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Body Composition in Patients with Atrial Fibrillation

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Background: Obesity is a risk factor for cardiovascular diseases, however evidence is mainly based on body mass index (BMI) analysis. The aim of this study was to estimate body composition using bioelectrical impedance analysis (BIA) and its prognostic value in patients with atrial fibrillation (AF) during one year of follow-up.

Methods: Medical history, anthropometric and biochemical examinations, and BIA were performed in 120 inpatients with AF and 240 patients hospitalized due to other cardiovascular disorders.

Results: Compared to the control group, the patients with AF had a significantly greater body mass, BMI, excess body mass in relation to ideal body mass, larger waist circumference, higher values of BIA parameters such as fat and fat-free mass, visceral adiposity, total body water (total water content in the body), metabolic rate and age, and lower percentage of skeletal muscle mass. Higher prevalence rates of obesity and sarcopenia were observed in the patients with AF compared to the control group, and in the patients with the paroxysmal form compared to those with the permanent form of AF. In logistic regression analysis, the percentage of fat mass was associated with a higher risk of AF (odds ratio, 1.10; 95% confidence interval, 1.05-1.15; $p < 0.001$).

Conclusions: Body composition parameters were associated with the occurrence and form of AF in our study cohort. However, further studies are needed to clarify the relationships due to an imbalance in comorbidities.

Key Words: Atrial fibrillation • Bioelectrical impedance analysis • Body composition • Risk factor

INTRODUCTION

Although obesity is recognized as an important risk factor for numerous health disorders including cardiovascular diseases, overweight and mildly obese patients with atrial fibrillation (AF) have a better prognosis than lean individuals, regardless of the advancement of arrhythmogenic substrate. This phenomenon is known as the "obesity paradox".[1-6] The obesity paradox has been confirmed in several cardiovascular disorders, in patients with cancer, and in the elderly.[1] However, most studies showing the existence of the obesity paradox have been based on body mass index (BMI) measurements, even though BMI has been shown to have insufficient sensitivity to diagnose obesity and to underestimate its prevalence.[7,8] In a study by Shah and Braverman,[9] a BMI > 30 kg/m^2 was found to have sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for obesity (defined as body fat percentage > 25% for men and > 30% for women) of 51%, 75%, 81% and 70%, respectively, for men, and 35%, 100%, 100% and 35%, respectively for women. Karas et al.[7] followed 4276 patients for an average of 19 years, and found that BMI was inadequate as a determinant of AF in older adults. Moreover, Shah and Braverman suggested that body fat percentage was more significant than BMI in predicting high-risk obesity,[9] and Fenger-Grøn et al.[10] reported that lean body mass was the strongest anthropometric risk factor for AF.

These data suggest that the better prognosis of overweight and mildly obese patients compared to leaner

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individuals may be due to the improper use of BMI as a nutritional status parameter, as using BMI may lead to erroneous classification of obese patients as being normal.[4] Further, electroanatomic, profibrillatory cardiac remodeling in obese patients depends mainly on the effect of adipose tissue infiltration, the activity of adipocytokines, lipotoxicity, progress of atherosclerosis and blood perfusion in atria, changes in sympathetic nervous system activity due to coexistence of obstructive sleep apnea and insomnia, hemodynamic (greater atrial size, left ventricular hypertrophy, diastolic dysfunction) and musculoskeletal load, and an excessive secretion of myokines, which stimulates cardiac hypertrophy, fibrosis and inflammation, and obstructive sleep apnea.[2,6,11-19] These findings suggest that a more detailed analysis of adiposity, fat distribution and body composition may be more appropriate to determine the association between the prevalence of cardiac arrhythmia and nutritional status rather than BMI measurements alone. However, to date, associations between the prevalence and types of AF and body composition have only been analyzed in a few studies.[8,10,13,20] Therefore, we performed bioelectrical impedance analysis (BIA) to compare body composition between inpatients with AF and patients who required scheduled hospitalization due to stable cardiovascular conditions such as life-limiting intermittent claudication.

MATERIALS AND METHODS

Patients

This study included 120 consecutive patients hospitalized due to AF (paroxysmal, persistent or permanent). The control group, matched 1:2 by age and sex, consisted of 240 patients who required scheduled hospitalization due to life-limiting intermittent claudication or stable cardiovascular conditions (e.g. stable angina pectoris). The exclusion criteria were: history or clinical signs of inflammatory processes or neoplasm; significant decrease in body weight during the three months prior to the current hospitalization [i.e. a quotient of (100% × (usual weight – actual weight) / usual body weight) > 5%]; history of disorders affecting food intake or absorption; disturbance in eating as the cause of hospitalization; or lack of informed consent for participation in the study. Patients were recruited to the study between July 1, 2015 and December 31, 2016.

During the first day of hospitalization, a medical history was obtained from each of the inpatients enrolled in the study, and a physical examination was performed including assessments of anthropometric parameters of nutritional status. The Charlson Comorbidity Index (CCI) adjusted for age was used.[21,22] Each patient underwent electrocardiography and transthoracic echocardiography. The inclusion and exclusion criteria were checked on the basis of these data.

Biochemical determinations

Blood samples were collected from the ulnar vein of the patients between 7 am and 8 am on the day of admission while they were in a fasting state. The following biochemical determinations were performed at the hospital's diagnostic laboratory using standard methods: blood morphology, low-density lipoprotein (LDL) cholesterol, triglycerides, glucose, albumin, C-reactive protein (CRP), total lymphocyte count, thyrotropin-stimulating hormone (TSH), and NH(2)-terminal pro-brain natriuretic peptide (NT-proBNP).

Parameters of nutritional status assessment

A nutritional status assessment was performed for all of the study participants. The following parameters were measured: height (cm), body weight (kg), waist circumference (WC, cm), hip circumference (HC, cm), mid-arm circumference (MAC, cm), mid-calf circumference (MCC, cm), triceps skinfold thickness (TSF, mm), biceps skinfold thickness (BSF, mm), subscapular skinfold thickness (SST, mm), abdominal (suprailiac) skinfold thickness (AST, mm), knee height (cm), as well as the handgrip strength of the predominant and non-predominant hands (not all of the results are presented in the tables).

All circumferences were measured using tape, skinfolds with a Harpenden MG-4800 skinfold manual caliper (BATY, UK), and handgrip strength using an electronic dynamometer (Kern, Germany). Body composition was determined using BIA and a TANITA BC 420 MA device (TANITA Corporation, Japan). The following BIA parameters were analyzed: fat mass (FM; % and kg), visceral fat level (VFL, in the range 1-59, a level > 26 showing abdominal adiposity), fat-free mass (FFM, kg), predicted muscle mass (PMM, kg), which assessed both smooth

and skeletal muscle mass (SMM), SMM (%, kg), bone mass (BM, kg), total body water (TBW; % and kg), BMI (kg/m^2), basal metabolic rate (BMR, kcal), and metabolic age (MA, years).

The following secondary parameters were calculated based on the aforementioned indices:

- An "ideal weight" calculated according to the Lorentz formula: for female patients, ideal weight = [height (cm) – 100] – {[height (cm) – 150]/2}; and for male patients, ideal weight = [height (cm) – 100] – {[height (cm) – 150]/4};
- The quotient of actual (current) to ideal body mass × 100%;
- Arm muscle area (AMA) according to the following formula: AMA = [MAC – (0.314 × TSF)]^2 / (4π);
- Arm fat area (AFA) according to the following formula: AFA = (MAC^2/4π) – [MAC – (0.314 × TSF)]^2 / (4π);
- Brachial adipo-muscular ratio (BAMR) according to the following formula: BAMR = AFA / AMA;
- Percentage of skeletal muscle mass obtained from BIA in relation to body weight; the cut-off values for class I sarcopenia chosen for this study were < 37% for men and < 27.6% for women;[23-25]
- Skeletal muscle index (SMI) calculated using the formula (SMM/height^2), where SMM is the skeletal muscle mass obtained in BIA expressed in kg; the chosen cut-off values for moderate sarcopenia were ≤ 10.76 kg/ m^2 for men and ≤ 6.76 kg/m^2 for women.[21-23]

Measured outcomes

All of the parameters were obtained during hospitalization on enrollment and were analyzed and compared between groups.

During one year of follow-up after discharge, the following outcomes were assessed for both patients with AF and the controls by a physician during telephone interviews with the patients or their relatives: all-cause mortality, cardiovascular mortality, all-cause readmission, readmission due to AF, and a diagnosis of permanent AF.

Bioethics

This investigation was conducted in compliance with the Declaration of Helsinki for medical research, after receiving permission from the local Bioethical Committee (No. 389/2015). Each patient gave written consent to participate in this study.

Statistics

Statistical analysis was conducted using the statistical software STATISTICA version 13.1 (StatSoft Inc., 2017). The distribution of study variables was checked using the Shapiro-Wilk test. The results were mainly presented as the mean ± standard deviation, or number (%). The statistical significance of differences between groups was verified using the Student's t-test, Mann-Whitney U-test and chi-square test. Due to the presence of statistically significant differences in values of clinical factors between groups, multifactorial analysis was performed to adjust for potential confounding. A stepwise progressing logit estimation model was used to determine the significance of nutritional status parameters for the occurrence of AF. The independent variables used in this model were as follows: age, sex, smoking habit, diabetes mellitus, hypertension, dyslipidemia, history of coronary artery disease (CAD), past myocardial infarction (MI), history of coronary artery bypass graft (CABG) or percutaneous coronary intervention (PCI), age-adjusted CCI, blood concentration of LDL cholesterol, triglycerides, potassium, use of statins and beta-blockers, left ventricular diastolic diameter, left ventricular posterior wall thickness, interventricular septum thickness, left ventricular ejection fraction, left atrial diameter, actual body weight, actual to ideal body weight, BMI, WC, handgrip strength, AMA, FM, VFL, FFM, TBW, PMM, and skeletal muscle mass (%). The variables which remained statistically significant in the logit model were subjected to logistic regression with quasi-Newton's estimation model as independent variables. The odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated.

RESULTS

Clinical characteristics

The patients with AF had significantly lower rates of smoking, a diagnosis of CAD or past MI, PCI and CABG, and statin use than the controls (Table 1). They also had a significantly lower CCI score than the controls (Table 1). Compared to the control group, the patients with AF also had significantly lower blood concentrations of LDL cholesterol, triglycerides and potassium, higher blood

Table 1. Clinical characteristics of the study group

Parameter	Patients with atrial fibrillation (n = 120)	Control group(n = 240)	p value
Age (years)	70.4 ± 9.3	70.1 ± 9.2	0.76
Male gender (n, %)	63 (51.2)	121 (50.4)	0.89
Smoking habit (n, %)			< 0.001
Currently	13 (10.6)	71 (29.6)	
In the past	41 (33.3)	109 (45.4)	
Hypertension (n, %)	102 (83.6)	208 (86.7)	0.38
Diabetes mellitus (n, %)	43 (35.0)	95 (39.6)	0.33
Diabetes mellitus treatment (n, %)			0.03
Diet	6 (4.9)	10 (4.2)	
Tablets	30 (24.4)	46 (19.2)	
Insulin + tablets	6 (4.9)	42 (17.5)	
Family history of AF (n, %)	5 (4.1)	0	0.002
Family history of cardiovascular diseases (n, %)	40 (32.5)	80 (33.3)	0.88
Past stroke or TIA (n, %)	18 (14.6)	50 (20.8)	0.153
History of hyperthyreosis (n, %)	3 (2.4)	9 (3.8)	0.51
CAD (n, %)	30 (24.4)	114 (47.5)	< 0.001
Past myocardial infarction (n, %)	14 (11.4)	54 (22.5)	< 0.001
CABG (n, %)	4 (3.3)	26 (10.8)	0.013
PCI (n, %)	11 (8.9)	46 (19.2)	0.011
EHRA score (0, 1, 2, 3) (n, %)	17 (13.8)		
	88 (71.5)		
	18 (14.6)		
Chronic kidney disease (n, %)	29 (23.6)	52 (21.7)	0.70
CCI (score)	4.2 ± 1.9	4.9 ± 1.8	0.002
Hemoglobin (g/dl)	13.6 ± 1.6	13.3 ± 1.6	0.035
NT-proBNP (pg/ml)	2124.1 ± 2936.7	878.82 ± 1977.8	< 0.001
LDL cholesterol (mg/dl)	92.5 ± 39.1	102.45 ± 39.8	0.025
Triglycerides (mg/dl)	109.3 ± 55.1	131.05 ± 78.3	0.007
Glucose (mg/dl)	113.3 ± 3.5	119.75 ± 4.7	0.15
Potassium (mmol/l)	4.45 ± 0.40	4.57 ± 0.45	0.015
Creatinine (mg/dl)	1.0 ± 0.3	1.00 ± 0.8	0.74
Statin use (n, %)	81 (66.4)	227 (94.6)	< 0.001
ACEI use (n, %)	79 (64.2)	156 (65.0)	0.88
β-blocker use (n, %)	106 (86.2)	172 (71.7)	0.002
Left ventricular diastolic diameter (mm)	50.4 ± 6.9	47.3 ± 8.4	< 0.001
Left ventricular posterior wall thickness (mm)	11.8 ± 1.9	11.3 ± 1.9	0.013
Interventricular septum thickness (mm)	11.7 ± 1.8	11.0 ± 1.9	0.001
Left ventricular ejection fraction (%)	52.7 ± 10.9	59.4 ± 10.3	< 0.001
Left atrial diameter (mm)	46.5 ± 7.7	40.3 ± 5.8	< 0.001
Left atrial area adjusted for body surface area (cm^2/m^2) in apical four-chamber view	13.7 ± 3.1	11.2 ± 5.9	< 0.001
Left atrial volume adjusted for body area (ml/m^2) in apical four-chamber view	53.4 ± 18.5	37.9 ± 13.0	< 0.001

ACEI, angiotensin converting enzyme inhibitor; AF, atrial fibrillation; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CCI, Charlson Comorbidity Index; EHRA, European Heart Rhythm Association score of AF-related symptoms; LDL, low-density lipoprotein; NT-proBNP, NH(2)-terminal pro-brain natriuretic peptide; PCI, percutaneous coronary intervention; TIA, transient ischemic attack.

concentrations of hemoglobin and NT-proBNP, larger left atrium (diameter, area, volume) and left ventricle size (diameter, posterior wall and interventricular septum thickness), and lower ejection fraction (Table 1).

Parameters of nutritional status and body composition at the beginning of the study

The patients with AF had a significantly higher actual body mass, BMI, excess of actual body mass in relation to ideal body mass, AMA, and WC than their counterparts (Table 2). Moreover, compared to the control group, the patients with AF had higher BIA parameters, including FM, visceral adiposity score, FFM, TBW, BMR and MA, and a lower percentage of skeletal muscle mass (Table 3). Compared to the control group, the patients with AF were also more obese, both in relation to an old

Table 2. Selected anthropometric parameters of nutritional status and body composition in the study groups

Parameter	Patients with atrial fibrillation (n = 120)	Control group (n = 240)	p value
Actual body mass (kg)	84.4 ± 19.4	76.1 ± 16.0	< 0.001
Ideal body weight according to the Lorentz formula (kg)	61.5 ± 8.2	60.7 ± 7.4	0.37
Ratio of actual to ideal body weight (%)	137.7 ± 28.9	125.6 ± 23.4	< 0.001
BMI (kg/m^2)	30.2 ± 6.3	27.6 ± 5.1	< 0.001
BMI ranges according to the WHO (kg/m^2) (n, %)			< 0.001
< 18.5	3 (1.6)	5 (2.1)	
18.5-24.9	22 (18.0)	73 (29.8)	
25.0-29.9	39 (32)	100 (42.0)	
≥ 30.0	59 (48.4)	62 (26.1)	
Waist circumference (cm)	105.7 ± 14.9	101.7 ± 13.3	0.010
Handgrip strength of predominant hand (kg)	30.5 ± 34.5	27.7 ± 17.4	0.32
Triceps skinfold thickness (mm)	20.2 ± 9.9	18.5 ± 9.7	0.09
Subscapular skinfold thickness (mm)	20.6 ± 8.5	20.2 ± 8.3	0.69
Abdominal skinfold thickness (mm)	29.8 ± 10.7	32.5 ± 64.6	0.64
AMA (cm^2)	72.7 ± 20.9	68.0 ± 17.5	0.03
Brachial adipo-muscular ratio (AFA/AMA)	3.7 ± 1.4	3.5 ± 1.4	0.28

AFA, arm fat area; AMA, arm muscle area; BMI, body mass index; WHO, World Health Organization.

Table 3. Parameters of body composition following BIA for the studied patients

Parameter	Patients with atrial fibrillation (n = 120)	Control group (n = 240)	p value
FM (%)	35.7 ± 9.6	30.7 ± 9.5	< 0.001
Patients with obesity: defined as FM > 25% for males and > 35% for females (n, %)	66 (55.4)	102 (42.5)	0.025
Level of visceral adipose tissue (score, 1-59)	15.2 ± 4.7	12.5 ± 4.1	< 0.001
Patients with excess of visceral adiposity (> 26 score) (n, %)	72 (71.3)	94 (39.2)	< 0.001
Fat-free mass (kg)	55.4 ± 12.1	52.4 ± 11.6	0.035
TBW (kg)	41.6 ± 25.1	36.6 ± 8.3	0.010
Predicted muscle mass (kg)	52.7 ± 11.5	49.9 ± 10.9	0.038
Percentage of skeletal muscle mass (%)	36.4 ± 5.4	39.2 ± 5.4	< 0.001
Patients with moderate sarcopenia in relation to established cut-off values given in abbreviations (n, %)	39 (32.5)	69 (28.8)	0.47
Patients with moderate sarcopenia in relation to established cut-off values for SMI (n, %)	34 (28.3)	37 (15.4)	0.037
Bone mass (kg)	2.8 ± 0.6	2.8 ± 2.8	0.825
Metabolic age (years)	71.1 ± 11.7	64.1 ± 12.2	< 0.001
Difference between metric and metabolic age (years)	0.9 ± 12.8	-5.7 ± 11.3	< 0.001
Patients with metabolic age greater than the metric age (n, %)	53 (52.4)	63 (26.3)	< 0.001
Basal metabolic rate (kcal)	1659.4 ± 353.0	1543.9 ± 323.9	0.004

BIA, bioelectrical impedance analysis; FM, fat mass; SMI, skeletal muscle index; TBW, total body water.
Established cut-off values for % of skeletal muscle mass were: < 37% for men (relevant to class I sarcopenia for men) and < 27.6% for women; established cut-off values for SMI were: ≤ 10.76 kg/m^2 for men and ≤ 6.76 kg/m^2 for women.

definition of obesity (a BMI cut-off value of > 30 kg/m^2; Table 2) and according to the newer WHO diagnostic recommendation of a percentage of FM > 25% for males and > 35% for females (Table 3).[26] The percentage of patients with moderate sarcopenia in relation to the SMI value was significantly higher among the patients with AF than the controls. Slightly more than 44% of the patients with AF were metabolically older than their chronological age compared with just over 26% in the control group (Table 3).

Body composition and AF types

We next compared the clinical characteristics and values of BIA parameters for the patients with AF classified according to the European Society of Cardiology 2016 classification of AF.[6] Patients with a permanent form of AF had significantly higher CCI scores and greater abnormalities in echocardiographic parameters related to ejection fraction and left atrium compared to the patients with paroxysmal and persistent forms (Table 4). Significant differences between subgroups of patients classified according to AF type were also seen in relation to the BIA parameters. Compared to the patients with paroxysmal AF, those with permanent AF were less obese using a definition based on the percentage of FM and less frequently sarcopenic. Patients with permanent AF also had greater FFM, PMM and BM (Table 4).

Risk of AF and measured outcomes in multifactorial analysis

To determine the independent risk factors that could differentiate the patients with AF from the controls, we used multivariate logistic regression analysis. The results showed that of the nutritional parameters studied, the only risk factor for the occurrence of AF was the percentage of FM (OR 1.10; 95% CI 1.05-1.15; $p < 0.001$) (Table 5).

Data concerning the occurrence of measured outcomes during the one-year follow-up period were obtained for 358 (99.4%) patients. The results of the patients with and without AF were as follows: all-cause death [11 (9.2%) vs. 19 (7.9%), statistically not significant (ns)], cardiovascular death [9 (7.5%) vs. 17 (7.1%), ns]; and all-cause rehospitalization [58 (48.3%) vs. 119 (49.6%), ns]. In the AF group, AF resulted in hospitalization in 49 (40.8%) patients, and a change from the paroxysmal to the permanent type of AF in 15 (12.5%) patients.

DISCUSSION

In this study, we compared the body composition of 120 consecutive AF patients with a control group consisting of 240 patients with stable or mildly exacerbated cardiovascular disorders. We found that the patients with AF were more obese and had an abdominal distribution of fatty tissue, and a higher prevalence of moderate sarcopenia (Table 2, Table 3). Moreover, among the patients with AF, those with paroxysmal and persistent AF had greater indices of adiposity and lower lean mass than those with permanent AF (Table 4). The patients with paroxysmal AF also had a higher rate of moderate sarcopenia than those with other forms of AF, which may explain why this group also had the lowest BMR and the highest percentage of individuals whose MA was greater than their chronological age (Table 4). However, even though the control group was matched in relation to age and sex, it had higher CCI scores (Table 1) and parameters of transthoracic echocardiography, which may have affected our observations. For this reason, we performed multifactorial analysis, which showed that the percentage of FM was the only independent parameter of nutritional status determining the risk of AF (Table 5).

Our observations (Table 3) are consistent with the data reported by Fenger-Grøn et al.,[10] Azarbal et al.[12] and Frost et al.,[27] who found that fat-free body mass was the predominant anthropometric risk factor for AF. Azarbal et al.[12] and Nattel[13] also suggested that the association between lean body mass and AF mediated the well-known relationship between cardiac arrhythmia and height, linking greater atrial size, left ventricular hypertrophy and diastolic dysfunction. Besides height, the potential pathomechanisms linking fat-free mass with AF include greater skeletal muscle mass and excessive secretion of myokines, which stimulates cardiac hypertrophy, fibrosis and inflammation.[12-14,19] These data are also partially confirmed by the results of our study, in that the patients with AF also higher parameters of fat-free body mass (Table 3), left atrium and left ventri-

Table 4. Baseline characteristics and parameters of body composition following BIA in patients with atrial fibrillation in relation to the ESC 2016 classification

Parameter	Patients with paroxysmal atrial fibrillation (n = 32)	Patients with persistent atrial fibrillation (n = 60)	Patients with permanent atrial fibrillation (n = 28)	p value		
	A	B	C	A vs. B	A vs. C	B vs. C
Age (years)	69.97 ± 9.81	69.27 ± 8.84	73.27 ± 9.35	0.720	0.185	0.055
Male gender (n, %)	15 (46.9)	30 (50.0)	15 (53.6)	0.640	0.467	0.704
Smoking habit (n, %)				0.072	0.490	0.343
Currently	3 (9.4)	6 (10.0)	4 (14.3)			
In the past	8 (25.0)	25 (41.7)	8 (28.6)			
Hypertension (n, %)	26 (81.3)	52 (86.7)	24 (85.7)	0.432	0.491	0.954
Diabetes mellitus (n, %)	11 (34.4)	20 (33.3)	12 (42.9)	0.966	0.402	0.364
CCI (score)	4.12 ± 1.98	3.85 ± 1.82	5.25 ± 1.73	0.509	0.021	0.001
NT-proBNP (pg/ml)	1856.39 ± 2831.35	2111.69 ± 3230.18	2479.48 ± 2374.31	0.704	0.366	0.597
LDL cholesterol (mg/dl)	96.24 ± 34.14	93.18 ± 42.54	86.57 ± 37.35	0.724	0.295	0.483
Triglycerides (mg/dl)	123.38 ± 69.21	107.43 ± 53.52	95.50 ± 30.46	0.216	0.053	0.275
Left ventricular diastolic diameter (mm)	49.59 ± 4.63	49.98 ± 6.54	52.30 ± 9.41	0.761	0.144	0.180
Left ventricular posterior wall thickness (mm)	11.71 ± 1.73	11.30 ± 1.75	11.98 ± 1.71	0.283	0.532	0.091
Interventricular septum thickness (mm)	11.94 ± 1.69	11.54 ± 1.88	12.21 ± 2.01	0.305	0.562	0.128
Left ventricular ejection fraction (%)	58.03 ± 8.79	53.28 ± 9.85	45.11 ± 11.25	0.021	< 0.001	0.001
Left atrial diameter (mm)	44.53 ± 9.11	45.60 ± 7.16	50.96 ± 5.17	0.531	0.002	0.001
Left atrial area adjusted for body surface area (cm^2/m^2) in apical four-chamber view	12.70 ± 2.89	13.12 ± 2.14	15.94 ± 3.96	0.419	< 0.001	< 0.001
Left atrial volume adjusted for body area (ml/m^2) in apical four-chamber view	47.83 ± 15.72	49.58 ± 12.46	68.17 ± 24.57	0.556	< 0.001	< 0.001
FM (%)	37.4 ± 9.9	36.8 ± 8.0	31.3 ± 11.3	0.788	0.045	0.019
Patients with obesity; defined as FM > 25% for males and > 35% for females (n, %)	20 (71.43)	35 (70.0)	11 (47.8)	0.896	0.049	0.045
Level of visceral adipose tissue (score 1-59)	15.2 ± 4.7	15.5 ± 4.8	14.7 ± 4.4	0.801	0.716	0.523
Patients with excess of visceral adiposity (> 26 score) (n, %)	20 (71.4)	36 (72.0)	16 (69.6)	0.958	0.887	0.834
Fat-free mass (kg)	52.4 ± 11.6	54.8 ± 11.0	60.6 ± 13.8	0.381	0.026	0.057
TBW (kg)	45.7 ± 5.6	38.8 ± 8.4	42.7 ± 9.9	0.355	0.035	0.092
Predicted muscle mass (kg)	49.8 ± 11.1	52.0 ± 10.5	57.6 ± 13.1	0.380	0.026	0.057
Percentage of skeletal muscle mass (%)	35.6 ± 5.5	35.8 ± 4.5	38.9 ± 6.4	0.843	0.054	0.021
Patients with sarcopenia in relation to established cut-off values given in abbreviations (n, %)	14 (43.8)	20 (33.3)	5 (17.8)	0.587	0.031	0.125
Patients with sarcopenia in relation to established cut-off values for SMI given in abbreviations (n, %)	13 (40.6)	17 (28.3)	4 (14.3)	0.231	0.024	0.151
Metabolic age (years)	72.1 ± 11.6	72.0 ± 11.2	68.0 ± 12.8	0.991	0.244	0.179
Difference between metric and metabolic age (years)	0.68 ± 12.7	2.8 ± 12.4	-2.9 ± 13.3	0.472	0.322	0.075
Patients with metabolic age greater than metric (n, %)	15 (53.6)	30 (60.0)	8 (34.8)	0.587	0.187	0.046
Basal metabolic rate (kcal)	1577.5 ± 333.7	1642.7 ± 318.4	1795.6 ± 415.0	0.397	0.043	0.088

BIA, bioelectrical impedance analysis; CCI, Charlson Comorbidity Index; ESC, European Society of Cardiology; FM, fat mass; LDL, low-density lipoprotein; NT-proBNP, NH(2)-terminal pro-brain natriuretic peptide; SMI, skeletal muscle index; TBW, total body water. Established cut-off values for % of skeletal muscle mass were: < 37% for men (relevant to class I sarcopenia for men) and < 27.6% for women; established cut-off values for SMI were: ≤ 10.76 kg/m^2 for men and ≤ 6.76 kg/m^2 for women.

Table 5. Factors affecting the risk of atrial fibrillation occurrence in a logistic regression analysis among all studied patients (Chi^2 = 33.7 p < 0.001)

Risk factor	Estimation	Standard error	OR; 95%CI	p value
Constant	-3.42	2.28	0.03; 0.00-2.93	0.14
Statins use	-2.00	0.50	0.14; 0.05-0.36	< 0.001
Smoking habit	0.66	0.19	1.93; 1.32-2.83	< 0.001
Past myocardial infarction	1.34	0.51	3.82; 1.41-10.33	0.008
CCI	0.26	0.10	1.30; 1.08-1.57	0.005
Fat mass (%)	0.10	0.023	1.10; 1.05-1.15	< 0.001
Left atrium diameter (mm)	0.13	0.03	1.14; 1.07-1.22	< 0.001
Left ventricular ejection fraction (%)	-0.07	0.02	0.93; 0.89-0.97	0.005

CCI, Charlson Comorbidity Index; CI, confidence interval; OR, odds ratio.

cle size, and hypertrophy (Table 1). Moreover, the patients with the permanent type of AF, being a more advanced phase of atrial arrhythmia, had greater left atrial size and fat-free body mass than their counterparts with the non-permanent form of arrhythmia (Table 4). However, in the logistic regression analysis, the percentage of FM but not FFM reached statistical significance as a risk factor for AF (Table 5). Nevertheless, this observation also corroborates current opinions recognizing obesity as a risk factor for AF.[1-3] The associations between AF and obesity can be explained by profibrillatory hemodynamics, and the musculoskeletal and lipotoxic effects of adipose tissue.[13]

As with most studies, there are several limitations which may have affected the interpretation of our observations. The greatest limitation of our study is the imbalance of confounding factors between the study groups, expressed mainly by a slightly higher CCI score and lower values of echocardiographic parameters in the control group (Table 1). It is known that comorbidities can negatively affect nutritional status, risk of AF, and prognosis.[27-29] Therefore, this may also explain the observed differences in body composition between the AF patients and controls (Table 1), and among the patients with the paroxysmal, persistent and permanent forms of AF (Table 4). On the other hand, apart from a family history of AF, greater NT-proBNP blood concentration and greater left atrium diameter, our patients with AF had no causes of cardiac arrhythmia other than being overweight and obese. There were no significant differences in the clinical characteristics recognized as risk factors for cardiac arrhythmia compared to the control group, and they even had a lower prevalence of CAD, brain ischemia and peripheral artery disease, as well as lower blood lipid concentrations. The independent effect of FM on the risk of AF was confirmed in logistic regression analysis.

CONCLUSIONS

Our study suggests the association of body composition with the occurrence and forms of AF. This is supported by the higher fat and fat-free mass, abdominal distribution of adipose tissue, and higher prevalence of sarcopenia in the patients with AF compared to those with non-arrhythmic cardiovascular disorders, as well as by the higher prevalence of obesity and sarcopenia in the patients with the paroxysmal form than in those with the permanent form of AF. Further, long-term prospective studies are needed to determine the importance of various BIA parameters and endocrine function of adipose tissue and skeletal muscles on the occurrence of AF and prognosis in patients with this arrhythmia.

CONFLICT OF INTEREST

The authors report no conflicts of interest.

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