

Original Article

Echocardiographic and Clinical Determinants of Atrial Fibrillation in Patients With Cardiovascular Disease: A Retrospective Study

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ABSTRACT

Background: Atrial fibrillation (AF) is the most common cardiac arrhythmia, affecting millions of individuals worldwide. This study aimed to evaluate the epidemiological, clinical, and echocardiographic characteristics of patients with AF in a regional population.

Methods: In this retrospective study, 652 patients admitted to a tertiary cardiac center were divided into AF and non-AF groups. Demographic and clinical data were collected. Transthoracic echocardiography was performed by a cardiologist. The 2 groups were compared to establish associations and potential predictor factors for AF.

Results: Each of the 2 groups consisted of 326 patients. Significant differences were observed between the 2 groups in terms of ejection fraction ($P = .001$), LA enlargement ($P = .001$), mitral regurgitation ($P = .001$), tricuspid regurgitation ($P = .001$), and pulmonary artery hypertension ($P = .001$). The univariable logistic regression model revealed a significant association between AF and hypertension (OR, 1.429; 95% CI, 1.050 to 1.945; $P = .023$), heart failure (OR, 1.494; 95% CI, 1.049 to 2.128; $P = .026$), reduced ejection fraction (OR, 2.276; 95% CI, 1.490 to 3.476; $P = .001$), and left atrial enlargement (OR, 3.751; 95% CI, 2.559 to 5.499; $P = .001$). The multivariable logistic regression model revealed a significant association between AF and hypertension (OR, 1.574; 95% CI, 1.047 to 2.367; $P = .029$) and left atrial enlargement (OR, 2.080; 95% CI, 1.327 to 3.261; $P = .001$).

Conclusions: This study revealed significant associations between atrial fibrillation and clinical and echocardiographic factors, especially hypertension and left atrial enlargement. (*Iranian Heart Journal 2026; 27(4): 16-24*)

KEYWORDS: atrial fibrillation; echocardiography; arrhythmias; heart atria

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Atrial fibrillation (AF) is the most common cardiac arrhythmia worldwide. The incidence and prevalence of AF have increased during the past 2 decades; in the coming years, it will become one of the greatest public health challenges, especially in countries with moderate sociodemographic indices.¹ A global burden of disease study revealed that the worldwide prevalence of AF increased from 33.5 million individuals in 2010 to 59 million individuals in 2019.^{2,3} The true prevalence of AF might be even greater since many cases of AF are asymptomatic, and a diagnosis is often made only when symptoms or complications occur. AF complications, such as stroke, can result in a substantial economic burden.⁴

AF is a multifactorial condition that commonly occurs alongside other cardiovascular diseases, as the risk factors for AF and these diseases are mostly shared.⁵ Both the incidence and prevalence of AF are age-dependent; considering the increasing age structure of many societies, the incidence of AF is rapidly increasing worldwide.⁶ Comorbidities can influence the progression of AF. Previous studies have shown that a lack of comorbidities can reduce the AF progression rate from 5% per year to 1% to 2% per year.⁷ AF has been shown to increase the lifetime risk of heart failure, and heart failure can similarly increase the incidence of AF, increasing the consequent mortality rate.⁸ Hypertension, older age, male sex, sedentary lifestyle, smoking, obesity, diabetes mellitus, and obstructive sleep apnea are among the mentioned risk factors for AF.⁹⁻¹¹ These conditions exert their effects through atrial structural and electrical alterations, inflammation, hypoxia, and metabolic changes.^{9,10}

Previous studies have shown variations in AF incidence across different ethnicities, indicating that White individuals present a greater risk of AF than Asian, Black, and Hispanic individuals.^{12, 13} Among White

individuals, the lifetime risk of AF for those older than 45 years is estimated to be 1 in 3, whereas among Black and Asian individuals, lower rates of 1 in 5 to 1 in 10 have been reported.¹⁴

Considering these differences worldwide, targeted studies are needed to clearly image AF in different regions. Since revealing the current epidemiological and clinical status of AF in different regions can help design targeted preventive approaches, we aimed to investigate the epidemiology and potential risk factors for AF in our region.

METHODS

Characteristics of the Study

This retrospective study was conducted at the Mazandaran Heart Center, Sari, Iran, which is affiliated with Mazandaran University of Medical Sciences. This tertiary center is the only specialized heart center in Mazandaran Province. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Mazandaran University of Medical Sciences (IR.MAZUMS.REC.1402.710).

Study Participants

The medical records of participants diagnosed with AF were retrieved from the date that the hospital started electronically registering patient diagnoses. The records of all participants diagnosed with AF between March 21, 2023, and April 8, 2024, were reviewed. AF diagnosis was based on 12-lead electrocardiography (ECG) via the following criteria¹⁵: (1) irregular R-R intervals (when atrioventricular conduction is present), (2) absence of distinct P waves, and (3) irregular atrial fibrillatory waves. Eligible participants were aged 18 years or older, were diagnosed with AF on the basis of ECG findings, and were admitted to the emergency department or hospital wards. Regarding the control

group, for every participant diagnosed with AF, an admitted cardiovascular participant without AF, with the same sex and within a 5-year age gap, was randomly selected. The exclusion criteria for participants were atrial flutter or other supraventricular arrhythmias, uninterpretable ECG, myocardial infarction, recent cardiothoracic surgery, and indefinite or unconfirmed diagnosis.

Clinical Variable Definitions

Hypertension was defined as a blood pressure of 140/90 mm Hg or greater or the use of blood pressure-lowering medications.¹⁶ Diabetes mellitus was defined as a fasting plasma glucose level of 126 mg/dL or greater or a glycated hemoglobin (HbA1c) level of 6.5% or greater.¹⁷ Hyperlipidemia was considered a total cholesterol level above 240 mg/dL, LDL above 160 mg/dL, or triglycerides above 200 mg/dL.¹⁸ In addition, if the participant was receiving pharmacologic treatment for these conditions or the answer to the question "Have you ever been told by a doctor or other health professional that you have hypertension, diabetes, or hyperlipidemia?" was "yes," they were classified as having the respective disease.

Echocardiographic Variable Definitions

Transthoracic echocardiography was performed by a cardiologist, and the left ventricular ejection fraction (LVEF) was calculated as the end-diastolic volume minus the end-systolic volume divided by the end-diastolic volume from biplane apical 2-chamber and 4-chamber views.¹⁹ The severity of mitral regurgitation and tricuspid regurgitation was classified according to the European Association of Echocardiography recommendations.²⁰ A pulmonary artery systolic pressure of greater than 30 mm Hg was considered pulmonary artery hypertension.²¹ LV hypertrophy was defined as an LV mass index greater than 115 g/m² for a man and 95 g/m² for a woman.²² LV

enlargement was defined as a ventricular end-diastolic diameter greater than 5.8 cm in men or greater than 5.2 cm in women.²³ Left atrial (LA) enlargement was defined as an LA diameter of 4.1 cm or greater in men and 3.9 cm or greater in women.²⁴

Data Collection

Demographic data, including age, sex, residential status, and comorbidities such as hypertension, diabetes mellitus, hyperlipidemia, and heart failure, were extracted from all participant records. A cardiologist performed transthoracic echocardiography after admission, and the ejection fraction, valvular regurgitation, and left chamber diameters were assessed. Laboratory measures for sodium, potassium, blood urea nitrogen, and creatinine were also obtained from blood samples.

Statistical Analysis

The collected data were imported into SPSS version 23 (IBM Corporation, Armonk, NY) software and recoded for analysis. The median (IQR) was used to describe age, and the mean (SD) was employed to describe body mass index (BMI), LVEF, and laboratory values. The frequency and percentage were calculated for categorical variables. The χ^2 test was used to compare categorical variables. Given that the distribution of the continuous variables was not normal, the Mann-Whitney *U* test was used to assess the relationships between continuous and categorical variables. Univariable and multivariable logistic regression using the Enter method were also performed to evaluate the odds ratios of potential risk factors for AF. A *P* value of .05 or less was considered significant.

RESULTS

The present study included 652 patients admitted with cardiovascular complaints, 326 of whom were diagnosed with AF and 326

matched cardiovascular patients without AF. The mean (SD) age of the patients was 63.26 (16.51) years, with a range of 20 to 99 years. Fifty-four percent of the participants were male. The mean (SD) BMI was 27.63 (4.73) in the AF group and 26.91 (3.99) in the non-AF group. The 2 groups did not differ in age or sex because these variables were matched during the sampling process ($P = .507$ and $P = 1.00$, respectively) (Table 1). Hypertension ($P = .02$), heart failure ($P = .03$), and BMI ($P = .03$) differed significantly between the groups, with higher prevalence in the AF group. The non-AF group had a greater percentage of smokers and patients with a history of malignancy ($P = .03$ and $P = .02$, respectively).

The echocardiographic findings of the 2 groups are summarized in Table 2. The groups differed significantly in ejection fraction ($P = .001$), LA enlargement ($P = .001$), mitral regurgitation ($P = .001$), tricuspid regurgitation ($P = .001$), and pulmonary artery hypertension ($P = .001$). The AF group included more patients with ejection fractions lower than 40%, LA enlargement, pulmonary

artery hypertension, and mild-to-moderate to severe mitral and tricuspid regurgitation.

The laboratory findings did not differ significantly between the 2 groups in serum sodium level ($P = .23$), blood urea nitrogen ($P = .14$), or serum creatinine ($P = .25$) (Table 3). However, the serum potassium level was greater in the non-AF group ($P = .005$).

Table 4 shows the univariable and multivariable regression models for potential risk factors for AF. The univariable logistic regression model revealed significant associations between AF and hypertension (OR, 1.429; 95% CI, 1.050 to 1.945; $P = .02$), heart failure (OR, 1.494; 95% CI, 1.049 to 2.128; $P = .03$), reduced EF (OR, 2.276; 95% CI, 1.490 to 3.476; $P = .001$), and LA enlargement (OR, 3.751; 95% CI, 2.559 to 5.499; $P = .001$). Mild-to-moderate to severe mitral and tricuspid regurgitation also were significantly associated with AF. The multivariable logistic regression model revealed significant associations between AF and hypertension (OR, 1.574; 95% CI, 1.047 to 2.367; $P = .03$) and LA enlargement (OR, 2.080; 95% CI, 1.327 to 3.261; $P = .001$).

Table 1. Demographic Characteristics and Medical History of Patients Stratified by AF Status

Variable	AF Patients (No. = 326)	Non-AF Patients (No. = 326)	<i>P</i>
Age, median (IQR), y	67.00 [51 – 76]	62.50 [51 – 74]	.507**
Sex, No. (%)			1.00*
Male	176 (54.0)	176 (54.0)	
Female	150 (46.0)	150 (46.0)	
Residence Status, No. (%)			.080*
Urban	204 (62.6)	182 (55.8)	
Rural	122 (37.4)	144 (44.2)	
Body mass index, mean (SD)	27.63 (4.73)	26.91 (3.99)	.028**
Hypertension, No. (%)	180 (55.2)	151 (46.3)	.023*
Diabetes, No. (%)	75 (23.0)	81 (24.8)	.582*
Hyperlipidemia, No. (%)	103 (31.6)	124 (38.0)	.084*
Heart failure, No. (%)	97 (29.8)	72 (22.1)	.025*
Smoker, No. (%)	26 (8.0)	43 (13.2)	.030*
Opium consumption, No. (%)	22 (6.7)	33 (10.1)	.121*
History of stroke, No. (%)	15 (4.6)	9 (2.8)	.212*
History of thyroid disease, No. (%)	29 (8.9)	39 (12.0)	.200*
History of malignancy, No. (%)	5 (1.5)	16 (4.9)	.015*

* χ^2 test ** Mann–Whitney *U* test

AF: atrial fibrillation

Table 2. Echocardiographic Findings of Patients Stratified by AF Status

Variable	AF Patients	Non-AF Patients	P
LVEF, mean (SD), %	44.58 (12.44)	46.20 (8.21)	.260 **
LVEF, No. (%)			.001*
EF <40%	82 (25.6)	38 (13.1)	
EF 40%–49%	54 (16.9)	103 (35.6)	
EF ≥50%	184 (57.5)	148 (51.2)	
LV enlargement, No. (%)	131 (48.0)	128 (50.0)	.643*
LA enlargement, No. (%)	145 (53.3)	56 (23.3)	.001*
MR, No. (%)			.001*
No/Trace	22 (7.5)	35 (13.2)	
Mild	95 (32.5)	134 (50.6)	
Mild to moderate/moderate	104 (35.6)	70 (26.4)	
Moderate to severe/severe	71 (24.3)	26 (9.8)	
TR, No. (%)			.001*
No/trace	32 (11.4)	62 (24.2)	
Mild	100 (35.7)	125 (48.8)	
Mild to moderate/moderate	91 (32.5)	50 (19.5)	
Moderate to severe/severe	57 (20.4)	19 (7.4)	
PAH	94 (56.3)	33 (32.7)	.001*
LVH	76 (23.3)	61 (18.7)	.149*

* χ^2 test ** Mann–Whitney U test

AF: atrial fibrillation; EF: ejection fraction; LV: left ventricle; LA: left Atrium; MR: mitral regurgitation; TR: tricuspid regurgitation; PAH: pulmonary artery hypertension; LVH: Left ventricular hypertrophy

Table 3. Laboratory Findings of Patients Stratified by Atrial Fibrillation Status

Variable	AF Patients	Non-AF Patients	P
Sodium, mean (SD), mEq/L	140.16 (3.69)	140.60 (4.38)	.230**
Potassium, mean (SD), mEq/L	4.24 (0.44)	4.33 (0.38)	.005**
Blood urea nitrogen, mean (SD), mg/dL	21.21 (11.15)	19.10 (6.53)	.143**
Creatinine, mean (SD), mg/dL	1.17 (0.77)	1.12 (0.35)	.252**

** Mann–Whitney U test

Table 4. Logistic Regression Analysis of Potential Risk Factors for Atrial Fibrillation

Variable	Univariable			Multivariable		
	OR	95% CI	P	OR	95% CI	P
Hypertension						
Yes	1.429	1.050-1.945	.023	1.574	1.047-2.367	.029
No	Reference	Reference	Reference	Reference	Reference	Reference
Heart Failure						
Yes	1.494	1.049-2.128	.026	0.473	0.212-1.053	.067
No	Reference	Reference	Reference	Reference	Reference	Reference
Body Mass Index						
≥30	1.404	0.925-2.130	.111	1.264	0.736-2.171	.397
25–29.9	0.990	0.688-1.425	.956	1.081	0.675-1.730	.747
<25	Reference	Reference	Reference	Reference	Reference	Reference
Ejection Fraction						
<40	2.276	1.490-3.476	.001	2.204	0.897-5.416	.085
≥40	Reference	Reference	Reference	Reference	Reference	Reference
Left Atrial Enlargement						
Yes	3.751	2.559-5.499	.001	2.080	1.327-3.261	.001
No	Reference	Reference	Reference	Reference	Reference	Reference
Mitral Regurgitation						

Moderate to severe/severe	4.344	2.163-8.725	.001	1.958	0.699-5.487	.201
Mild to moderate/moderate	2.364	1.280-4.365	.006	1.791	0.770-4.166	.176
Mild	1.128	0.622-2.044	.692	0.840	0.383-1.843	.664
No/trace	Reference	Reference	Reference	Reference	Reference	Reference
Tricuspid Regurgitation						
Moderate to severe/severe	5.812	2.968-11.382	.001	2.066	0.818-5.214	.125
Mild to moderate/moderate	3.526	2.037-6.104	.001	1.615	0.777-3.356	.199
Mild	1.550	0.939-2.558	.087	1.196	0.640-2.236	.575
No/trace	Reference	Reference	Reference	Reference	Reference	Reference

DISCUSSION

The current study investigated cardiovascular patients admitted with or without AF and their clinical and paraclinical features at admission. The findings revealed associations between AF and several conditions, including higher frequencies of hypertension, heart failure, LA enlargement, pulmonary artery hypertension, and mitral and tricuspid regurgitation. Patients with AF were also more likely to have a higher BMI and reduced ejection fraction on echocardiography.

Hypertension has been associated with AF in numerous studies. One explanation is that AF and hypertension share risk factors that influence the incidence of both conditions.²⁵ Compared with normotensive individuals, hypertensive individuals were shown to have a 1.7-fold greater risk of AF, and 1 in 6 cases of AF were attributed to hypertension.²⁶ Several mechanisms have been proposed as possible pathways for increased AF incidence in patients with hypertension. One reported mechanism is atrial cardiomyopathy, which results in structural, contractile, and electrophysiologic changes.²⁷

Heart failure with either reduced EF or preserved EF has been associated with the development of AF in previous studies.²⁸ Regarding the temporal relationship between AF and heart failure, the Framingham Heart Study reported that, among 382 participants who developed both heart failure and AF between 1948 and 1995, 41% developed

heart failure first, 38% developed AF first, and the remaining 21% were diagnosed with both conditions simultaneously.²⁹ The proposed mechanisms linking AF and heart failure include neurohormonal hyperactivation, electrophysiologic remodeling, and fibrosis.^{30, 31}

Our findings are consistent with those of numerous studies regarding LA enlargement and the risk of AF. A retrospective cohort study of 1655 participants aged 65 years or older in the United States reported that a 30% larger LA volume was associated with a 43% greater risk of AF.³² Another retrospective study in Japan also reported associations between LA enlargement, LV indices, and AF incidence.³³ AF can itself result in atrial remodeling over time, creating a cycle of AF and its predisposing conditions.³⁴ This concept makes treating AF more difficult in long-standing and persistent cases, as additional predisposing conditions develop over the course of AF. We also found an increasing association between AF and the severity of mitral and tricuspid regurgitation. AF has previously been shown to result in atrial functional mitral regurgitation by causing mitral annular dilation and LA enlargement. Nonetheless, this condition can improve with treatment of AF.^{35,36} A population-based cohort study of 691 patients with new-onset AF in the United States reported that nearly one-third of patients developed moderate or greater tricuspid regurgitation over time.³⁷ These findings are consistent with those of our study and highlight the structural changes that AF can cause in the

heart. The significant association between valvular regurgitation and AF in our study may also reflect regional or population-specific factors, such as underlying rheumatic heart disease.

In the present study, the prevalence of smoking and the serum potassium level were greater in the non-AF group, and no significant association was found for diabetes. This observation may be attributable to our inclusion criteria for the control group, which consisted of other cardiovascular patients, including those with chronic heart conditions. Although previous studies have shown associations between smoking, diabetes, and AF, these associations were reported to be weaker than those with other cardiovascular diseases.⁵

The present study has several strengths and limitations. First, the retrospective study design limits our ability to establish causality between AF and risk factors. Second, asymptomatic individuals with AF were likely not referred to or admitted to the hospital. Therefore, these cases were unavailable in the hospital database for inclusion in our analysis. Because asymptomatic and undiagnosed patients constitute a large portion of patients with AF, proactive screening of high-risk individuals is encouraged. Third, the study was conducted at a single center; thus, additional multicenter studies are recommended to validate these results and assess their generalizability. The strengths of this study include comprehensive data collection focused on modifiable risk factors and providing insight into AF in our specific region.

CONCLUSIONS

The present study highlights the associations between AF and key clinical and echocardiographic predictors, including hypertension, heart failure, LA enlargement, and valvular regurgitation. Based on these

findings, targeted screening and preventative strategies are needed to address modifiable risk factors. Future prospective and multicenter studies are recommended to validate and explore additional predictors and the role of early interventions.

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Conflict of Interest

The authors declare that they have no competing interests. This study was supported by Mazandaran University of Medical Sciences, Sari, Iran.

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