Original Article

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Peripheral Arterial Occlusive Disease

Clinical Efficacy of Transthoracic Echocardiography for Screening Abdominal Aortic Aneurysm in Turkish Patients

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Background: The objective of this study was to investigate the prevalence of abdominal aortic aneurysm (AAA) in Turkish patients aged ≥ 65 years, and to demonstrate the applicability of echocardiography to AAA screening.

Methods: Transthoracic echocardiography (TTE) was performed in all consecutive patients aged ≥ 65 years who were referred to cardiology clinics or were referred from other outpatient clinics. The abdominal aorta (AA) of each patient was scanned using the same probe, and the time spent was recorded. Demographic and clinic characteristics of the patients were recorded at the end of the echocardiography.

Results: Among 1948 patients (mean age 70.9 ± 6 years; 49.8% male), the AA was visualized in 96.3%. AAA was identified in 3.7% (69/1878) of the patients, of whom AAA was previously known in 20.3% (n = 14). The prevalence of unknown AAA was 2.93%. The average time needed to scan and measure the AA was 1 minute and 3 seconds (±23 seconds). Aortic root diameters were significantly higher in the patients with AAA than in those without AAA (34.7 ± 4.2 vs. 29.8 ± 4.7; $p < 0.001$). Age (per 1 year increase) [odds ratio (OR), 1.245; $p < 0.001$], male gender (OR, 5.382; $p < 0.001$), smoking (OR, 2.118; $p = 0.037$), and aortic root diameter (per 1 mm increase) (OR, 1.299; $p < 0.001$) were independent predictors of AAA.

Conclusions: This study is important in that it showed a high prevalence of AAA in Turkish patients aged ≥ 65 years, and demonstrated that AAA can be visualized in the majority of patients in as little as 1 minute during TTE.

Key Words: Abdominal aortic aneurysm • Screening abdominal aortic aneurysm • Transthoracic echocardiography

INTRODUCTION

Abdominal aortic aneurysm (AAA) is the pathologic local dilation of the abdominal aorta (AA), and is defined as an aorta size more than 30 mm or a local dilation of the AA by more than 50% compared to another site along the aorta.[1] AAA usually remains asymptomatic unless it ruptures, in which case the operative mortality rate often exceeds 50%.[2] However, if patients undergo elective surgery for AAA, the hospital mortality rate is greatly reduced to < 5%.[3] Therefore, the early diagnosis of AAA is crucial, and screening of AAA is recommended especially for those at high risk.[4] Significant variations in the prevalence of AAA have been reported among various populations.[4] In Western countries, the reported prevalence of AAA is 1.3-8.9% in men and 1.0-2.2% in women, while the prevalence is lower in Asian countries.[5-9] Ultrasonography is an excellent tool for screening AAA without risk and at low cost. In addition to ultrasonography, many studies have shown that the AA can be visualized with the same probe during standard echocardiography. The objective of this study was to in-

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vestigate the prevalence of AAA in Turkish patients ≥ 65 years, and to demonstrate the applicability of echocardiography to screen AAA.

METHODS

All consecutive patients ≥ 65 years who presented to cardiology clinics at three different hospitals (two secondary care and one tertiary care) or were referred from other outpatient clinics between November 01, 2016 and May 31, 2017 were given information about the study. Standard echocardiography was performed in all patients who agreed to participate in the study and who provided informed consent. The study was commenced after approval from the Ethics Board of the Medical Faculty of Gaziantep University was received. Following echocardiography, the AA was scanned using the same probe. Demographic characteristics and the medical history of the patients were recorded at the end of the AA scan. Patients with a history of abdominal aortic interventions (either endovascular or surgery) were excluded from the study. Hypertension was defined as repeated measurements of systolic blood pressure > 140 mmHg, diastolic > 90 mmHg, or chronic treatment with antihypertensive medications. Type 2 diabetes mellitus was defined as a previous diagnosis and/or fasting blood glucose > 126 mg/dl or the use of anti-diabetic medications. Hyperlipidemia was defined as a total cholesterol level > 200 mg/dl or the use of lipid-lowering medications. Smoking history was classified as either current smoker or past smoker. Patients who smoked at least 1 cigarette/day were defined as current smokers, and patients who had quit smoking for at least 1 year were defined as past smokers. Chronic heart failure was defined as reduced left ventricular ejection fraction (< 40%). A family history of AAA was defined as a history of AAA in the first-degree relatives of the patients.

Echocardiography

Echocardiographic evaluations were performed by three experienced cardiologists who conducted more than 30 echocardiography examinations a day and who were experienced in vascular ultrasonography. We used a Vivid S5 system (General Electric, Horten, Norway) with a 3S-RS transducer (1.5 to 3.6 MHz) and a Philips HD 11XE system (Philips, Andover, MA, USA) with a S3-1 transducer (1-3 MHZ). Routine transthoracic 2-dimensional echocardiography was performed as recommended by the American Society of Echocardiography.[10] The aortic root size was measured at the level of the sinus of Valsalva from the parasternal long-axis view. Measurements were made from the leading edge to the leading edge of the aorta at the end of the diastole. At the end of the standard echocardiography examination, the AA was visualized with the patient in the supine position, using the same echocardiography transducer. The AA was scanned from the subcostal position, and the infrarenal abdominal aorta was visualized below the origin of the renal artery and then traced distally as far as possible. The longitudinal image of the AA was visualized with the transducer marker pointing toward the patient's feet. The transducer was then rotated 90° counterclockwise and the transverse image of the AA was visualized. The size of the AA was measured at the maximum short-axial diameter in the antero-posterior plane from the leading edge to the leading edge at the end of the diastole. AAA was defined as an AA > 30 mm. The time taken to scan the AA was calculated and recorded using a chronometer by an assistant.

Statistical analysis

Continuous variables were presented as mean ± standard deviation [mean ± standard deviation (SD)], and categorical variables were expressed as number and percentage (%). The continuous variables were compared across groups using the Students' *t*-test or the Mann-Whitney U test. Normality of data distribution was verified using the Kolmogorov-Smirnov test, and homogeneity of variance was assessed using Levene's test. The categorical variables were compared using the chi-square or Fisher's exact test. A p value less than 0.05 was considered to be statistically significant. Logistic regression analysis was performed to determine the independent correlates of AAA. A stepwise model with backward selection was used. Results were tabulated as odds ratio (OR) and 95% confidence interval (CI). Receiver operating characteristics (ROC) curves were also used to demonstrate the sensitivity and specificity of aortic root diameter and its cut-off values to predict AAA. All data were analyzed using SPSS software for Windows Version 20.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Among 1948 patients, the AA was visualized in 96.3% (n = 1876). The examiners rated the imaging quality as excellent in 48.5% of the patients and good in 29.8% of the patients. The mean age of the patients was 70.9 ± 6 years (49.8% male). AAA was identified in 3.7% (69/ 1876) of the patients, in whom AAA was previously known in 20.3% (n = 14) and unknown in 79.7% (n = 55). The prevalence of unknown AAA was 2.93%. The prevalence of AAA was significantly higher in men (6.07%, n = 57) than in women (1.28%, n = 12) ($p < 0.001$). The mean size of AAA was 37.0 ± 5.0 mm (30.0-51), in which the proportions of AAA within 30 to 34, 35 to 39, 40 to 44, 45 to 49 and > 50 mm were 40.6%, 30.4%, 23.2%, 2.9% and 2.9%, respectively. The average time needed to scan and measure the AA was 1 minute and 3 seconds (±23 seconds). The imaging took < 3 minutes in 99.3% (n = 1846) of the patients and < 2 minutes in 96.5% (n = 1298) of the patients. The clinical and demographic parameters of the patients with and without AAA are listed in Table 1. The mean age of the patients with AAA was significantly higher than in those without AAA (79.6 ± 6.4, 70.5 ± 5.6 years; $p < 0.001$, respectively). In addition, male gender, history of coronary artery disease (CAD), heart failure (HF), chronic obstructive pulmonary disease (COPD), family history of AAA, and smoking were significantly higher in the patients with AAA than in those without AAA (Table 1). There were no significant differences between the two groups in systolic and diastolic blood pressure or heart rate. Among the patients with AAA, left ventricular end-diastolic and systolic diameters were significantly higher and left ventricular ejection fraction was significantly lower than in the patients without AAA (Table 2). In addition, aortic root diameters were significantly higher in the patients with AAA than in those without AAA (34.7 ± 4.2 vs. 29.8 ± 4.7 mm; $p < 0.001$) (Table 2). All patients with AAA had an aortic root diameter > 29 mm. An aortic root diameter > 33 mm was as predictive of AAA according to ROC curve analysis (area under the curve, 0.812; sensitivity 84.51%, specificity 74.54%; $p < 0.001$) (Figure 1). A logistic regression model including age, gender, smoking, HF, CAD, COPD, family history of AAA, and aortic root was constructed. The accuracy of the model was 96.8%. Analysis revealed that age (per 1 year increase) (OR, 1.245; 95% CI, 1.193-1.299; $p < 0.001$), male gender (OR, 5.382; 95% CI, 2.493-11.616; $p < 0.001$), smoking (OR, 2.118; 95% CI, 1.049-4.295; p =

Table 1. Baseline characteristic of patients with and without abdominal aortic aneurysm

Variable	Abdominal aortic aneurysm		
	Yes (n = 69)	No (n = 1807)	p
Age (years ± SD)	79.6 ± 6.4	70.5 ± 5.6	< 0.001
Male gender	82.6 (57)	48.8 (882)	< 0.001
Body mass index (kg/m^2)	26.8 ± 4.1	25.5 ± 5.5	0.08
SBP (mmHg)	131 ± 19	132 ± 19	0.697
DBP (mmHg)	76 ± 10.5	77 ± 12.5	0.433
Pulse pressure (mmHg)	55 ± 17	54 ± 17	0.913
Heart rate (bpm)	85 ± 10	84 ± 12	0.337
Creatinine (mh/dL)	0.9 ± 0.1	0.8 ± 0.1	0.764
Smoking, % (n)	42.0 (29)	25.8 (461)	0.003
Hypertension, % (n)	81.2 (56)	73.6 (1322)	0.159
Diabetes mellitus, % (n)	13.0 (9)	18.7 (335)	0.235
Hyperlipidemia, % (n)	24.6 (17)	30.1 (541)	0.333
Coronary artery disease, % (n)	66.7 (46)	50.1 (896)	0.007
Heart failure, % (n)	40.5 (28)	20.5 (372)	< 0.001
Cerebrovascular disease, % (n)	5.8 (4)	4.7 (84)	0.567
Chronic kidney disease, % (n)	2.9 (2)	2.5 (44)	0.687
Chronic obstructive pulmonary disease, % (n)	17.4 (12)	9.2 (164)	0.022
Family history of AAA, % (n)	4.3 (3)	0.7 (13)	0.020

AAA, abdominal aortic aneurysm; DBP, diastolic blood pressure; SBP, systolic blood pressure; SD, standard deviation.

Table 2. Comparison of echocardiographic indices of patients with and without abdominal aortic aneurysm

Variables	Abdominal aortic aneurysm		
	Yes (n = 69)	No (n = 1807)	p
LV end-diastolic diameter (mm)	51.4 ± 6	48.4 ± 5.6	< 0.001
LV end-systolic diameter (mm)	33.0 ± 8.6	29.5 ± 6.7	< 0.001
Posterior wall thickness (mm)	10.2 ± 1.5	10.3 ± 1.9	0.682
Septal thickness (mm)	10.4 ± 1.7	10.8 ± 1.9	0.081
LV ejection fraction	52.4 ± 10.4	55.8 ± 9.8	0.005
Abdominal aorta diameter (mm)*	37.0 ± 5.0	22.0 ± 2.8	< 0.001
Aortic root (mm)	34.7 ± 4.3	29.8 ± 4.7	< 0.001
Aortic regurgitation 2+, % (n)	8.7 (6)	3.9 (70)	0.046
Mitral regurgitation 2+, % (n)	5.8 (4)	7.9 (142)	0.530

* Anterior - posterior diameter. LV, left ventricular.

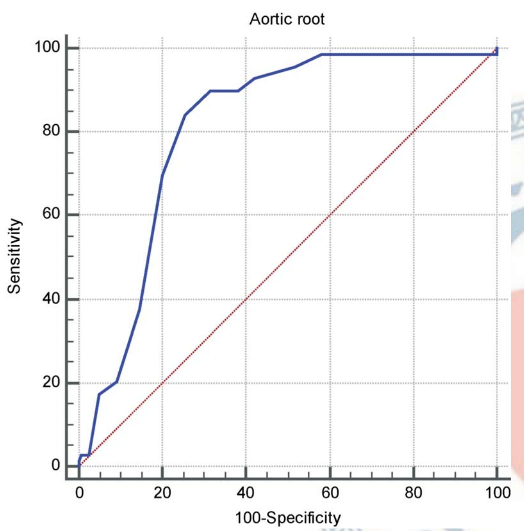

Figure 1. Receiver operating characteristics curve analysis showing the cutoff aortic root value for abdominal aortic aneurysm. [aortic root > 33 mm with a sensitivity of 84.51% and a specificity of 74.54% (AUC 0.812; 95% confidence interval, 0.794 to 0.830; p < 0.001)].

0.037), and aortic root diameter (per 1 mm increase) (OR, 1.299; 95% CI, 1.205-1.401; p < 0.001) were independent predictors of AAA (Table 3).

DISCUSSION

The present study has three major findings. First, the prevalence of AAA was 3.7% during trans-thoracic echocardiography (TTE) in patients > 65 years, and the prevalence of unknown AAA was 2.93%. Second, the feasibility of AA visualization during TEE was excellent (96.3%); and the imaging lasted < 3 minutes in 95.1% of the patients. Third, higher age, male gender, increased aortic root diameter and smoking were independent predictors of AAA.

Rupture of AAA is fatal, with a mortality rate of more than 50% before arrival at a hospital. Even if the

Table 3. Logistic regression analysis for predictors of abdominal aortic aneurysm

Variables	Univariate			Multivariate		
	p	OR	95% CI	p	OR	95% CI
Age (per 1 year increase)	< 0.001	1.202	1.161-1.245	< 0.001	1.245	1.193-1.299
Male gender	< 0.001	4.982	2.655-9.347	< 0.001	5.382	2.493-11.616
Smoking	0.003	2.089	1.280-3.408	0.037	2.118	1.049-4.295
Aortic root diameter (per 1 mm increase)	< 0.001	1.287	1.206-1.375	< 0.001	1.299	1.205-1.401
COPD	0.025	2.089	1.098-3.972	-	-	-
Heart failure	0.006	2.706	1.338-5.473	-	-	-
CAD	0.008	1.993	1.198-3.316	-	-	-
Family history AAA	0.005	4.189	1.772-10.241	-	-	-
Aortic regurgitation 2+	0.053	2.363	0.989-5.646	-	-	-

AAA, abdominal aortic aneurysm; CAD, coronary artery disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; OR, odds ratio.

patient survives to the operating room, operation-related mortality has been reported to be up to 70%.[11,12] However, the mortality rate of elective surgery for unruptured AAA is only 2-6%.[8] Screening for AAA in patients at high risk has been shown to reduce mortality and to be cost-effective in several prospective randomized trials. Ultrasonography is an excellent tool for screening and surveillance without risk and at low cost. However, abdominal aortic ultrasonography requires additional analysis. Therefore, AA imaging performed during standard echocardiography can be more cost effective. Many studies have shown that the AA can be scanned with the same probe during standard TTE.[7,13-16]

Studies differ significantly with regards to the rate of AA imaging, its duration and prevalence.[7-9,13,14,17-23] Many studies have reported AA scanning in more than 90% of patients.[9,13,14,20,21,23] Several studies have also shown that it takes less than 3 minutes to evaluate the AA in the majority of patients.[7,9] Consistent with most previous studies, the rate of AA imaging was high in our study (96.3%), taking on average 1 minute. These results become more meaningful when considering that almost all cardiology outpatient clinics in Turkey have echocardiography devices and that cardiologists perform echocardiography during routine examinations. The main reasons underlying the significant differences across studies on the prevalence AAA include the diversity of the patient populations included or excluded and different definitions of AAA. Although many studies have considered a threshold value of > 30 mm for AAA, others have adopted different values including > 40 mm, > 35 mm, and > 25 mm.[13,17,18] The European Society of Cardiology (ESC) guidelines on the diagnosis and treatment of aortic disease recommend using a > 30 mm threshold.[4] We used a > 30 mm threshold, the value that is most frequently used to diagnose AAA as well as the recommended value in the ESC guidelines. Moreover, parameters including age, the fact that the studies were performed in reference centers, and differences in the population studied may have led to different results of the prevalence of AAA. Because the number of identified patients may be higher in studies performed in reference centers, the prevalence of AAA may be higher and the number of undiagnosed AAA patients may be lower. To overcome this, we included patients from different hospitals providing secondary and tertiary care in this study. In addition, based on the recommendations of ESC guidelines, we included patients aged ≥ 65 years who have the highest frequency of AAA. The prevalence of AAA among patients undergoing TTE has been reported in several studies to range from 0.8% to 6.5%.[7,13,14,18,21,22,24-27] In a multi-center study in France including 1382 patients aged > 65 years, the prevalence of AAA was 3.7%, which is consistent with our study.[7] However, differences in the prevalence of AAA across studies may be due to the population involved. To the best of our knowledge, no previous study has focused on the prevalence of AAA in Turkish patients. Similar to previous studies, we found that increased age, male gender and smoking history were independent risk factors for AAA. In addition, we found that an increased aortic root was an independent risk factor for AAA.[7,22,23,28-30] Unlike other studies, a family history of AAA was not an independent risk factor for AAA in our study. The fact that patients cannot always precisely remember their relatives' medical histories may account for this finding.

Limitations

This study has several limitations. The most important is the potential inability of our patient population to represent all Turkish patients aged > 65 years. Although we included all patients aged > 65 years who were referred to hospitals and who underwent echocardiography to circumvent this issue, patients may have higher rates of cardiovascular risk factors compared to non-selected individuals in the general population. The second important limitation is that there may have been bias in selecting the patient population due to the patients in whom imaging could not be performed, particularly in obese patients, although the AAA imaging ratio was high in our study. The third limitation is that the patients may have provided inaccurate or incomplete information about their medical histories, particularly a family history of AAA, given their advanced age of > 65 years.

CONCLUSIONS

To the best of our knowledge, this is the first study to evaluate the prevalence of AAA in Turkish patients and to evaluate the applicability of echocardiography for AAA screening. This study is important in that it showed a high prevalence of AAA in patients aged > 65 years, and demonstrated that AAA could be scanned in as little as 1 minute during standard echocardiography.

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