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Appraisal of transthoracic echocardiography for opportunistic screening of abdominal aortic aneurysm

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Abstract

Abdominal aortic aneurysm is a life threatening disease. Most of the patients diagnosed incidentally because of the asymptomatic nature of this disease. This study aimed to determine the frequency of abdominal aortic aneurysm and evaluate the value of opportunistic screening during transthoracic echocardiography.

A total of 5138 patients referred for echocardiographic evaluation for any reason were screened for abdominal aortic aneurysm between November 2014 to July 2019. The aneurysm was defined as an abdominal aorta with a diameter greater than 30 mm, or segmental dilatation of more than 50% of its size in non-dilated parts.

The overall frequency of abdominal aortic aneurysm was 2.2% (n = 109) in the study population. Male sex ($P < .001$), older age ($P < .001$), presence of diastolic dysfunction ($P = .036$), hypertension ($P < .001$), coronary artery disease ($P < .001$), and hyperlipidemia ($P < .001$) were associated with abdominal aortic aneurysm. Patients with aneurysm had significantly increased diameters of the aortic trunk ($P < .001$) and ascending aorta ($P < .001$), significantly thicker interventricular septum ($P < .001$) and posterior wall ($P < .001$), significantly increased end-diastolic diameter ($P < .001$) and enlarged left atrium ($P < .001$), and significantly decreased ejection fraction ($P < .001$). The mostly met criteria for screening abdominal aortic aneurysm in international guidelines was the age of the patients.

Based on the results of this study, screening patients over 60 years of age who undergo a transthoracic echocardiography for any reason would be beneficial to detect an asymptomatic abdominal aortic aneurysm in Turkish population.

Abbreviations: AAA = Abdominal aortic aneurysm, TTE = Transthoracic echocardiography.

Keywords: abdominal aortic aneurysm, frequency, prevalence, screening, transthoracic echocardiography, Turkish population

1. Introduction

An abdominal aortic aneurysm (AAA) is an aorta with a diameter greater than 30 mm, or segmental dilatation of the abdominal aorta more than 50% of its size in non-dilated parts.[1] It is a potentially life-threatening condition because only half of the patients can admit to the hospital once the AAA is ruptured, and only half of the ones operated can survive.[2] Thus, early diagnosis of the AAA before it is ruptured is critical to avoid excess mortality and morbidity. Today, the United Kingdom, the United States of America, and Sweden implemented the screening for AAA, and several guidelines by the United States Preventive Services Task Force, the Society for Vascular Surgery, and the European Society for Vascular Surgery defined the screening criteria for the AAA.[3–8] Nevertheless, there are some concerns about AAA screening, particularly associated with the different criteria suggested.

One convenient way for AAA screening is performing the ultrasonographic assessment of the abdominal aorta in the patients undergoing transthoracic echocardiography (TTE) evaluation for any reason. Since the patients with an indication for echocardiography assessment share some common cardiovascular risk factors with AAA patients, opportunistic screening is valuable for detecting the asymptomatic AAAs.[9] Several previous studies reported varying results about the AAA screening during TTE.[10] In general, the prevalence of AAA was estimated to range between approximately 1% to 7% associated with the characteristics of the relevant study populations.[11] Based on this body of evidence, we aimed to evaluate AAA's frequency and associated factors and AAA screening feasibility during TTE.

2. Material and methods

From November 2014 to June 2019, all patients referred for an echocardiographic assessment from the Cardiology and other clinical departments in our hospital were included in the study.

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The datasets generated during and/or analyzed during the present study are available from the corresponding author on reasonable request.

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The exclusion criteria were inadequate abdominal ultrasonographic assessment, having a history of percutaneous or surgical intervention for abdominal aorta, being younger than 18 years of age, and being pregnant. During the study period, a total of 188 patients were excluded, and the analyses were completed with the participation of 4950 patients. The study protocol was approved by the local ethics committee, and written informed consent was obtained from all patients.

2.1. Echocardiographic assessment

All echocardiographic assessments were done by the same researcher using a GE Vivid 7 Dimension ultrasound system (General Electric Company, Fairfield, Connecticut, USA). Routine transthoracic 2-dimensional, M-mode, and Doppler echocardiography were performed The left ventricular ejection fraction, left ventricular diameters, right ventricular function and valvular pathologies were evaluated. After TTE evaluation, the abdominal aorta was visualized in the supine position using the same echocardiography probe within a short period of time. The abdominal aorta was scanned from the subcostal position. First, longitudinal image of the abdominal aorta was visualized. Secondly, transverse image of the abdominal aorta was visualized. and then traced distally as far as possible.

2.2. Statistical analyses

Descriptive statistics were presented using mean and standard deviation for continuous data, and frequency and percent for categorical data. The comparisons between independent groups were made using independent sample *t*-test and chi-square test for continuous and categorical data, respectively. A type-I error level of 5% was considered to be statistically significant in a two-sided hypothesis testing design. All analyses were performed in SPSS 23 software (IBM Inc., Armonk, NY, USA).

3. Results

A total of 5138 patients were included in the study; 188 were excluded due to inadequate visualization because of gas collection (n = 137; 72.9%), being younger than 18 years of age (n = 25; 13.3%), abdominal guarding (n = 10; 5.3%), operation (n = 6; 3.2%), pregnancy (n = 5; 2.7%), and other reasons including noncooperation, wound dressing, and ascites (n = 5; 2.7%); and remaining 4950 patients were included in the analyses.

The patients' mean age was 58.0 (±15.4) years, and 56.9% of them were males. The proportion of smokers was 22.9%. About 10.1% of patients had diastolic dysfunction, 53% had hypertension, 22.9% had diabetes, 41.4% had coronary artery disease, and 44.1% had hyperlipidemia.

During TTE assessments, AAA was detected in 109 patients (2.2%). Comparison of demographic parameters between patients with and without AAA revealed that male sex ($P < .001$), older age ($P < .001$), presence of diastolic dysfunction ($P = .036$), hypertension ($P < .001$), coronary artery disease ($P < .001$), and hyperlipidemia ($P < .001$) were associated with AAA. Creatinine levels were also significantly increased in patients with AAA ($P = .001$) (Table 1).

The association between the atrial fibrillation parameters and AAA was evaluated in Table 2. Accordingly, 10.2% of the patients had atrial fibrillation. Comparisons between patients with and without AAA showed that the distribution of atrial fibrillation ($P = .892$) was similar among groups. However, when atrial fibrillation was separated as non-valvular and valvular types, the distribution of valvular atrial fibrillation cases was significantly different between patients with and without AAA ($P = .046$), none of the patients with AAA had valvular atrial fibrillation, and distribution of non-valvular atrial fibrillation was similar between AAA groups ($P = .206$). Likewise, the mean CHA_2DS_2-VASc scores were similar between AAA groups in

Table 1

Baseline characteristics of patients.

	All patients Mean ± SD / n (%)	AAA None (n = 4841) Mean ± SD / n (%)	AAA Present (n = 109) Mean ± SD / n (%)	*P*
Demographic parameters				
Age (years)	57.97 ± 15.37	57.7 ± 15.37	70.07 ± 10.20	<.001
Age group				<.001
60 <	2656 (53.7)	2632 (91.9)	24 (0.9)	
61–70	1206 (24.4)	1175 (97.4)	31 (2.6)	
71–80	825 (16.7)	785 (95.2)	40 (4.8)	
80 >	263 (5.3)	249 (94.7)	14 (5.3)	
Age group				<.001
65 <	3276 (66.2)	3240 (98.9)	36 (1.1)	
66–80	1411 (28.5)	1352 (95.8)	59 (4.2)	
80 >	263 (5.3)	249 (94.7)	14 (5.3)	
Sex				<.001
Female	2134 (43.1)	2118 (43.8)	16 (14.7)	
Male	2814 (56.9)	2721 (56.2)	93 (85.3)	
Smoking	1135 (22.9)	1113 (23)	22 (20.2)	.488
Diastolic dysfunction	499 (10.1)	481 (9.9)	18 (16.5)	.036
Hypertension	2623 (53)	2543 (52.6)	80 (73.4)	<.001
Diabetes	1134 (22.9)	1113 (23)	21 (19.3)	.360
Coronary artery disease	2047 (41.4)	1972 (40.8)	75 (68.8)	<.001
Hyperlipidemia	2180 (44.1)	2109 (43.6)	71 (65.1)	<.001
Creatinine	0.93 ± 0.42	0.93 ± 0.38	1.30 ± 1.12	.001

Table 2

Atrial fibrillation parameters in patients.

	All patients Mean ± SD / n (%)	AAA None (n = 4841) Mean ± SD / n (%)	AAA Present (n = 109) Mean ± SD / n (%)	P
AF parameters				
Atrial fibrillation	503 (10.2)	491 (10.1)	12 (11)	.892
Non-valvular	367 (7.4)	355 (7.3)	12 (11)	.206
Valvular	136 (2.7)	136 (2.8)	-	.046
CHA_2DS_2-VASc score				
All patients	3.35 ± 1.7	1.71 ± 3.08	1.51 ± 3.34	.594
Patients with atrial fibrillation	3.36 ± 1.7	3.37 ± 1.70	3.08 ± 1.51	.566

both the entire group ($P = .594$) and in the cases with atrial fibrillation ($P = .566$).

Table 3 summarized the distribution of valvular diseases in the study group and according to the presence of AAA. Comparisons revealed that the presence of mitral ring ($P = .285$), mitral valve replacement ($P = .096$), aortic valve replacement ($P = .444$), rheumatic valvular disease ($P = .596$), rheumatic valvular stenosis ($P = .985$), mitral valve prolapse ($P = .468$), and bicuspid aorta ($P = .635$) were similar between patients with and without AAA. The distributions of the other valvular abnormalities were presented in Table 3, but the statistical comparisons could not be made due to the inadequate number of cases for the analyses.

The echocardiographic parameters in the entire study population and according to AAA groups were summarized in Table 4. Comparisons between groups revealed that patients with AAA had a significantly higher frequency of abdominal aortic plaques ($P < .001$), significantly increased diameters of the aortic trunk ($P < .001$) and ascending aorta ($P < .001$), significantly thicker interventricular septum ($P < .001$) and posterior wall ($P < .001$), significantly increased end-diastolic diameter ($P < .001$) and enlarged left atrium ($P < .001$), and significantly decreased ejection fraction ($P < .001$).

According to different guidelines, the frequencies of AAA determined in the patients meeting the screening criteria were presented in Table 5. According to the Canadian Task Force on Preventive Health Care criteria, 49.5% of patients with AAA met the criteria of "men between 65–80 years of age," and 10.1% met "men older than 80 years of age". For the Canadian Society for Vascular Surgery guideline, 34.9% of cases with AAA met the criteria of "men between 65–75 years of age", 14.7% met "men between 76–80 years of age", 8.3% met "women between 65–80 years of age + smoking history", and 4.6% met "women between 65–80 years of age + coronary artery disease". According to the US Preventive Services Task Force criteria, 4.6% of cases were in the "women between 65–75 years of age" group, 34.9% were in the "men between 65–75 years of age" group, and 5.5% were in "men between 65–75 years of age + smoking history" group. The American College of Cardiology and American Heart Association criteria of "men between 65–75 years of age + smoking history" was met by 5.5% of the patients, and the European Society for Vascular Surgery criteria of "men older than 65 years of age" was met by the 59.6% of the cases. Finally, the Society for Vascular Surgery criteria of "women between 65–75 years of age" and "women older than 75 years of

Table 3

Valvular disease in patients.

	All patients Mean ± SD / n (%)	AAA None (n = 4841) Mean ± SD / n (%)	AAA Present (n = 109) Mean ± SD / n (%)	P
Valvular disease				
Mitral ring	56 (1.1)	56 (1.2)	0	.285
Mitral valve replacement	104 (2.1)	104 (2.1)	0	.096
Aortic valve replacement	111 (2.2)	108 (2.2)	3 (2.8)	.444
Rheumatic valvular disease	209 (4.2)	206 (4.3)	3 (2.8)	.596
Rheumatic valvular stenosis	92 (1.9)	90 (1.8)	2 (1.8)	.985
Rheumatic aortic stenosis	21 (0.5)	21 (0.5)	0	*
Rheumatic mitral regurgitation	112 (2.2)	110 (2.2)	2 (1.8)	*
Rheumatic aortic regurgitation	98 (1.9)	96 (1.9)	2 (1.8)	*
Mitral stenosis	11 (0.2)	11 (0.2)	0	*
Mitral regurgitation	538 (10.8)	522 (10.8)	16 (14.6)	*
Aortic stenosis	197 (3.9)	189 (3.9)	8 (7.3)	*
Aortic regurgitation	220 (4.5)	208 (4.3)	12 (11.0)	*
Mitral regurgitation in the presence of mitral valve prolapse	26 (0.6)	26 (0.6)	0	*
Mitral valve prolapse	34 (0.7)	34 (0.7)	0	.468
Bicuspid aorta	45 (0.9)	44 (0.9)	1 (0.9)	.635

* Statistical analysis is nonvalid.

Table 4

Echocardiographic assessments in patients.

	All patients Mean ± SD / n (%)	AAA None (n = 4841) Mean ± SD / n (%)	AAA Present (n = 109) Mean ± SD / n (%)	*P*
Echocardiographic parameters				
Plaques in abdominal aorta (mm^2)	926 (18.7)	840 (17.4)	86 (78.9)	<.001
Aortic trunk (cm)	3.36 ± 0.39	3.36 ± 0.39	3.70 ± 0.33	<.001
Ascending aorta (cm)	3.42 ± 0.52	3.41 ± 0.51	3.85 ± 0.61	<.001
Interventricular septum (cm)	0.96 ± 0.16	0.96 ± 0.16	1.06 ± 0.16	<.001
Posterior wall (cm)	0.88 ± 0.11	0.88 ± 0.11	0.92 ± 0.11	<.001
End diastolic diameter (cm)	4.88 ± 0.55	4.87 ± 0.55	5.16 ± 0.63	<.001
Ejection fraction (%)	56.61 ± 8.63	56.7 ± 8.55	52.52 ± 10.98	<.001
Left atrium (cm)	3.91 ± 0.6	3.9 ± 0.6	4.16 ± 0.51	<.001

age" were met by 3.7% and 4.6% of the patients with AAA, respectively.

4. Discussion

The AAA is a critical vascular abnormality that may be life-threatening if ruptured, and early detection when it is still asymptomatic may save the lives of the patients. Since it shares some common etiological factors with other cardiovascular disorders, a visit to a cardiologist may be an opportunity to evaluate the patients for the presence of AAA. During a transthoracic echocardiography session, the same probe can be used to visualize the abdominal aorta. In this study, we evaluated the feasibility of AAA screening during TTE. Based on our results, the frequency of AAA in our study population was 2.2%. In a review by Sprynger et al in 2019, the prevalence of the AAA in elderly population older than 65 years of age in the Europe was reported to decrease to 4% in the last decades, but there are still reports about that it may reach up to 8% associated with the study population's characteristics.[12–14] Our patients were recruited from our cardiology department's echocardiography laboratory, and had very heterogenous clinical backgrounds and indications for echocardiographic assessments. Thus, the relatively low frequency of AAA might be associated with this heterogeneity. Also, another significant factor associated with this relatively low frequency of AAA might be the age distribution of our patients. The guidelines on AAA screening recommend to screen the elderly patients over 65 years of age. But in our study population, the proportion of the patients younger than 60 and 65 years of age were 53.7% and 66.2%, respectively. Thus, the 2.2% frequency of the AAA in the general population is reasonable from this perspective. When we dig further and evaluated the AAA frequency according to the age groups, we found that the frequency was 3.7% among patients over 60 years of age, and 4.4% for patients over 65 years of age. These frequencies were similar to the previous reports in the literature. In our country, a literature search returned only two studies on AAA screening, which the Koc et al reported the AAA frequency as 4.6% among 239 males over 60 years of age and recruited from the family health centers, and Kilic et al reported a frequency of 3.7% among 1948 patients over 65 years of age and referred for echocardiography.[15,16]

Table 5

Distribution of patients for meeting the criteria for AAA screening by the international guidelines.

	AAA (n = 109) n (%)
Guideline / Criteria	
Canadian Task Force on Preventive Health Care	
Men between 65–80 years of age	54 (49,5)
Men older than 80 years of age	11 (10,1)
Canadian Society for Vascular Surgery	
Men between 65–75 years of age	38 (34,9)
Men between 76–80 years of age	16 (14,7)
Women between 65–80 years of age + smoking history	9 (8,3)
Women between 65–80 years of age + CAD	5 (4,6)
US Preventive Services Task Force	
Women between 65–75 years of age	4 (3,7)
Women between 65–75 years of age + smoking history	–
Men between 65–75 years of age	38 (34,9)
Men between 65–75 years of age + smoking history	6 (5,5)
American College of Cardiology and American Heart Asssociation	
Men between 65–75 years of age + smoking history	6 (5,5)
European Society for Vascular Surgery	
Men older than 65 years of age	65 (59,6)
The Society for Vascular Surgery	
Women between 65–75 years of age	4 (3,7)
Women older than 75 years of age	5 (4,6)

The main risk factor for AAA development is tobacco smoking.[17,18] Previous studies reported that the prevalence of AAA is four times higher in smokers than the non-smokers.[19] Moreover, the risk of developing AAA due to smoking was three-times higher than the other cardiovascular diseases and four times higher than the atherosclerosis diseases.[20] Nevertheless, this difference was not obvious among our patients. The proportions of smokers were similar among patients with and without AAA. The smoking status assessed in this study was questioning the current cigarette smoking at the time of the cardiovascular assessment, and we did not evaluate the smoking history in the previous short and long-term. This might also be a factor for the indifference of smoking rates in patients with and without AAA.

The other major risk factors for AAA are male sex, hypertension, and hyperlipidemia.[19,21] When these risk factors were evaluated in our patients, all found to be significantly higher in the AAA group. Moreover, other clinically relevant surrogate markers including the frequencies of coronary artery disease and diastolic dysfunction were also significantly more prevalent AAA group. These findings suggest that the established risk factors

were critically important when selecting the patients for screening.

The evidence about AAA in the literature suggests that this disorder is steadily associated with the atherosclerosis and relevant damages in the aortic wall.[22] Nevertheless, not all patients with an atherosclerotic disorder have AAA, thus, it is still under research that if atherosclerosis is an etiological factor or a surrogate during development of a systemic disease. In our study, our echocardiographic findings supported the presence of atherosclerosis in AAA patients. The proportion of patients with plaque formations in the abdominal aorta was 78.9% in the AAA group, whereas this was only 17.4% among non-AAA patients. Other echocardiographic findings were also clinically relevant with the presence of AAA, and significantly suggested a more severe cardiovascular risk in these patients. But, the presence of AAA was not associated with the valvular pathologies among our patients. The only valvular pathology that is significantly different between AAA and non-AAA cases was the valvular atrial fibrillation, but this difference was associated with the absence of valvular atrial fibrillation in AAA patients. The previous studies in the literature suggest that the atrial fibrillation is rather an outcome that develops following surgical repairs of AAA, and reported to increase the mortality risk in these patients.[23–25] In our AAA patient group, none had valvular atrial fibrillation, but 11% of the cases had non-valvular atrial fibrillation without statistically significant difference from the non-AAA cases. This suggests that atrial fibrillation is not a significant risk factor for neither development nor prognosis of the AAA.

Currently, there are several guidelines on the screening of AAA in the asymptomatic period before it is ruptured. Most widely used guidelines are published by the Canadian Task Force on Preventive Health Care, the Canadian Society for Vascular Surgery, the US Preventive Services Task Force, the American College of Cardiology and American Heart Association, the European Society for Vascular Surgery, and the Society for Vascular Surgery.[8,26–30] Based on the criteria reported by these organizations about the screening of AAA, we categorized our cases and evaluated how many of them met the reported criteria. Accordingly, mostly the criteria about screening men over 65 years of age were met in our study group, and the criteria about screening women were not adequately met by our cases. Moreover, when the history of smoking or coronary artery disease was added on to the age criteria, the proportion of patients meeting the criteria were significantly decreased. These findings suggest that age is the single and most important factor to decide the patients to be screened for AAA during TTE assessments.

This study has also some limitations. One and the most important is its single-center experience design. This may affect the sociodemographic backgrounds of patients who are admitted to our hospital. Second, the heterogeneity of the clinical background of patients may affect our findings. Third, since it is difficult for controlling all cardiovascular risk factors in the analyses, the other prognostic factors that have not been controlled may confound our outcomes. And last, absence of the long-term follow-up of these patients for the clinical outcomes is another limitation in this study. On the other hand, it has also major strengths. Our study is the largest study that evaluated the frequency of AAA in Turkish patient population, and provided most reliable estimates for further studies.

5. Conclusion

Based on the results of this study and the evidence in the literature, we concluded on that screening patients over 60 years of age who undergo a TTE for any reason would be beneficial to detect an asymptomatic AAA in Turkish population.

Author contributions

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