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-
vestigate the prevalence of AAA in Turkish patients ≥ 65
years, and to demonstrate the applicability of echocar-
diography 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 com-
enced 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 aor-
tic 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
sugar > 126 mg/dl or the use of anti-diabetic medica-
tions. Hyperlipidemia was defined as a total cholesterol
level > 200 mg/dl or the use of lipid-lowering medica-
tions. 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 pa-
tients who had quit smoking for at least 1 year were de-
efined 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-dimen-
sional echocardiography was performed as recommended
by the American Society of Echocardiography.10 The aor-
tic root size was measured at the level of the sinus of
Valsalva from the parasternal long-axis view. Measure-
ments were made from the leading edge to the leading
gap 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 infra-
renal 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° counterclock-
wise 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 dias-
tole. 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 com-
pared 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 ho-
mogeneity 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 re-
gression analysis was performed to determine the inde-
pendent correlates of AAA. A stepwise model with back-
ward selection was used. Results were tabulated as odds
ratio (OR) and 95% confidence interval (CI). Receiver op-
erating 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, family 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>
<thead>
<tr>
<th>Variable</th>
<th>Yes (n = 69)</th>
<th>No (n = 1807)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years ± SD)</td>
<td>79.6 ± 6.4</td>
<td>70.5 ± 5.6</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Male gender</td>
<td>82.6 (57)</td>
<td>48.8 (882)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.8 ± 4.1</td>
<td>25.5 ± 5.5</td>
<td>0.08</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>131 ± 19</td>
<td>132 ± 19</td>
<td>0.697</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>76 ± 10.5</td>
<td>77 ± 12.5</td>
<td>0.433</td>
</tr>
<tr>
<td>Pulse pressure (mmHg)</td>
<td>55 ± 17</td>
<td>54 ± 17</td>
<td>0.913</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>85 ± 10</td>
<td>84 ± 12</td>
<td>0.337</td>
</tr>
<tr>
<td>Creatinine (mh/dL)</td>
<td>0.9 ± 0.1</td>
<td>0.8 ± 0.1</td>
<td>0.764</td>
</tr>
<tr>
<td>Smoking, % (n)</td>
<td>42.0 (29)</td>
<td>25.8 (461)</td>
<td>0.003</td>
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<tr>
<td>Hypertension, % (n)</td>
<td>81.2 (56)</td>
<td>73.6 (1322)</td>
<td>0.159</td>
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<tr>
<td>Diabetes mellitus, % (n)</td>
<td>13.0 (9)</td>
<td>18.7 (335)</td>
<td>0.235</td>
</tr>
<tr>
<td>Hyperlipidemia, % (n)</td>
<td>24.6 (17)</td>
<td>30.1 (541)</td>
<td>0.333</td>
</tr>
<tr>
<td>Coronary artery disease, % (n)</td>
<td>66.7 (46)</td>
<td>50.1 (896)</td>
<td>0.007</td>
</tr>
<tr>
<td>Heart failure, % (n)</td>
<td>40.5 (28)</td>
<td>20.5 (372)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Cerebrovascular disease, % (n)</td>
<td>5.8 (4)</td>
<td>4.7 (84)</td>
<td>0.567</td>
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<tr>
<td>Chronic kidney disease, % (n)</td>
<td>2.9 (2)</td>
<td>2.5 (44)</td>
<td>0.687</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease, % (n)</td>
<td>17.4 (12)</td>
<td>9.2 (164)</td>
<td>0.022</td>
</tr>
<tr>
<td>Family history of AAA, % (n)</td>
<td>4.3 (3)</td>
<td>0.7 (13)</td>
<td>0.020</td>
</tr>
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</table>

AAA, abdominal aortic aneurysm; DBP, diastolic blood pressure; SBP, systolic blood pressure; SD, standard deviation.
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 2. Comparison of echocardiographic indices of patients with and without abdominal aortic aneurysm

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

* 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)].

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

<table>
<thead>
<tr>
<th>Variables</th>
<th>Univariate</th>
<th>Multivariate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p</td>
<td>OR 95% CI</td>
</tr>
<tr>
<td>Age (per 1 year increase)</td>
<td>&lt; 0.001</td>
<td>1.202-1.6145</td>
</tr>
<tr>
<td>Male gender</td>
<td>&lt; 0.001</td>
<td>4.982-26.555</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.003</td>
<td>2.089-6.385</td>
</tr>
<tr>
<td>Aortic root diameter (per 1 mm increase)</td>
<td>&lt; 0.001</td>
<td>1.287-1.206</td>
</tr>
<tr>
<td>COPD</td>
<td>0.025</td>
<td>2.089-1.206</td>
</tr>
<tr>
<td>Heart failure</td>
<td>0.006</td>
<td>2.706-5.347</td>
</tr>
<tr>
<td>CAD</td>
<td>0.008</td>
<td>1.993-3.116</td>
</tr>
<tr>
<td>Family history AAA</td>
<td>0.005</td>
<td>4.189-10.241</td>
</tr>
<tr>
<td>Aortic regurgitation 2+</td>
<td>0.053</td>
<td>2.363-5.646</td>
</tr>
</tbody>
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AAA, abdominal aortic aneurysm; CAD, coronary artery disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; OR, odds ratio.

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patient survives to the operating room, operation-related mortality has been reported to be up to 70%. However, the mortality rate of elective surgery for unruptured AAA is only 2-6%. 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.

Studies differ significantly with regards to the rate of AA imaging, its duration and prevalence. Many studies have reported AA scanning in more than 90% of patients. Several studies have also shown that it takes less than 3 minutes to evaluate the AA in the majority of patients. 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. The European Society of Cardiology (ESC) guidelines on the diagnosis and treatment of aortic disease recommend using a > 30 mm threshold. 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%. 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. 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. 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.

ACKNOWLEDGEMENTS

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aneurysms, or a relatively large diameter of non-aneurysmal aortas, increase total and cardiovascular mortality: the Tromsø study. *Int J Epidemiology* 2009:dyp320.
