



Increased EHRA score predicts atrial fibrillation recurrence in paroxysmal atrial fibrillation patients undergoing cryoablation

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Abstract

ARTICLE INFO

Keywords:

Paroxysmal atrial fibrillation
Cryoablation
EHRA score
Atrial fibrillation recurrence

Received: Nov 19, 2023

Accepted: Feb 12, 2024

Available Online: 27.02.2024

DOI:

[10.5455/annalsmedres.2023.11.299](https://doi.org/10.5455/annalsmedres.2023.11.299)

Aim: Atrial fibrillation (AF) recurrence occurs in 20-30% of patients despite cryoablation treatment. We aimed to investigate the importance of CHA₂DS₂-VASc, TIMI-AF, ATRIA, HASBLED and EHRA scoring systems in identifying patients with late-stage AF recurrence in patients who received cryoablation due to paroxysmal AF (PAF).

Materials and Methods: This cross-sectional study included 300 patients who received cryoablation because of PAF. EHRA, CHA₂DS₂-VASc, TIMI AF, ATRIA and HASBLED scores used in the clinic were calculated for AF burden, stroke and bleeding risk in patients. AF recurrence was defined as detection of AF in 12-lead electrocardiography or observation of AF attack for at least 30 seconds in Holter ECG recording. Patients were divided into 2 groups as patients with and without AF recurrence.

Results: In the follow-up of patients who underwent cryoablation due to PAF, AF recurrence was detected in 47 (16%) patients. CHA₂DS₂-VASc, ATRIA, HASBLED and EHRA scores were significantly higher in the patient group with AF recurrence ($p < 0.05$ for each). TIMI-AF score was similar between the two groups. When logistic regression analysis was performed to identify patients with AF recurrence, variables of HT (OR:3.322, 95% CI:1.659 – 6.620, $p=0.001$), BMI (OR:1.087, 95% CI:1.011 – 1.169, $p=0.024$) and EHRA scoring system (OR:3.503, 95% CI:1.680 – 7.306, $p=0.001$) were determined as independent markers for AF recurrence.

Conclusion: The results of our study showed that EHRA scoring system should be used for AF ablation decision, as well as its ability to predict AF recurrence, would be clinically useful.



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Introduction

Atrial fibrillation (AF) is a form of cardiac arrhythmia whose frequency increases with age, characterized by irregular R-R distances, in which P waves cannot be detected on electrocardiography. Catheter ablation is recommended with class 1 indication by guidelines in medically refractory AF patients [1]. After a single ablation procedure, these success rates are approximately 80% in patients with paroxysmal AF (PAF) [2, 3], and 69% in patients with persistent AF [4].

The CHA₂DS₂-VASc (congestive heart failure, hypertension, age ≥ 75 [doubled], diabetes, stroke [doubled], vascular disease, age 65–74, and sex [female]) score is an current scoring system that can give an idea about the possible risk of stroke in patients with AF and therefore the initiation

of oral anticoagulant therapy [1]. TIMI-AF (thrombolysis in myocardial infarction-atrial fibrillation) is a more updated scoring system than CHA₂DS₂-VASc that predicts clinically life-threatening bleeding, stroke and death from all causes [1]. The ATRIA (anticoagulation and risk factors in atrial fibrillation) score, is a useful risk calculation method in which proteinuria is also evaluated, unlike previous scoring systems [1]. HASBLED (hypertension, abnormal renal/liver function [1 point each], stroke, bleeding history or predisposition, labile INR, elderly [>65 years], drugs/alcohol concomitantly [1 point each]) score is a useful scoring method that predicts the risk of bleeding in patients with AF [1]. The recently recommended symptom scoring system, the modified EHRA (European Heart Rhythm Association) score, evaluates only those symptoms attributable to AF and that improve or decrease with effective rate control or restoration of sinus rhythm.

Although there are studies in the literature comparing the effects of these general scoring systems on mortality and

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morbidity after ablation in patients with AF [1, 5, 6], and there are limited data investigating the effects of AF ablation on AF recurrence in PAF patients. In a previous study performed in our clinic in a limited number of patients and evaluating AF recurrence, it was shown that increased CHA₂DS₂-VASc, HASBLED, and modified EHRA score were associated with AF recurrence in univariate analyzes [2, 3]. To the best of our knowledge, there are other studies that associate AF recurrence with CHA₂DS₂-VASc score [4, 5, 7–14] and EHRA [13–15], and HASBLED score [3, 13]. The most important reason for the lack of an independent relationship between AF scoring systems and AF recurrence may be the insufficient number of patients in the studies conducted. Therefore, we thought that the relationship between AF recurrence and these scoring systems recommended in the ESC AF guideline should be revealed with a study in which more cryoablation patients were recruited with a longer follow-up period. In this study, we planned to investigate the importance of CHA₂DS₂-VASc, TIMI-AF, ATRIA, HASBLED, and EHRA scoring systems in determining patients with AF recurrence in patients who were cryoablated due to PAF.

Materials and Methods

Patient selection

This project received institutional review board approval from University of Health Sciences Institutional Review Board and the Ethics Committee and written informed consent was obtained from the parents of each participants. This cross-sectional study included 300 patients who underwent cryoablation due to PAF. The patients included in the study were processed at Adana City Training and Research Hospital. The procedure center is the largest AF ablation facility in the region. AF was diagnosed by 12-lead superficial ECG on admission. Patients who returned to sinus rhythm spontaneously or with electrical cardioversion within 7 days were considered to have paroxysmal AF. ESC 2020 guideline recommendations were used for AF decision in patients with PAF [1]. Various comorbid conditions may negatively affect ablation success through different pathophysiological mechanisms, such as acute or end-stage liver or kidney disease, severe chronic obstructive pulmonary disease, acute coronary syndrome, malignancy, active infection in the last 2 weeks, severe aortic and mitral valve disease, Patients with a left atrium (LA) diameter >55 mm were excluded from the study. A detailed medical history was obtained and a complete physical examination was performed for all patients, after which baseline characteristics of patients such as age, gender, hypertension (HT), diabetes mellitus (DM), hyperlipidemia, current smoking status, family history of heart disease, and drug use were recorded. Electrocardiography (ECG), telecardiography, complete blood count, fasting blood glucose, uric acid, NT-proBNP, serum electrolytes, serum lipids, prothrombin time, kidney and liver function tests were performed.

Patients were stratified according to the modified EHRA score for AF-related symptoms. In addition, the CHA₂DS₂-VASc, TIMI-AF, ATRIA, and HAS-BLED scoring systems were calculated for the risk of stroke and haemorrhage risk as recommended by the ESC AF guide-

lines. The local institutional ethics committee approved the study protocol, and each participant gave written informed consent.

Statement of Human and Animal Rights

The authors under sign, certificate that the procedures and the experiments. The authors have done respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2000, as well as the national law.

Scoring systems

Modified EHRA classification was used to evaluate the symptoms observed in patients with AF. When determining the EHRA score, patients were grouped as EHRA class 1 if there is no symptom, EHRA class 2a if mildly symptomatic (normal daily activities are not affected and the patient is not disturbed by the symptoms), EHRA class 2b if mildly symptomatic (normal daily activities are not affected, but the patient is disturbed by the symptoms), EHRA class 3 if severe symptomatic and normal daily activities are affected, and EHRA class 4 if severe symptomatic and normal daily activities cannot be performed.

The CHA₂DS₂-VASc score was determined by assigning 1 point each for the presence of congestive heart failure and/or left ventricular ejection fraction (LVEF) <40%, HT, age 65 to 74 years, DM, peripheral vascular and/or coronary artery disease, and female gender. A score of 2 points was given for stroke history and age ≥75 years [1]. TIMI-AF score was determined by assigning 3 points each for age ≥75 and LVEF <30%, 2 points each for non-white race and LVEF 30-49%, and 1 points each for all other (unknown LVEF, AF on baseline ECG, previous ischemic stroke, carotid artery disease, previous myocardial infarction, DM, hemoglobin value <13 g/dL and creatinine value >110 mmol/L) parameters [1].

ATRIA score was determined by assigning 1 point each for female gender, presence of DM, heart failure, HT, proteinuria and glomerular filtration rate <45 mL/min or endstage renal failure parameters. In patients without stroke risk, 6, 5, 3, and 0 points were assigned for patients age >85 years, 75-84 years, 65-74 years and <65 years, respectively, and 9, 7, 7, and 8 points were assigned for patients with a history of stroke, respectively [5].

HASBLED score was determined by assigning 1 point to each of the following parameters HT, abnormal renal function, abnormal liver function, age >65 years, presence of stroke, blood injury, labile INR, drug and alcohol use [1].

Cryoablation procedure

All procedures were performed under sedation with midazolam. Invasive arterial blood pressure, oxygen saturation and ECG were continuously monitored throughout the procedure. Femoral venous access was obtained from the right and left femoral veins using the Seldinger technique. A 6 Fr steerable decapolar catheter (Dynamic Deca, Bard Electrophysiology, Lowell, MA, USA) was placed in the coronary sinus. Trans-septal access was provided using the modified Brockenbrough technique (BRK-1, St. Jude Medical, Minnetonka, MN, USA). An 8 Fr guided trans-septal sheath (Biosense Webster, CA, USA)

was placed in the left atrium. Heparin boluses were used to provide clotting time between 300 and 350 seconds. Thereafter, the sheath was replaced with a 12-F steerable sheath (FlexCath, Medtronic CryoCath, Minneapolis, USA). Pulmonary vein recordings were made with an Achieve (Medtronic) recording catheter. Pulmonary vein isolation was achieved with a single large (28 mm) cryoablation balloon (Arctic Front©, Medtronic CryoCath LP, Kirkland, Canada) in all patients. Occlusion was evaluated by injection of 50% diluted contrast. Two freezing cycles of 240 seconds or a single freezing cycle of 300 seconds were applied to each pulmonary vein. At the end of the procedure, the pulmonary vein conduction was reassessed with the Achieve catheter. Successful pulmonary vein isolation was defined as the elimination (or dissociation) of all pulmonary vein potentials recorded from the Achieve catheter. Direct palpation of the right hemidiaphragmatic outlet was performed during phrenic nerve stimulation.

Post-ablation assessment and definition of AF recurrence

Oral anticoagulation was initiated 6 hours after the procedure and continued at least 3 months after the procedure. The need for oral anticoagulation was also evaluated 3 months later according to the CHA₂DS₂VASc score. Antiarrhythmic drug therapy also continued for 3 months. ECG, medical history and clinical evaluations were performed during regular follow-up. Holter ECG monitoring for 48 hours was recorded at least 12 months after ablation. Patients with symptoms consistent with AF before 12 months had Holter ECG monitoring for 24 hours before. AF recurrence was defined as AF on ECG or arrhythmia lasting at least 30 seconds on Holter ECG.

Statistical analysis

Variables were divided into two groups as categorical and continuous variables. Categorical data were presented as numbers and percentages and compared using the chi-square test. Continuous variables were expressed as mean \pm SD. The normal distribution of continuous variables was evaluated using the Shapiro-Wilk test. Normally distributed continuous variables were compared with independent sample t-test, and variables not showing normal distribution were compared with Mann-Whitney U test. Binomial logistic regression analysis was performed with variables with $p < 0.05$. Independent markers were found for the development of recurrent AF. Results are expressed as p-value and odds ratio (OR) at 95% confidence interval (CI). Statistical analyzes were performed with SPSS 20.0 (SPSS Inc., Chicago, IL, USA), $p < 0.05$ was considered as statistically significant.

Results

AF recurrence was observed in 47 (16%) of 300 patients who underwent cryoablation for PAF. Patients were divided into two groups as patients with or without recurrence, and all parameters were compared. Parameters that may cause AF recurrence were determined.

Comparison of demographic and medical treatment data of patients with and without atrial fibrillation recurrence

When the demographic data were compared between the two groups, age, BMI and the frequency of HT were found to be significantly higher in the group with AF recurrence, whereas the other findings were similar (Table 1). The use of ACE inhibitors or ARBs was significantly higher in the group with AF recurrence, while there was no statistically significant difference between other drug treatments (Table 1). Laboratory data were analyzed between both groups and no significant difference was observed between the two groups (Table 1).

Comparison of risk scoring systems of patients with and without atrial fibrillation recurrence

When the scoring systems were compared between the two groups, the CHA₂DS₂-VASc score, ATRIA score, HAS-BLED score and EHRA score were significantly higher in the patient group with AF recurrence. TIMI-AF score was similar between the two groups (Table 2).

Determination of independent variables predicting patients with atrial fibrillation recurrence

In binomial logistic regression analysis performed with data that was significantly different for AF recurrence in univariate analyzes, HT, BMI, and EHRA scoring system were identified as independent markers for AF recurrence (Table 3).

The EHRA score, which indicates symptom burden with a scoring system, seems to take its place in clinical use more due to its contribution to determining the indication for ablation in symptomatic patients, as well as its association with recurrence in patients.

Discussion

To the best of our knowledge, our study is the first study in the literature that includes all current general scoring systems used in clinical practice for AF patients and recommended by the ESC AF diagnosis and treatment guidelines and investigate their effects on recurrence. We observed an AF recurrence rate of 15.7% after cryoablation performed in our clinic, and we found that the presence of HT and BMI were independent markers to predict AF recurrence. In addition, we observed that there was an independent relationship between the EHRA scoring system and AF recurrence. For every 1 unit increase in the EHRA score, the probability of recurrence increased by approximately 3.5 times. Although significantly higher values were detected in the group with AF recurrence in univariate analysis with CHA₂DS₂-VASc, TIMI-AF, ATRIA and HASBLED scores, no independent relationship was found with AF recurrence in regression analysis.

Some studies have shown that the presence of some conditions post-catheter ablation is predictive of recurrence of AF. Treatment efficacy can be predicted by considering these clinical features in patient selection. These features have been determined by studies as non-paroxysmal AF, sleep apnea, obesity, increased left atrial volume, HT, increased age and, presence of atrial fibrosis in cardiac magnetic resonance imaging (MRI) [16]. As known, HT and

Table 1. Comparison of demographic, medical treatment, and laboratory data of patients with and without atrial fibrillation recurrence.

	Patients with AF recurrence (n=47)	Patients without AF recurrence (n=253)	P value
Age (years)	58.9 ± 10.8	53.6 ± 12.5	0.008
Male sex, n (%)	20 (42.6)	140 (55.3)	0.107
Systolic blood pressure (mmHg)	125.2 ± 16.4	121.3 ± 16.6	0.297
Diastolic blood pressure (mmHg)	78.2 ± 13.1	76.7 ± 11.0	0.552
Heart rate (bpm)	77.8 ± 8.3	76.9 ± 9.9	0.332
Body mass index (kg/m ²)	29.6 ± 5.1	27.9 ± 4.1	0.042
Smoking, n (%)	4 (8.5)	38 (15.0)	0.238
Diabetes mellitus, n (%)	10 (21.3)	39 (15.4)	0.318
Hypertension, n (%)	32 (67.1)	95 (37.5)	<0.001
Hyperlipidemia, n (%)	1 (2.1)	6 (2.4)	0.919
Coronary artery disease	4 (8.5)	17 (6.7)	0.632
Excessive alcohol consumption	0 (0)	17 (6.7)	0.085
Cerebrovascular disease	2 (4.3)	3 (1.2)	0.176
ACE inhibitor or ARB (n, %)	23 (48.9)	58 (22.9)	<0.001
Calcium channel blocker (n, %)	5 (10.6)	14 (5.5)	0.187
βeta blocker (n, %)	31 (66.0)	140 (55.3)	0.177
Furosemid (n, %)	7 (14.9)	19 (7.5)	0.098
Statine (n, %)	2 (4.3)	4 (1.6)	0.229
ASA (n, %)	3 (6.4)	6 (2.4)	0.139
Warfarin (n, %)	10 (21.3)	39 (15.4)	0.318
NOAC (n, %)	14 (29.8)	63 (24.9)	0.481
Amiodarone (n, %)	6 (12.8)	18 (7.1)	0.19
White blood cells (μL)	12.6 ± 3.6	13.1 ± 3.1	0.459
Hemoglobin (mg/dl)	13.3 ± 1.2	13.5 ± 1.8	0.768
Urea (mg/dL)	29.7 ± 9.8	30.3 ± 9.5	0.728
Creatinine (mg/dL)	0.7 ± 0.2	0.8 ± 0.2	0.413
Sodium (mmol/L)	138.2 ± 3.9	138.4 ± 3.3	0.857
Potassium (mmol/L)	4.2 ± 0.5	4.2 ± 0.4	0.799
Total cholesterol (mg/dL)	193.0 ± 38.2	191.9 ± 44.5	0.888
LDL (mg/dL)	125.9 ± 36.3	130.7 ± 35.1	0.459
HDL (mg/dL)	46.5 ± 14.7	41.5 ± 10.9	0.019
Triglyceride (mg/dL)	184.9 ± 93.8	182.1 ± 107.3	0.884
Hs-CRP (mg/L)	0.4 ± 0.3	0.5 ± 0.6	0.759
Uric acid (mg/dL)	4.8 ± 1.3	5.1 ± 1.2	0.285
BNP (pg/mL)	166.3 ± 210.1	157.4 ± 271.4	0.866
TSH (uIU/dL)	1.8 ± 0.7	1.8 ± 0.6	0.97
GFR (mL/min)	109.3 ± 25.5	111.8 ± 29.9	0.715

AF, atrial fibrillation; ACE, angiotensin converting enzyme; ARB, angiotensin receptor blocker; ASA, acetylsalicylic acid; NOAC, novel oral anticoagulants; LDL, low density lipoprotein; HDL, high density lipoprotein; Hs-CRP, high sensitive-C reactive protein; BNP, brain natriuretic peptide; TSH, thyroid stimulating hormone; GFR, glomerular filtration rate.

Table 2. Comparison of scoring systems of patients with and without atrial fibrillation recurrence.

	Patients with AF recurrence (n=47)	Patients without AF recurrence (n=253)	P value
CHA ₂ DS ₂ VASc score, n	1.9 ± 1.5	1.1 ± 1.3	0.001
TIMI-AF score, n	1.8 ± 1.2	1.4 ± 1.0	0.331
ATRIA score, n	2.6 ± 2.3	1.8 ± 2.0	0.018
HASBLED score, n	1.0 ± 0.8	0.6 ± 0.9	0.009
EHRA class, n	1.9 ± 0.3	1.7 ± 0.6	<0.001

AF, atrial fibrillation; CHA₂DS₂-VASc: congestive heart failure, hypertension, age, diabetes mellitus, stroke, vascular disease, sex female; TIMI-AF: thrombolysis in myocardial infarction-atrial fibrillation; ATRIA: anticoagulation and risk factors in atrial fibrillation; HASBLED: hypertension, abnormal renal/ liver function, age, stroke, blood injury, labile INR, elderly, drugs; EHRA, European Heart Rhythm Association.

Table 3. Independent risk factors predicting atrial fibrillation recurrence.

	Odds ratio	95% Confidence interval	P value
Age	1.017	0.986 – 1.050	0.287
Hypertension	3.322	1.659 – 6.620	0.001
Body mass index	1.087	1.011 – 1.169	0.024
CHA ₂ DS ₂ VASc score	1.197	0.706 – 2.031	0.505
ATRIA score	0.804	0.615 – 1.051	0.11
HASBLED score	0.871	0.484 – 1.561	0.645
EHRA class	3.503	1.680 - 7.306	0.001

CHA₂DS₂-VASc: congestive heart failure, hypertension, age, diabetes mellitus, stroke, vascular disease, sex female; ATRIA: anticoagulation and risk factors in atrial fibrillation; HASBLED: hypertension, abnormal renal/liver function, age, stroke, blood injury, labile INR, elderly, drugs; EHRA, European Heart Rhythm Association.

obesity also play an important role in AF physiopathology [1]. In our study, in accordance with the literature, the presence of hypertension and increased BMI were found to be significantly higher in the group with AF recurrence. Many studies have been conducted on demographic, clinical, laboratory, ECG, echocardiographic, MRI parameters and scoring systems in determining recurrence after AF ablation [10–16]. In particular, scoring systems related to AF recurrence are grouped as general and specific systems. Among the general scoring systems, CHADS₂ and CHA₂DS₂-VASc have been evaluated the most [7–14]. There are data on MB-LATER [9, 17], C₂HEST [18], BASE-AF₂ [9, 10], APPLE [9], CAAP-AF [9, 19], HATCH [9, 20], AFA-Recur [21], PAT₂C₂H [22] and ALARMEc [23] from specific scoring systems. However, these scoring systems are not used in our daily practice. In our clinic, we had more than 200 case experience per year for AF ablation and a study on AF recurrence [2, 3]. All the scores highlighted and recommended in the AF diagnosis and treatment guidelines are recorded in all our patients. These are the EHRA classification and score obtained from mostly symptoms, CHA₂DS₂-VASc score, TIMI-AF score, ATRIA score and HASBLED score. Therefore, we thought it would be more appropriate to evaluate these general scores rather than using specific scores for AF recurrence. We did not find any other study in the literature evaluating these scores together in determining the AF recurrence. It has been observed that the quality of life of patients with AF is significantly lower than that of healthy people. Various symptoms such as fatigue, palpitations, shortness of breath, chest tightness, sleep disturbance and psychosocial distress are common in these patients [1]. There are significant data in the literature that the quality of life of these patients can be improved with pharmacological and ablation treatments [24, 25]. Highly reliable and comparable data have been obtained with the EHRA, which is a scoring system completely related to symptoms. As the burden of AF symptoms increases in patients, the EHRA score will also increase. While the quality of life of patients with the lowest EHRA score is equivalent to the quality of life of a healthy person and patients with multiple symptoms will also have higher EHRA scores [26]. It is clear that AF ablation therapy improves quality of

life and especially the EHRA score [27, 28]. In a limited number of studies evaluating AF recurrence in the literature, univariate analysis showed that the EHRA score was higher in patients with AF recurrence [13, 15]. It has been reported that AF recurrence is more common in EHRA class 3 patients [13]. However, in both studies, the EHRA score did not independently determine AF recurrence in multivariate analysis. In our study, the EHRA score was significantly higher in the patient group with AF recurrence. In the regression analysis, it was found to be independently associated with recurrence. Increased symptom burden in patients with high EHRA scores indicates the severity of AF. In our opinion, the high rate of AF recurrence in the patient group with severe AF burden should also be considered natural.

In many studies in the literature, including our own studies, have shown that the CHA₂DS₂-VASc score used for determining oral anticoagulant treatment indication is significantly higher in patient groups with AF recurrence [2, 3, 7, 14]. In some of these studies, the CHA₂DS₂-VASc score independently determines AF recurrence [7–9]. In a recent study by Zhou et al [7], it was reported that the CHA₂DS₂-VASc score independently determined the 1-year AF recurrence risk and CHA₂DS₂-VASc ≥ 3 could be used as a cut-off value. A similar finding showed that the CHA₂DS₂-VASc score was as effective as the specific AF recurrence score in a study including specific AF recurrence scores [9]. In another study, the importance of CHADS₂, R₂CHADS₂, and CHA₂DS₂-VASc scores in determining early AF recurrence was investigated and among these scores, it was reported that only CHA₂DS₂-VASc score was found to be independently associated with early AF recurrence [8]. A limited number of studies have shown that the HASBLED score is higher in patients with AF recurrence but does not independently determine AF recurrence [3, 13]. As far as we analyzed, ATRIA and TIMI-AF scores have not been evaluated in patients with AF recurrence, and there is no information in the literature on this subject. In our study, similar to previous studies, CHA₂DS₂-VASc, and HASBLED scores were found to be significantly higher in the recurrence group in univariate analysis. Also, ATRIA score was higher in patients with AF recurrence. However, CHA₂DS₂-VASc, ATRIA and HASBLED scores were not found as independent markers for AF recurrence in regression analysis with the addition of age, HT, and EHRA score. We think that HT and EHRA score, which are added to the multivariate logistic regression analysis, may affect the results of other scoring systems.

Limitations

The number of patients in our study is relatively low compared to similar studies. If Holter ECG recording for longer than 48 hours had been available, more AF recurrences could have been detected. We think that this situation may have caused data loss. The mean BMI was over 25 in both groups. Although BMI was not included in any scoring system, it was found to be associated independently. Scoring systems could have been compared more objectively if BMI values of the patients were within normal limits. We did not use the specific scoring systems

used for AF recurrence in our study. The most important reason for this was that these scores were preferred more in daily practice and were not used routinely in every electrophysiology or AF ablation center.

Conclusion

The results of our study showed that AF recurrence after cryoablation due to PAF was more frequent in patients with high EHRA score. It was thought that this scoring system, which is used for AF ablation decision and is mostly related with symptoms, may be clinically useful to predict AF recurrence. It was concluded that patients with high EHRA scores at initial evaluation should be followed up more closely in terms of both symptom relief and prediction of AF recurrence.

Acknowledgements

None.

Financial support

None.

Conflict of interests

The authors declare no conflict of interest.

Patient consent

Each patient provided informed consent to participate in the study.

Availability of data and material

The data that support the findings of this study are available from the corresponding author on reasonable request.

Ethical approval

This project received ethical approval from the Health Sciences University Adana Numune Training and Research Hospital Clinical Research Ethics Committee (Date: 28.03.2017, Decision no: 46). Written informed consent was obtained from the parents of each participants.

Author contributions

All authors have read and approved the manuscript and they have substantially contributed to the manuscript.

References

- Kirchhof, P., Benussi, S., Kotecha, D., Ahlsson, A., Atar, D., Casadei, B., ... Duncan, E. (2016). 2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration with EACTS. *European heart journal*, 37(38). <https://doi.org/10.1093/EURHEARTJ/EHW210>.
- Kaypakli, O., Koca, H., Şahin, D. Y., Okar, S., Karataş, F., & Koç, M. (2018). Association of P wave duration index with atrial fibrillation recurrence after cryoballoon catheter ablation. *Journal of electrocardiology*, 51(2), 182–187. <https://doi.org/10.1016/J.JELECTROCARD.2017.09.016>.
- Okar, S., Kaypakli, O., Sahin, D. Y., & Koç, M. (2018). Fibrosis Marker Soluble ST2 Predicts Atrial Fibrillation Recurrence after Cryoballoon Catheter Ablation of Nonvalvular Paroxysmal Atrial Fibrillation. *Korean circulation journal*, 48(10), 920–929. <https://doi.org/10.4070/KCJ.2018.0047>.
- Cicconte, G., Baltogiannis, G., De Asmundis, C., Seira, J., Conte, G., Di Giovanni, G., ... Brugada, P. (2015). Circumferential pulmonary vein isolation as index procedure for persistent atrial fibrillation: a comparison between radiofrequency catheter ablation and second-generation cryoballoon ablation. *Europace: European pacing, arrhythmias, and cardiac electrophysiology: journal of the working groups on cardiac pacing, arrhythmias, and cardiac cellular electrophysiology of the European Society of Cardiology*, 17(4), 559–565. <https://doi.org/10.1093/EUROPACE/EUU350>.
- Yao, X., Gersh, B. J., Sangaralingham, L. R., Kent, D. M., Shah, N. D., Abraham, N. S., & Noseworthy, P. A. (2017). Comparison of the CHA2DS2-VASc, CHADS2, HAS-BLED, ORBIT, and ATRIA Risk Scores in Predicting Non-Vitamin K Antagonist Oral Anticoagulants-Associated Bleeding in Patients With Atrial Fibrillation. *The American journal of cardiology*, 120(9), 1549–1556. <https://doi.org/10.1016/J.AMJCARD.2017.07.051>.
- Letsas, K. P., Efremidis, M., Giannopoulos, G., Deftereos, S., Lioni, L., Korantzopoulos, P., ... Sideris, A. (2014). CHADS2 and CHA2DS2-VASc scores as predictors of left atrial ablation outcomes for paroxysmal atrial fibrillation. *Europace: European pacing, arrhythmias, and cardiac electrophysiology: journal of the working groups on cardiac pacing, arrhythmias, and cardiac cellular electrophysiology of the European Society of Cardiology*, 16(2), 202–207. <https://doi.org/10.1093/EUROPACE/EUT210>.
- Zhao, J., Zhou, D., Chen, M., Zhuo, C., Lin, Z., Zheng, L., & Wang, Q. (2020). CHA2DS2-VASc and SAMe-TT2R2 scores as predictors of recurrence for non-valvular atrial fibrillation patients on vitamin K antagonists after radiofrequency catheter ablation. *Journal of cardiovascular medicine (Hagerstown, Md.)*, 21(3), 200–208. <https://doi.org/10.2459/JCM.0000000000000930>.
- Kornej, J., Hindricks, G., Kosiuk, J., Arya, A., Sommer, P., Husser, D., ... Bollmann, A. (2014). Comparison of CHADS2, R2CHADS2, and CHA2DS2-VASc scores for the prediction of rhythm outcomes after catheter ablation of atrial fibrillation: the Leipzig Heart Center AF Ablation Registry. *Circulation. Arrhythmia and electrophysiology*, 7(2), 281–287. <https://doi.org/10.1161/CIRCEP.113.001182>.
- Deng, H., Shantsila, A., Guo, P., Potpara, T. S., Zhan, X., Fang, X., ... Lip, G. Y. H. (2019). Sex-related risks of recurrence of atrial fibrillation after ablation: Insights from the Guangzhou Atrial Fibrillation Ablation Registry. *Archives of cardiovascular diseases*, 112(3), 171–179. <https://doi.org/10.1016/J.ACVD.2018.10.006>.
- Bavishi, A. A., Kaplan, R. M., Peigh, G., Diaz, C. L., Baman, J. R., Trivedi, A., ... Passman, R. S. (2019). Patient characteristics as predictors of recurrence of atrial fibrillation following cryoballoon ablation. *Pacing and clinical electrophysiology: PACE*, 42(6), 694–704. <https://doi.org/10.1111/PACE.13669>.
- Vitali, F., Serenelli, M., Airaksinen, J., Pavasini, R., Tomaszuk-Kazberuk, A., Mlodawska, E., ... Bertini, M. (2019). CHA2DS2-VASc score predicts atrial fibrillation recurrence after cardioversion: Systematic review and individual patient pooled meta-analysis. *Clinical cardiology*, 42(3), 358–364. <https://doi.org/10.1002/CLC.23147>.
- Wu, J. T., Zhao, D. Q., Li, F. F., Wu, R., Fan, X. W., Hu, G. L., ... Chu, Y. J. (2019). Advanced interatrial block predicts recurrence of atrial fibrillation after accessory pathway ablation in patients with Wolff-Parkinson-White syndrome. *Clinical cardiology*, 42(9), 806–811. <https://doi.org/10.1002/CLC.23222>.
- Kranert, M., Shchetynska-Marinova, T., Liebe, V., Doesch, C., Papavassiliou, T., Akin, I., ... Hohneck, A. (2020). Recurrence of Atrial Fibrillation in Dependence of Left Atrial Volume Index. *In vivo (Athens, Greece)*, 34(2), 889–896. <https://doi.org/10.21873/INVIVO.11854>.
- von Olshausen, G., Uijl, A., Jensen-Urstad, M., Schwieler, J., Drea, N., Bastani, H., ... Braunschweig, F. (2020). Early recurrences of atrial tachyarrhythmias post pulmonary vein isolation. *Journal of cardiovascular electrophysiology*, 31(3), 674–681. <https://doi.org/10.1111/JCE.14368>.
- Canpolat, U., Aytemir, K., Yorgun, H., Şahiner, L., Kaya, E. B., Çay, S., ... Oto, A. (2015). The role of preprocedural monocyte-to-high-density lipoprotein ratio in prediction of atrial fibrillation recurrence after cryoballoon-based catheter ablation. *Europace: European pacing, arrhythmias, and cardiac electrophysiology: journal of the working groups on cardiac pacing, arrhythmias, and cardiac cellular electrophysiology of the European Society of Cardiology*, 17(12), 1807–1815. <https://doi.org/10.1093/EUROPACE/EUU291>.

16. Balk, E. M., Garlitski, A. C., Alsheikh-Ali, A. A., Terasawa, T., Chung, M., & Ip, S. (2010). Predictors of atrial fibrillation recurrence after radiofrequency catheter ablation: a systematic review. *Journal of cardiovascular electrophysiology*, 21(11), 1208–1216. <https://doi.org/10.1111/J.1540-8167.2010.01798.X>.
17. Potpara, T. S., Mujovic, N., Sivasambu, B., Shantsila, A., Marinkovic, M., Calkins, H., ... Lip, G. Y. H. (2019). Validation of the MB-LATER score for prediction of late recurrence after catheter-ablation of atrial fibrillation. *International journal of cardiology*, 276, 130–135. <https://doi.org/10.1016/J.IJCARD.2018.08.018>.
18. Levent, F., Kanat, S., & Tutuncu, A. (2023). Predictive Value of C2HEST Score for Atrial Fibrillation Recurrence Following Successful Cryoballoon Pulmonary Vein Isolation in Paroxysmal Atrial Fibrillation. *Angiology*, 74(3). <https://doi.org/10.1177/00033197221102230>.
19. Winkle, R. A., Jarman, J. W. E., Mead, R. H., Engel, G., Kong, M. H., Fleming, W., & Patrawala, R. A. (2016). Predicting atrial fibrillation ablation outcome: The CAAP-AF score. *Heart rhythm*, 13(11), 2119–2125. <https://doi.org/10.1016/J.HRTHM.2016.07.018>.
20. Efficacy of catheter ablation of atrial fibrillation beyond HATCH score - PubMed. (n.d.). Retrieved March 16, 2023, from <https://pubmed.ncbi.nlm.nih.gov/23044300/>.
21. Saglietto, A., Gaita, F., Blomstrom-Lundqvist, C., Arbelo, E., Dagues, N., Brugada, J., ... Anselmino, M. (2023). AFA-Recur: an ESC EORP AFA-LT registry machine-learning web calculator predicting atrial fibrillation recurrence after ablation. *Europace: European pacing, arrhythmias, and cardiac electrophysiology: journal of the working groups on cardiac pacing, arrhythmias, and cardiac cellular electrophysiology of the European Society of Cardiology*, 25(1). <https://doi.org/10.1093/EUROPACE/EUAC145>.
22. Cay, S., Kara, M., Ozcan, F., Ozeke, O., Korkmaz, A., Cetin, H., ... Topaloglu, S. (2022). A new scoring system: PAT2C2H score. Its clinical use and comparison with HATCH and CHA2DS2-VASc scores in predicting arrhythmia recurrence after cryoballoon ablation of paroxysmal atrial fibrillation. *Journal of interventional cardiac electrophysiology: an international journal of arrhythmias and pacing*, 65(3), 701–710. <https://doi.org/10.1007/S10840-022-01328-4>.
23. Wójcik, M., Berkowitsch, A., Greiss, H., Zaltsberg, S., Pajitnev, D., Deubner, N., ... Neumann, T. (2013). Repeated catheter ablation of atrial fibrillation: how to predict outcome? *Circulation journal: official journal of the Japanese Circulation Society*, 77(9), 2271–2279. <https://doi.org/10.1253/CIRCJ.CJ-13-0308>.
24. Grönefeld, G. C., Lillenthal, J., Kuck, K. H., & Hohnloser, S. H. (2003). Impact of rate versus rhythm control on quality of life in patients with persistent atrial fibrillation. Results from a prospective randomized study. *European heart journal*, 24(15), 1430–1436. [https://doi.org/10.1016/S0195-668X\(03\)00261-6](https://doi.org/10.1016/S0195-668X(03)00261-6).
25. Jones, D. G., Haldar, S. K., Hussain, W., Sharma, R., Francis, D. P., Rahman-Haley, S. L., ... Wong, T. (2013). A randomized trial to assess catheter ablation versus rate control in the management of persistent atrial fibrillation in heart failure. *Journal of the American College of Cardiology*, 61(18), 1894–1903. <https://doi.org/10.1016/J.JACC.2013.01.069>.
26. Rienstra, M., Lubitz, S. A., Mahida, S., Magnani, J. W., Fontes, J. D., Sinner, M. F., ... Benjamin, E. J. (2012). Symptoms and functional status of patients with atrial fibrillation: state of the art and future research opportunities. *Circulation*, 125(23), 2933–2943. <https://doi.org/10.1161/CIRCULATIONAHA.111.069450>.
27. Boersma, L., Koźluk, E., Maglia, G., De Sousa, J., Grebe, O., Eckardt, L., ... Goette, A. (2020). Paroxysmal and persistent atrial fibrillation ablation outcomes with the pulmonary vein ablation catheter GOLD duty-cycled phased radiofrequency ablation catheter: quality of life and 12-month efficacy results from the GOLD Atrial Fibrillation Registry. *Europace: European pacing, arrhythmias, and cardiac electrophysiology: journal of the working groups on cardiac pacing, arrhythmias, and cardiac cellular electrophysiology of the European Society of Cardiology*, 22(6), 888–896. <https://doi.org/10.1093/EUROPACE/EUAA042>.
28. Mörtzell, D., Jansson, V., Malmberg, H., Lönnholm, S., & Blomström-Lundqvist, C. (2019). Clinical outcome of the 2nd generation cryoballoon for pulmonary vein isolation in patients with persistent atrial fibrillation - A sub-study of the randomized trial evaluating single versus dual cryoballoon applications. *International journal of cardiology*, 278, 120–125. <https://doi.org/10.1016/J.IJCARD.2018.10.097>.