:79-108.
11. Galderisi M. Diagnosis and management of left ventricular diastolic dysfunction in the hypertensive patient. Am J Hypertens 2011;24:507-17.
12. Nishino M, Masugata H, Yamada Y, Abe H, Hori M, Kamada T. Evaluation of thoracic aortic atherosclerosis by transesophageal echocardiography. Am Heart J 1994;127:336-44.
13. Hong YM. Atherosclerotic cardiovascular disease beginning in childhood. Korean Circ J 2010;40:1-9.
14. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur Heart J 2018;39:3021-104.
15. Koc AS, Gorgulu FF, Donmez Y, Icen YK. There is a significant relationship between morning blood pressure surge and increased abdominal aortic intima-media thickness in hypertensive patients. J Med Ultrason (2001) 2018;45:597-603.
16. Mensah GA. Hypertension and target organ damage: don't believe everything you think! Ethn Dis 2016;26:275-8.
17. Doi Y, Iwashima Y, Yoshihara F, Kamide K, Takata H, Fujii T, et al. Association of renal resistive index with target organ damage in essential hypertension. Am J Hypertens 2012;25:1292-8.