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High ABSI values and association with AF recurrence after AF ablation: a prospective single-center study

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Abstract. – OBJECTIVE: Studies have shown that obesity is an independent risk factor for the development of atrial fibrillation (AF). Body Mass Index (BMI) and waist circumference (WC) have become accepted indicators of obesity. However, BMI is not sufficient to locate the fat-muscle distribution pattern and the fat-muscle ratio of the body.

A Body Shape Index (ABSI) based on WC adjusted for height and weight: ABSI: WC/(BMI$^{2/3}$ x height$^{1/2}$). High ABSI is associated with higher all-cause, cardiovascular, and cancer mortality than BMI, WC, waist-to-height ratio. Our aim was to investigate ABSI score characteristics in patients undergoing RF (radiofrequency) ablation of AF.

PATIENTS AND METHODS: A total of 345 consecutive patients who underwent catheter ablation for atrial fibrillation between October 2015 and April 2019 were included in this study. Patients were followed up one month after the procedure and then every 3 months for one year. Recurrent AF was defined as an AF episode lasting longer than 30 seconds on Holter recording or ECG recording.

RESULTS: ABSI value was higher in the AF recurrence group than in the patients without recurrence (0.0908±.0119 *vs.* 0.084±0.009, *p*=0.00*). We divided the study population into quintiles according to the ABSI z-score, with the middle (third) quintile comprising those who were near the population mean ABSI. The highest percentage of patients was observed in quintile 5. Patients with AF recurrence had a higher proportion of patients in quintile 5 than patients without recurrence. 65.1% of patients with AF recurrence were in quintile 5, while only 37.6% of patients without recurrence were in quintile 5 (*p*=0.003).

CONCLUSIONS: High ABSI values indicate patients at high risk for AF. These patients should be better monitored for AF-related complications. Electrophysiologists should keep in mind that patients with high ABSI are at increased AF risk of recurrence.

Key Words:
ABSI values, Atrial fibrillation, Obesity, Body Mass Index, Waist circumference, RF ablation.

Introduction

Obesity has been shown to be associated with dyslipidemia, diabetes mellitus, and hypertension. Body mass index (BMI) and waist circumference (WC) are generally considered indicators of obesity. Nevertheless, there are many doubts about the reliability of these markers. Obesity has many different aspects, such as the distribution of fat in the body and the effects of these fat distribution patterns on metabolic parameters. BMI alone is not sufficient to locate the fat-muscle distribution pattern and the fat-muscle ratio of the body. An increase in muscle mass lowers metabolic risk, whereas an increase in fat mass increases metabolic risk. Abdominal or central fat deposition also increases the risk of premature death. Therefore, more appropriate body indices which also consider body shape have been studied to better predict metabolically compromised obesity.

Krakauer and Krakauer[1] looked at a US population sample of 14,105 adults from the National Health and Nutrition Examination Survey (NHANES, 1999-2004) with a follow-up period of 5 years on average (828 deaths). Krakauer and Krakauer[1] developed A Body Shape Index (ABSI) based on WC adjusted for height and weight: ABSI: WC/(BMI$^{2/3}$ x height$^{1/2}$). A z-score can also be calculated from the ABSI mean and standard deviation (SD) within a population, depending on the adjustment for age and sex [(ABSI-ABSI$_{mean}$)/ABSI$_{SD}$].

A high ABSI means that a person's WC is larger than would be expected given their height and weight, which corresponds to a higher concentration of body volume at the center. Scholars[2] have shown that high ABSI is associated with higher all-cause, cardiovascular, and cancer mortality than BMI, WC, and waist-to-height ratio. Grant et al[3] divided the ABSI score into quartiles: quartile 1 was the lowest and quartile 4 was the highest,

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showing that all-cause, cardiovascular, and cancer mortality increased from ABSI quartile 1 to quartile 4.

Observational studies[2,4] have described obesity as an independent risk factor for the development of AF. In the Women's Health Study, BMI was linearly associated with risk AF, with risk increasing by 4.7% with each kg/m^2. In a retrospective Korean study, Lee et al[5] demonstrated that metabolically healthy obese individuals (without diabetes, hypertension, and dyslipidemia) had a 20% increased AF risk compared to nonobese individuals, whereas metabolically unhealthy individuals had a 40% increased AF risk. Obesity leads to remodeling of the left atrium and ventricle, which is related to both activation of the renin-angiotensin-aldosterone system and enhancement of the sympathetic nervous system. Weight gain was associated with an increase in left atrial volume (LA), left atrial fibrosis, and upregulation of inflammatory markers. These restructurings in LA lead to decreased conduction velocity and an increase in conduction heterogeneity, which is accompanied by an increase in inducible and spontaneous AF. Obesity not only increases the risk of a new onset AF but also AF recurrence after catheter ablation. According to literature, obesity is associated with a 30% increased risk of AF recurrence in patients undergoing catheter ablation. In this study, we investigated ABSI score characteristics in patients undergoing RF (radiofrequency) ablation.

Patients and Methods

Study Population

A total of 345 consecutive patients who underwent catheter ablation for atrial fibrillation between October 2015 and April 2019 were included in this study. All patients were symptomatic and had paroxymal atrial fibrillation that did not respond to beta-blockers or antiarrhythmic drugs (AAD). Paroxysmal was defined as AF if it ceased spontaneously or within 7 days of treatment. Patients were excluded from the study if they had undergone catheter ablation for persistent AF, moderate-to-severe valvular heart disease, coronary revascularization (percutaneous or coronary bypass surgery), acute or chronic renal or hepatic dysfunction, or previous ablation attempts. The patients' C_2HEST, CHA_2DS_2-VASc, HAS-BLED scores were calculated. The C_2HEST score [coronary artery disease or chronic obstructive pulmonary disease (1 point each), hypertension (1 point), elderly (age ≥ 75 years, 2 points), systolic heart failure (2 points), thyroid disease (hyperthyroidism, 1 point)], CHA_2DS_2-VASc score [(congestive heart failure, hypertension, age ≥ 75 (doubled), diabetes mellitus, stroke (doubled), vascular disease, age 65 to 74 years, and female sex], HAS-BLED score [hypertension, abnormal renal/liver function, stroke, bleeding history or bleeding tendency, labile international normalized ratio (INR), elderly (age ≥ 65 years), concomitant drug/alcohol use] were calculated using the above parameters. Demographic, clinical, and laboratory characteristics of study patients were obtained from patient records. Electrocardiograms were also obtained from the entire study population. The study protocol was approved by the local Ethics Committee of the University of Health Sciences, Bursa Research and Education Hospital.

Anthropometric Measurements

Body weight was measured to the nearest kilogram using a standard analog scale. Height and waist circumference measurements were taken with a non-stretch tape measure to the nearest 0.5 cm. All these measurements were taken without shoes, sweaters and jackets. Waist circumference (WC) was measured midway between the iliac crests and rib edges with minimal breathing. Systolic and diastolic blood pressure were measured with a digital blood pressure monitor according to recommended procedures. BMI was calculated by dividing weight (kg) by height (m) squared. ABSI: WC/(BMI$^{2/3}$ x height^{½}). A z-score was calculated from the mean and standard deviation ABSI (SD), depending on the adjustment for age and sex [(ABSI-ABSI$_{mean}$)/ABSI$_{SD}$]. We divided the study population into quintiles according to the ABSI z-score, with the middle (third) quintile comprising those who were near the population mean ABSI (ABSI z-score: < -0.868: quintile 1, -0.868 and -0.272: quintile 2, -0.272 and +0.229: quintile 3, 0.229 and 0.798: quintile 4, > 0.798: quintile 5).

Echocardiography

Two-dimensional transthoracic echocardiography (Philips i33, Eindhoven, The Netherlands) was performed before the ablation procedure and three months after the ablation procedure. According to a standard examination protocol, diastolic and systolic function of the left ventricle (LV) the left atrium (LA) were examined in detail. Left ventricular ejection fraction was determined by the biplane Simpson method. Left ventricular diastolic function (LVDD) was assessed by pulsed Doppler analysis of diastolic mitral inflow and tissue Doppler imaging of the left ventricular wall at the basal segments of the lateral and septal walls. Conventional Doppler parameters and LVDD grading according to the latest guidelines were assessed, calculated, and recorded.

Electrophysiological Study and Radiofrequency Catheter Ablation Procedure

All RFCA procedures were performed by a single operator. Before the ablation procedure, patients were given detailed information about the procedure, and all patients provided written informed consent. Within 24 hours before the procedure, transesophageal echocardiography was performed to determine the structure of the interatrial septum and to exclude the presence of a possible LA thrombus. New oral anticoagulants (NOAC) and oral vitamin K antagonists were not discontinued during the periprocedural period (except for an INR value above 3 in patients treated with oral vitamin K antagonists). During ablation, midazolam and fentanyl were administered as boluses to sedate consciousness. Initially, a decapolar catheter was placed into the coronary sinus *via* the left femoral venous access. Double transseptal puncture was performed under fluoroscopic guidance. Immediately after transseptal puncture, a bolus of unfractionated heparin (UFH) was administered, and the infusion was titrated to maintain the active clotting time (ACT) at 300-350 s throughout the procedure. ACT measurements were repeated every 30 minutes. Esophageal monitoring was not performed during the ablation procedure. Procedure duration (from femoral vein puncture to catheter removal) and fluoroscopy duration were recorded. A circumferential mapping catheter (CMC, LassoTM, Biosense Webster, Johnson & Johnson, NJ, USA) was placed in the LA with an 8.5 Fr SL1 sheath. Subsequently, the contact force sensing ablation catheter (CF) (Thermocool® SmartTouch, Biosense Webster, Johnson & Johnson, NJ, USA) was inserted into the LA simultaneously with the CMC using a second 8.5 Fr SL1 long sleeve. Reconstruction and mapping of the pulmonary veins (PVs) and LA was performed through the CMC and ablation catheter using the CARTO® mapping system (Biosense Webster, Johnson & Johnson, NJ, USA). The ablation strategy consisted of pulmonary vein isolation (PVI), in which large circumferential radiofrequency lesions (RF) were created around both ipsilateral PVs, demonstrating conduction block. Circumferential lesions were created at the level of the PV-LA junction (PV antrum) using the point-by-point technique. A temperature mode with a power of 35-40 W (flow rate 17-20 mL/min) was used. A lower power of 25-30 W (flow rate, 17 mL/min) and time settings were used to avoid esophageal damage and steam pop formation at the posterior LA wall and roof area. CF data were displayed to the operator throughout the procedure. RF energy was delivered with a target CF of 10-40 g until a bipolar signal reduction of at least 70% was achieved. A successful PVI was defined as recording the entrance and exit block (bidirectional block) for the four PVs after the ablation procedure. RF Energy delivery occurred at the earliest potential registered in the carina between the superior and inferior PVs when bidirectional blockade with antral isolation was not achieved. At the end of the procedure, a waiting period of at least 20 minutes was observed to evaluate the LA-PV connections, and then bidirectional blockade was re-evaluated.

Follow-Up

After discharge, patients were followed up in the outpatient clinic one month after the procedure and then every 3 months. Follow-up of patients continued until the end of the first year after ablation. Antiarrhythmic drugs were used during the first 6 months after ablation to prevent early recurrences. The first 3 months after ablation were defined as the blanking period. A 48-hour Holter ECG was recorded at each 3-month visit. Recurrent AF was defined as an AF episode lasting longer than 30 seconds on Holter recording or ECG recording.

Statistical Analysis

All statistical analyses were performed with the SPSS 23.0 for Windows software package (IBM Corp., Armonk, NY, USA). Whether the distribution of continuous variables was normal or not was assessed with the Kolmogorov-Smirnov test. Continuous variables were expressed as mean (SD) or median (interquartile range). Categorical variables were expressed as numbers and percentages. Chi-square tests and Fisher's exact tests were used to compare categorical variables when appropriate. Comparison of continuous variables was performed using Student's *t*-test and Wilcoxon Rank sum test, respectively. A *p*-value < 0.05 was considered statistically significant.

Table I. Demographic, clinical and laboratory characteristics of the study population.

	Mean±SD
Age (years)	60.05±10.04
Gender	162 male/183 female
Weight (kg)	79.89±11.72
Height (cm)	166.43±8.71
Body Mass Index (kg/m^2)	28.93±4.44
Waist circumference (cm)	104.53±18.83
ABSI	0.085±0.010
ABSI z-score	0.30 (-5.55-12.73)
CHEST score	1 (0-5)
CHADVASC	2 (0-6)
HASBLEED	1 (0-3)
Diabetes Mellitus (number/percentage)	109/31.6%
Hypertension (number/percentage)	124/35.9%
Smoking (number/percentage)	108/31.3%
COPD (number/percentage)	20/5.8%
Stroke (number/percentage)	18/5.2%
Coronary artery disease (number/percentage)	71/20.6%
Heart Failure (number/percentage)	53/15.4%
Hypertiroidism (number/percentage)	19/5.5%
Anticoagulant drug (number/percentage)	305/88.4%
Antiarrhythmic drugs (number/percentage)	277/80.3%
Beta-blocker (number/percentage)	262/75.9%
Calcium channel blocker (number/percentage)	108/31.3%
ACEI/ARB (number/percentage)	144/41.7%

Results

385 consecutive patients (162 men, 183 women) were included in the study. The mean age of the patients was 60.05±10.04 years. 31% of the patients had diabetes mellitus, 35.9% had hypertension, and 20.6% had coronary artery disease. The mean BMI of the study participants was 28.93±4.44 kg/m^2. The mean WC was 104.53±18.83 cm. The median ABSI z-score was 0.084 (0.062-0.122). The mean ABSI z-score was 0.30 (-5.55-12.73). The demographic, clinical, and laboratory characteristics of the study population are summarized in Table I. Ablation was performed by radiofrequency catheter ablation with a 3-dimensional mapping system. The mean fluoroscopy time was 13.71±4.75 minutes. The median procedure time was 99 (55-257) minutes (Table II).

The mean left atrial volume index was 25.46±4.11, and the parasternal diameter of the left atrium in the long axis was 41.38±3.53. Echocardiographic characteristics of the study population are summarized in Table III.

Table II. Characteristics of catheter ablation in the study population.

	Mean±SD
Fluoroscopy time	13.71±4.75
Procedure time	99 (55-257)
Recurrence	63 (18.3%)

ABSI value was higher in the AF recurrence group than in the patients without recurrence (0.0908±0.0119 *vs.* 0.084±0.009, *p*=0.00*). The study population was divided into quintiles according to the ABSI z-score, with the middle (third) quintile comprising those who were near the population mean ABSI (ABSI z-score: < -0.868: quintile 1, -0.868 and -0.272: quintile 2, -0.272 and +0.229: quintile 3, 0.229 and 0.798: quintile 4, > 0.798: quintile 5). 95 patients (27.5%) were in quintile 1, 38 patients (11%) were in quintile 2, 29 patients (8.4%) were in quintile 3, 36 patients (10.4%) were in quintile 4, and 197 patients (42.6%) were in quintile 5 (Figure 1). The highest percentage of patients was observed in quintile 5. Patients with AF recurrence had a higher proportion of patients in quintile 5 than patients without recurrence (Table IV). 65.1% of patients with AF recurrence were in quintile 5, whereas only 37.6% of patients without recurrence were in quintile 5. (*p*=0.003) (Figure 2).

BMI, weight, height, and waist circumference were compared between subjects with AF recurrence and without AF recurrence. BMI, weight, and height were the same in both groups. A statistically significant difference was observed only for the WC parameter (Figure 3).

In patients with AF recurrence the C_2HEST score, HAS-BLEED score and CHA_2DS_2-VASc score were higher than the patients without recurrence (p=0.000) (Figure 4).

We compared risk scores (HAS-BLEED, C_2HEST, CHA_2DS_2-VASc) with ABSI indices. HAS-BLEED score did not correlate with ABSI mean, ABSI z-score, and ABSI z-score quintiles. The C_2HEST score did not correlate with the ABSI mean but showed a significant relationship with the ABSI z-score and the ABSI z-score quintiles (χ^2=16.45; p=0.006, χ^2=13.62; p=0.018). CHA_2DS_2-VASc score correlated with ABSI mean value (p=0.00, F=4.66) and ABSI z-score (χ^2=14.35, p=0.02) (Figure 5). However, the quintiles of the ABSI z-score were not correlated with the CHA_2DS_2-VASc score.

Table III. Echocardiographic characteristics of the study population.

	Mean±SD
Left Atrial Volume Index	25.46±4.11
PLAX Left Atrial Diameter	41.38±3.53
E/E'	10.24±2.96
Septal E'	7.82±1.93
Lateral E'	10.3±2.65
E	0.85 (0.49-1.60)
A	0.85 (0.5-1.80)
E' mean	9.06±2.05
E wave deceleration time	190 (130-440)
E/A	1.08±0.25
IVRT	69 (40-148)
IVCT	53 (14-114)
LVEDV	102.36±16.54
LVESD	48.89±13.84

Discussion

The main objective of the study was to investigate the relationship between ABSI and various anthropometric indices and AF recurrence. As far as we know, this is the first study about ABSI and AF recurrence. ABSI was proposed as a new anthropometric index by Krakauer and Krakauer[1]. BMI and other indices have been shown to be insufficiently informative to make statements about the true metabolic risk and fat-muscle distribution

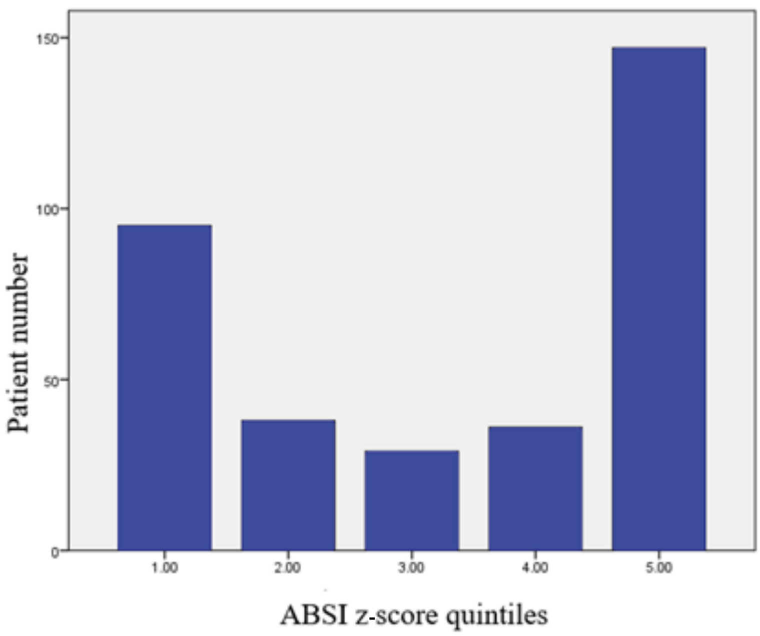


Figure 1. ABSI z-score quintiles of the study population. ABSI z-score: < -0.868: quintile 1; -0.868 and -0.272: quintile 2; -0.272 and +0.229: quintile 3; 0.229 and 0.798: quintile 4; >0.798: quintile 5. 95 patients (27.5%) were in quintile 1; 38 patients (11%) were in quintile 2; 29 patients (8.4%) were in quintile 3; 36 patients (10.4%) were in quintile 4; 197 patients (42.6%) were in quintile 5.

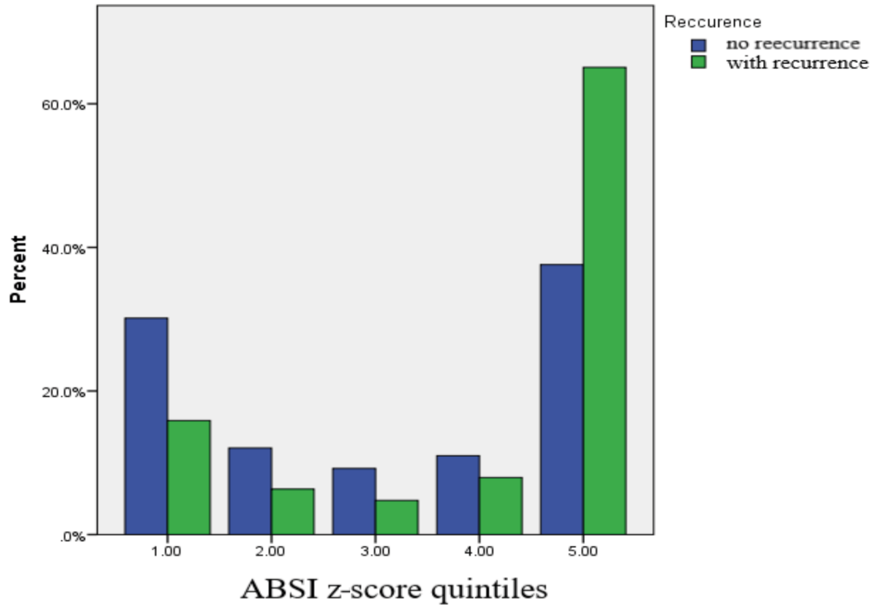


Figure 2. Distribution of patients in recurrence and no recurrence population in ABSI z-score quintiles. 65.1% of patients with AF recurrence was in quintile 5, whereas only 37.6% of patients without recurrence was in quintile 5 (p=0.003).

of the body. A high ABSI means that a person's WC is greater than would be expected given his or her height and weight, which corresponds to a higher concentration of body volume at the center, i.e., a higher accumulation of visceral fat, a higher accumulation of fat on the trunk, and a lower lean mass on the limbs. Obesity, which is a true pandemic, was found to be an independent predictor of the occurrence of AF after adjustment for traditional risk factors. Results from the Women's Heart Study[4], in which incident AF was confirmed in 2.4% of the cohort during a follow-up period of 12.9 years, showed a linear association between BMI and the risk of AF, with the risk increasing by 4.7% with each kg/m^2.

Obesity leads to left atrial and ventricular remodeling *via* several hemodynamic mechanisms. It is associated with an increase in both cardiac output and systolic blood pressure through activation of the renin-angiotensin-aldosterone system and amplification of the sympathetic nervous system. Venous return to the heart increases, leading to increased atrial and ventricular wall stretch and eventually to dilation[6-9]. In addition to its direct effects on the heart, obesity also increases numerous comorbidities such as hypertension, sleep apnea, and diabetes mellitus. The consequences of these comorbidities for the heart include increased left ventricular afterload, left ventricular hypertrophy, diastolic dysfunction, left atrial dilatation, increased sympathetic nervous system activity, and hypoxia. These changes create a vicious cycle that traps the patient for cardiovascular disease.

In our study, the mean WC was 104.53±18.83 cm. In a meta-analysis, Ural et al[10] showed that the mean value of WC in the Turkish population was 91.46 cm (95% CI: 89.39-93.53 cm). AF pa-

Table IV Distribution of patients in total population in ABSI z-score quintiles.

ABSI quintiles	Patients with recurrence (of total population)	Patients without recurrence (of total population)
Quintile 1	2.9%	24.6%
Quintile 2	1.2%	9.9%
Quintile 3	0.9%	7.5%
Quintile 4	1.4%	9.0%
Quintile 5	11.9%	30.7%

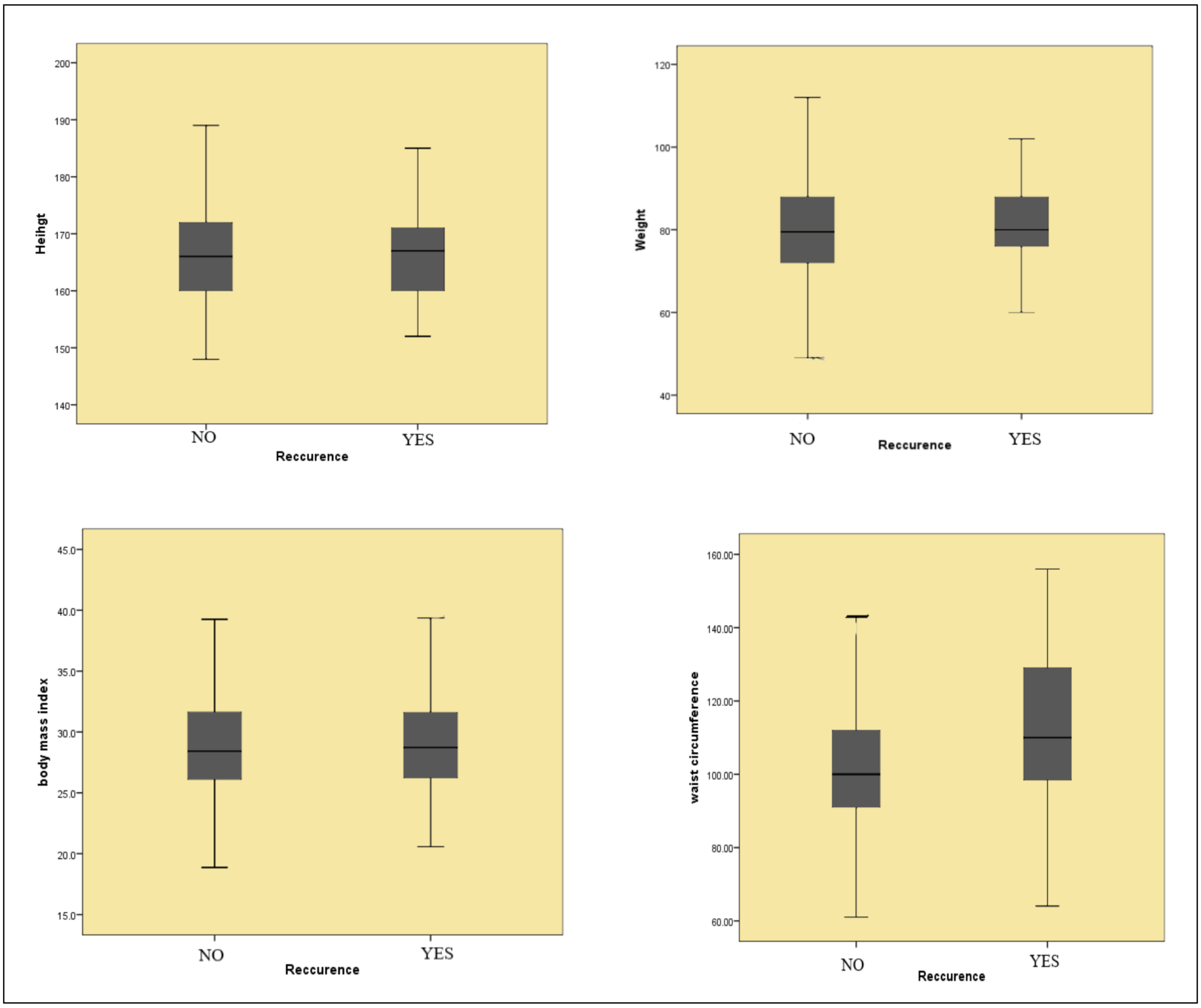
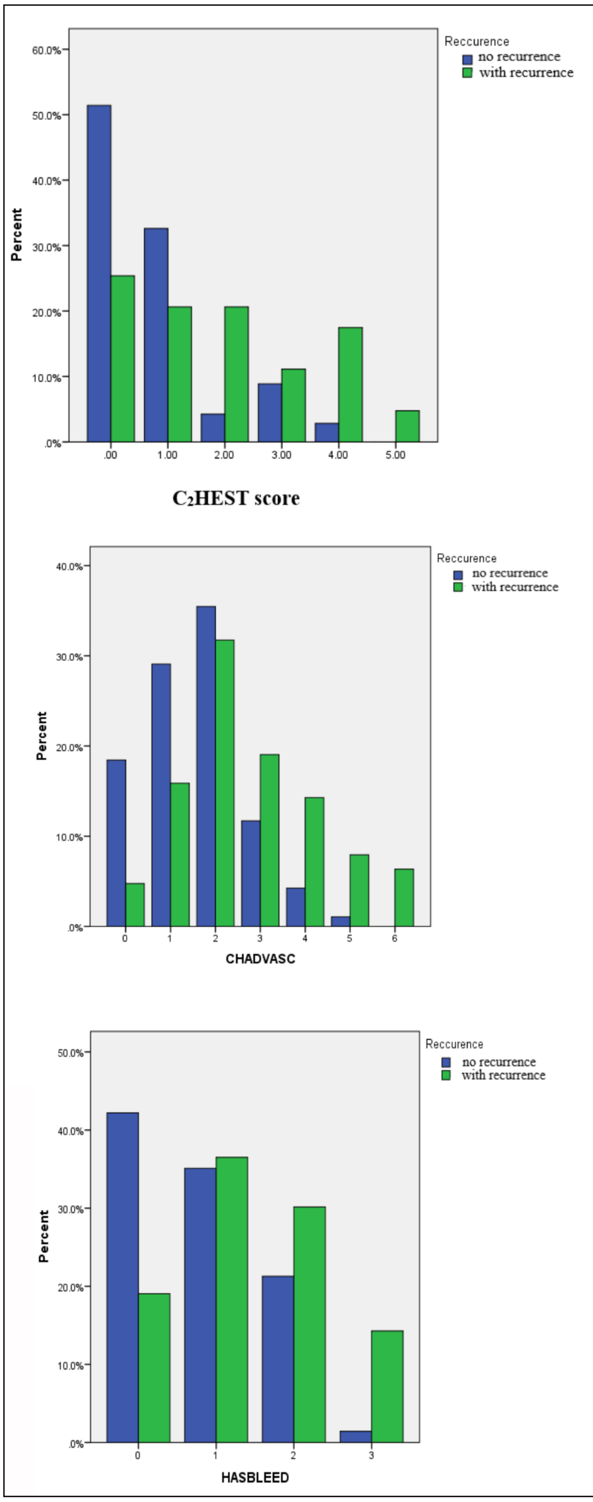


Figure 3. Mean height, weight, BMI, waist circumference values in patients with recurrence and without recurrence.

tients have a broader WC than the normal Turkish population. The median ABSI score was 0.084 (0.062-0.122). The mean ABSI z-score was 0.30 (-5.55-12.73). Regarding AF recurrence, BMI, weight, and height did not differ between subjects with and without recurrence. Only WC was higher in the recurrence group (112.79±21.31 *vs.* 102.69±17.76 cm, p=0.00*).

ABSI value was higher in the AF recurrence group than in the patients without recurrence (0.090±.0119 *vs.* 0.084±0.009, p=0.00*). Patients with AF recurrence had a higher proportion of patients in quintile 5 than patients without recurrence. 65.1% of patients with AF recurrence were in quintile 5, whereas only 37.6% of patients without recurrence were in quintile 5 (p=0.003). These findings indicate the importance of abdominal obesity and abdominal fat deposition for the recurrence of AF. Abdominal obesity and abdominal fat deposition are directly related to AF recurrence and not to increased BMI.

In patients with AF recurrence, the C_2HEST score, HAS-BLEED score, and CHA_2DS_2-VASc score were higher than in patients without recurrence (p=0.000). Patients with recurrence had characteristics of high-risk patients in terms of both thromboembolism and bleeding. We compared risk scores (HAS-BLEED, C_2HEST, CHA_2DS_2-VASc) with ABSI indices. C_2HEST score showed a significant association with the ABSI z-score and the ABSI z-score quintiles. The CHA_2DS_2-VASc score correlated with the ABSI mean and the ABSI z-score. High ABSI values indicate patients at high risk for AF. These patients should be better monitored for AF related complications. Electrophysiologists should keep in mind



		AF recurrence (% of patients with no recurrence)	Without AF recurrence (% of patients with recurrence)
C_2HEST score	0	51.4%	25.4%
	1	32.6%	20.6%
	2	4.3%	20.6%
	3	8.9%	11.1%
	4	2.8%	17.5%
	5	0	4.8%
HASBLEED score	0	42.2%	19%
	1	35.1%	36.5%
	2	21.3%	30.2%
	3	1.4%	14.3%
CHADVASc score	0	18.4%	4.8%
	1	29.1%	15.9%
	2	35.5%	31.7%
	3	11.7%	19%
	4	4.3%	14.3%
	5	1.1%	7.9%
	6	0	6.3%

Figure 4. Distribution of C_2HEST score, HASBLEED score and CHADVASc score in patients with recurrence and without recurrence.

that patients with high ABSI are at increased AF risk of recurrence.

Limitations

The results of this study must be seen in the light of some limitations. The current study is a nonrandomized study at a single center, so selection bias could occur. Patients with persistent AF were not included in this study, so the significance of the score in these patients is unknown. The distinction between paroxysmal and persistent AF was made on the basis of clinical diagnosis only.

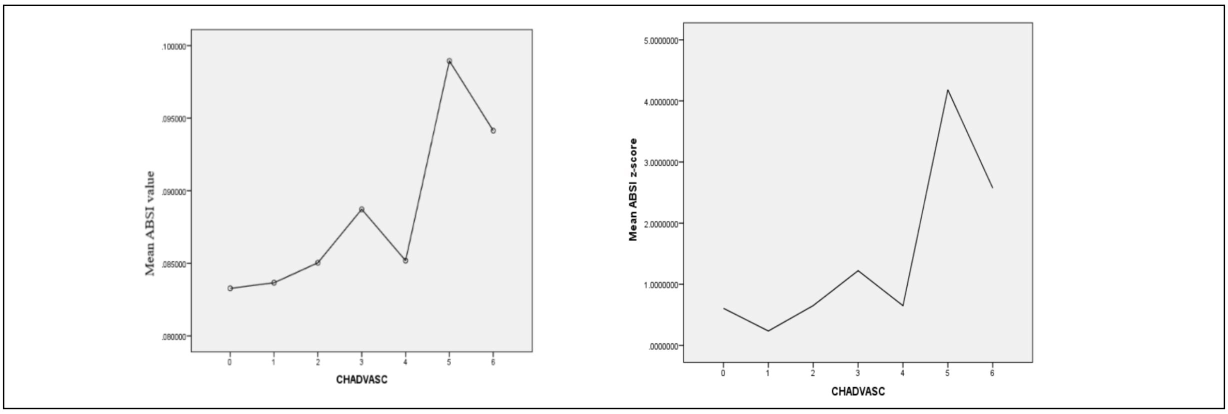


Figure 5. CHA2DS2-VASc score correlation with ABSI mean value and ABSI z-score.

No long-term rhythm recording devices, such as internal loop recorders, were used during follow-up. Therefore, the recurrence of AF may have been underestimated.

Conclusions

As for AF recurrence, BMI, weight, and height did not differ between subjects with and without recurrence. Only WC was higher in the recurrence group. The ABSI value was higher in the AF recurrence group than in the patients without recurrence. The percentage of patients with AF recurrence was higher in quintile 5 than in patients without recurrence. These results indicate the importance of abdominal obesity and abdominal fat deposition for AF recurrence. Abdominal obesity and abdominal fat deposition are directly related to AF recurrence and not to increased BMI.

In patients who have undergone RFCA intervention for paroxysmal AF, the ABSI value and the ABSI z-score, a simple clinical score, may be the preferred score to identify the risk of AF recurrence.

Conflicts of Interest

The authors declare that they have no conflict of interest.

Ethics Approval

The study protocol was approved by the Ethics Committee of the University of Health Sciences, Bursa Research and Education Hospital, Department of Cardiology, Turkey.

Informed Consent

Informed consent was obtained from each patient.

Authors' Contributions

Özlem Karakurt and Selçuk Kanat did the research, wrote the main text of the manuscript, and prepared the figures and tables. Both authors reviewed the manuscript, designed the study, and conducted additional analyses.

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