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ORIGINAL ARTICLE

Validity of MENARI plus (self-pulse assessment and clinical scoring) mobile apps for detecting atrial fibrillation in high-risk population

Muhamad R. Fadlan MD[1] | Ardian Rizal MD[1] | Budi Satrijo MD[1] | Tri Astiawati MD[2] | Mohammad S. Rohman MD[1] | Shalahuddin S. Baskoro MD[1]

[1]Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Brawijaya, Dr. Saiful Anwar General Hospital, Malang, East Java, Indonesia

[2]Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Brawijaya, Dr. Iskak General Hospital, Tulung Agung, East Java, Indonesia

Correspondence
Ardian Rizal, Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Brawijaya, Dr. Saiful Anwar General Hospital, Malang East Java, Indonesia.
Email: kikifadlan@gmail.com

Abstract

Background: Even before it is clinically diagnosed, atrial fibrillation (AF) can cause a stroke. This study validates self-pulse assessment and clinical scoring (MENARI Plus) based on android apps.

Objective: The aim of this study was to examine the validity of AF screening using MENARI Plus compared with an ECG recording.

Methods: We collected a total of 1385 subjects from high-risk population according to CHA2DS2-VASc score ≥2, attending 8 primary care centers (PCCs) in Malang between July 2021 and December 2021. Every participant underwent self-pulse assessment, and then was evaluated for MENARI Plus Score on android Apps. These cases had been classified as low or high probability for AF (cut-off score 7). After that, electrocardiography examinations were performed and classified with AF and Sinus Rhythm group.

Results: In this study, the mean age of these patients was 61.5 ± 6.9 years old. We found that 156/1385 (11%) patients had AF. There were 68/156 (43.5%) new cases of AF. The sensitivity for self-pulse palpation was 73.1% (95% CI: 68%–76%) and specificity was 68.3% (95% CI: 65%–72%). MENARI Plus had an area under the receiver operating curve (AUC) of 0.86 (95% CI: 0.82–0.89) with sensitivity per measurement occasion was (84%, 95% CI: 82%–88%) and specificity was (87.9%, 95% CI: 82%–90%).

Conclusion: In this study, we found that MENARI Plus has high sensitivity and specificity for AF. It is therefore useful for ruling out AF. It may also be a useful screen that can be applied opportunistically for previously undetected AFs.

KEYWORDS

atrial fibrillation, pulse palpation, scoring system

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1 | INTRODUCTION

Atrial fibrillation (AF) is characterized by disorganization of atrial depolarization resulting in impaired atrial mechanical function. It results in the absence of a P wave and is replaced by a rapid fibrillation or oscillatory wave that varies in shape, amplitude, or interval, followed by an irregular ventricular response. Atrial fibrillation is the most common cardiac arrhythmia in daily clinical practice.[1,2] It is associated with a significant increase in morbidity, mortality, and health care burdens.[3]

According to data from the Outcomes Registry For Better Informed Treatment Of Atrial Fibrillation (ORBIT-AF) Study, 31% of AF patients had one or more episodes of hospitalization after 1 year of follow-up.[3] The cost of emergency room visits and hospitalizations related to AF is a burden, which has significant impact on the healthcare system.[4,5]

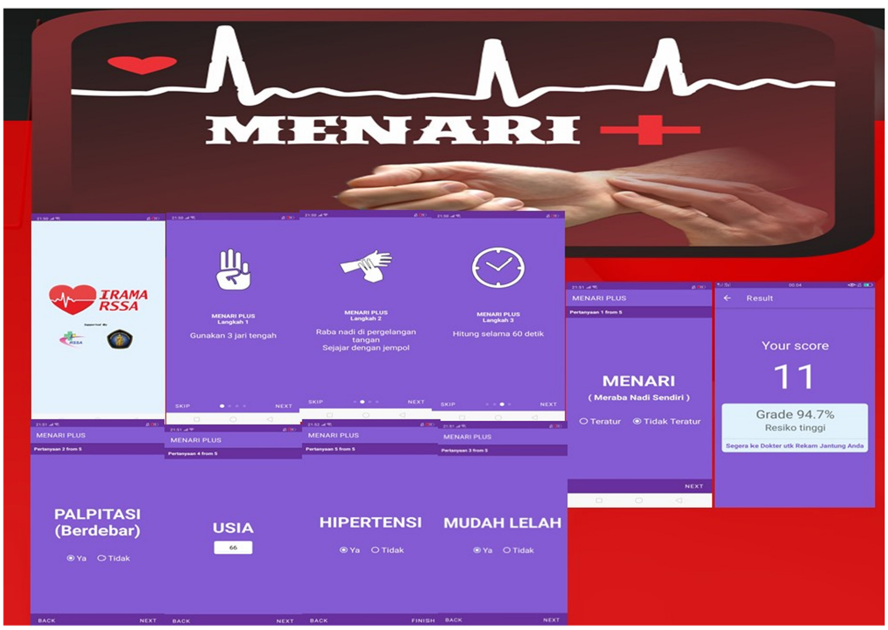
In previously undiagnosed AF patients, ischemic stroke may be the first clinical manifestation of the AF condition. It is seen in 10% of patients diagnosed with a first-onset ischemic stroke. Therefore, early detection in asymptomatic AF patients is important because these strokes can be prevented by anticoagulation.[5] According to the STROKESTOP study (2016), early detection of AF with early anticoagulation is associated with a reduced risk of ischemic stroke by 64%, the risk of death by 26%, and there was no difference in major bleeding complications such as hemorrhagic stroke with an incidence of <0.3%.[6]

Early detection is suggested as a strategy to increase the detection rate of AF and initiate anticoagulation earlier in high-risk individuals.[7] According to the REHEARSE-AF study (2017), the value of CHA2Ds2-VASc 2 represents AF patients with a high risk of developing AF with complications such as ischemic stroke and require early anticoagulation.[8] Early detection by pulse palpation or rhythm strip electrocardiogram (ECG) is recommended by the European Society of Cardiology (ESC) in all patients over 65 years of age visiting health services and is also recommended by the National Institute For Health And Care Excellence (NICE) in patients who have symptoms suggestive of AF.[3,9]

The Indonesian Cardiology Association recommends self-pulse assessment, in Bahasa "Meraba Nadi Sendri" (MENARI) for an early detection of AF.[2] The preliminary research that has been carried out on 461subjects 50–75 years old obtained a MENARI sensitivity of 66% and specificity of 69.1%.[10] The results of another study on self-palpation in 1010 subjects by Ghazal et al,[11] sensitivity and specificity values were found to be higher when pulse measurements were performed by nurses, with a sensitivity of 80% (95% CI: 28%–99%) and specificity 98% (95% CI: 97%–99%). Increased knowledge about how to do self pulse palpation and interpretation of pulse palpation is suspected to be the cause of increased sensitivity and specificity.

This study is the continuation of a previous study using MENARI to detect AF. The addition of several clinical characteristics to improve the accuracy of diagnosis has been widely used in other diagnostic methods, to increase the accuracy of the test results With this idea, a preliminary study was conducted to evaluate the accuracy of MENARI Plus simple clinical characteristics (MENARI Plus). MENARI Plus application integrated clinical-based scoring system with medical advice in the form of an education leaflet regarding AF for the user. MENARI Plus apps is shown in Picture 1.

This study aims to determine the validation of MENARI Plus, a scoring system based on MENARI with the addition of simple clinical features, in high-risk patients, based on the CHA2Ds2-VASc ≥2 value.



PICTURE 1 MENARI Plus mobile apps. Shows the MENARI Plus application based on android smart phone. This application consists of tutorial screen for self-pulse palpation and self checklist screening.

2 | MATERIALS AND METHODS

This was an observational analytic study with a cross-sectional design, This research was conducted at primary care centres (PCCs) in Malang Regency (Cepoko Mulyo, Karang Duren, Kendal Payak, Kepanjen, Majang Tengah, Mendalan Wangi, Sepanjang, Sidorahayu, and Bulu Lawang). Our study was conducted from January to July 2022. Inclusion criteria were patients aged 50–75 years, patients with a high risk of AF based on a CHAD2VAS2C score ≥2, and agreed to participate in this study. We excluded patients who were unable to use smartphones, patients with decreased cognitive function based on Mini Mental State Examination (MMSE) <27, patients with incomplete clinical data, patients using pacemakers, and hemodynamically unstable patients.

2.1 | Ethics statement

All of the protocols in this research have already been approved through informed consent by the patients and by the Ethical Committee of Universitas Brawijaya Malang, Indonesia (no. 400/79/K.3/302/2018).

2.2 | Collection of demographic, medical, and laboratory data

All participants were individually interviewed with a structured questionnaire and information on gender, age, smoking status, medical history, and physical exercise. Body mass index (BMI) and waist to the hip are measured with scales and midline. Blood pressure was measured in a standard manner.

2.3 | Atrial fibrillation

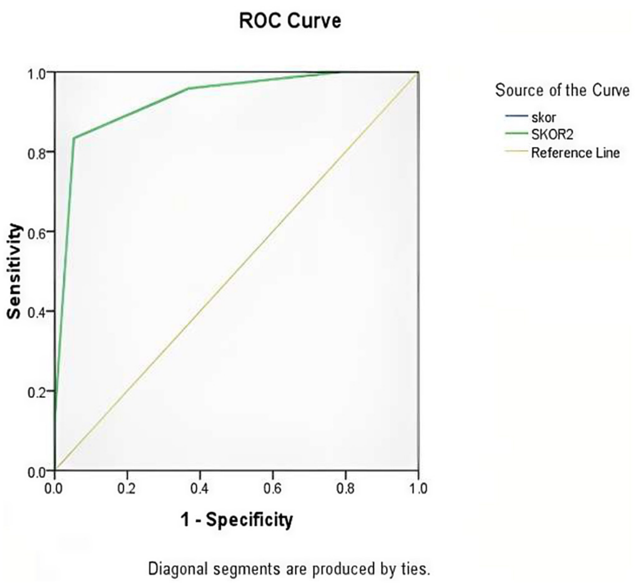
Atrial fibrillation is supraventricular arrhythmias characterized by uncoordinated electrical activation of the atria resulting in ineffective atrial contractions,[1] that signed with irregularly-irregular R-R interval, not visible P wave, and irregular atrial activity based on the ECG.

2.4 | MENARI PLUS

Every participant received an explanation of the benefit of pulse palpation especially the technique of radial artery pulse palpation. Every participant performed self-pulse palpation (MENARI). Then they performed MENARI Plus scoring on an android smartphone. MENARI Plus scoring was based on multivariable analysis from a previous study[10] that consisted of irregular self-pulse palpation (MENARI) (4 points each); P: Palpitation (2 points); L: oLd (age >65 years, 2 points); U: fatigUe (1 point); and S: hypertenSion (2 points). The total score ranged from 0 to 11 points. A score of 7 was used as the threshold for MENARI Plus scoring based on our previous study.[10] The contents of MENARI Plus scoring are listed in Table 1.

TABLE 1 MENARI plus score. Shows the list of MENARI Plus score based on multivariate analysis in previous study.

Predictors	Multiplying factor
Irregular (self-pulse palpation) "MENARI"	+4
Palpitation	+2
Age >65	+2
Hypertension	+2
Fatigue	+1
Total score	11



PICTURE 2 AUC derivation test for MENARI Plus score. Shows the area under the receiver operating curve (AUC) of 0.83 (95% CI 0.84–0.92), sensitivity of 0.84 (95% CI: 0.82–0.94), and specificity of 0.80, and the score demonstrated excellent discrimination of MENARI Plus score ≥7 from derivation set (95% CI: 0.79–0.86).

We developed this score into an android mobile phone application that added guidance for performing self-pulse palpation and evaluating the regularity of pulse rate. After the MENARI score was evaluated, a 12-lead ECG was performed. The score showed good discrimination with an area under the receiver operating curve (AUC) of 0.83 (95% CI: 0.84–0.92) with a sensitivity of 0.84 (95% CI: 0.82–0.94) and a specificity of 0.80 (95% CI: 0.79–0.84). The AUC of this derivation test is shown in Picture 2.

2.5 | Statistics

Mean with SD is presented for the continuous variable and several patients (%) for the categorical variable. All data are in mean ± SD.

We used a 2×2 table to evaluate sensitivity, specificity, likelihood ratio, and accuracy for this score. We used an independent *t* test to perform statistical analysis in parametric data. If the data were not homogenous, it was conducted by Mann–Whitney test for significant difference and Wilcoxon rank test for a significant relationship. For subgroup analysis, we used ANOVA. It was analyzed by SPSS version 17 (SPSS Inc). $p<.05$ was statistically significant. The area under the curve (AUC) was used to evaluate performance of this score.

The result of the totality of 1135 patients was re-collected, with 76% being women. 156/1385 (11.3%) were diagnosed with AF, 18/156 (11.5%) were with asymptomatic AF and 52/156 (33.3%) had AF for the first time. Comorbidities in the subjects of this study included hypertension as much as 633/1385 (45.7%), diabetes mellitus 605/1385 (43.7%), history of stroke 149/1385 (10.8%), intermittent claudication 158/1385 (11.4%) and heart failure 238/1385 (17.2%). There was a significant difference in the age of patients diagnosed with AF compared with subjects without AF 63.6±5.0 vs. 61.2±7.1, $p<.001$. There was a significant difference in systolic blood pressure of patients diagnosed with AF compared to subjects without AF 133±17.7 vs. 122.8±16.7, $p<.001$. There was a significant difference in CHA2DS2-VASC values in patients diagnosed with AF compared with subjects without AF 2.92±0.48 vs. 2.5±0.28, $p<.001$. There was a significant difference in the proportion of hypertensive patients diagnosed with AF compared to subjects without AF 67.9% vs. 32.8%, $p<.001$. There was a significant difference in clinical symptoms such as palpitations ($p<.001$), fatigue $p=.003$, irregular pulse palpation $p<.001$, and MENARI Plus scores ≥7 ($p<.001$) in patients diagnosed with AF compared to subjects without AF.

As for risk factors, there were no statistically significant differences between the AF and non-AF groups, including diabetes ($p=.105$), smoking ($p=.82$), obesity ($p=.45$), intermittent claudication ($p=.39$) and stroke ($p=.24$). Based on the clinical manifestation data, there were no statistically significant differences between the AF and non-AF groups, including dyspnea ($p=.74$), chest pain ($p=.34$), and syncope ($p=.09$). The univariate analysis is described in Table 2.

Based on the 2×2 table, it shows that from 156 AF patients, there were 84.6% with MENARI Plus ≥7, and the other 15.4% with MENARI Plus <7. As for the 1229 patients in the non-AF group, there were 12.1% with MENARI Plus ≥7 and the other 87.9% with MENARI Plus <7. The 2×2 table is given in Table 3.

The 2×2 table shows that of the 156 AF patients, there were 67.9% with irregular self-palpation, and 32.1% with regular self-feeling. As for the 1229 patients in the non-AF group, 31.7% had irregular own pulse and 68.3% had regular self-palpation. The 2×2 table of self-pulse palpation is given in Table 4.

To analyze the accuracy of diagnostic values in MENARI Plus and self-pulse palpation for diagnosing AF, the sensitivity, specificity, likelihood ratio, and predictive values are calculated, with a summary given in Table 5.

The score showed good discrimination with an area under the receiver operating curve (AUC) of 0.86 (95% CI: 0.82–0.89). It is shown in Picture 3.

TABLE 2 Univariate analysis. Shows the univariate analysis, proportion and mean±SD between AF and Non-AF group.

Variables	AF	No AF	*p*
Age	63.6±5.0	61.2±7.1	.000
Male	27.6%	23.6%	.32
Age >65 years old	64.7%	53.5%	.01
Heart failure	23.7%	20.4%	.39
CAD	27.6%	24.2%	.40
HR	82.5±9.7	80.7±12.8	.037
SBP	133±17.7	122.8±16.7	.000
DBP	80.8±10.3	79±12.8	.37
Education <9th	66.7%	67.7%	.79
MMSE	28.6±0.6	28.7±0.4	.39
BW	61±7.9	60.5±9.5	.33
BMI	24.9±4.0	24.7±4.5	.47
CHA2DS2-VASc score	2.92±0.48	2.5±0.28	.000
Hypertension	67.9%	42.9%	.000
Diabetes mellitus	44%	41%	.47
Smoker	25%	23.0.3%	.70
Stroke/TIA	13.5%	10.4%	.30
Intermittent caludication	13.5%	11.1%	.39
Dyspneu	25.6%	24.1%	.74
Palpitation	68.6%	51%	.000
Chest pain	30.1%	25.6%	.26
Syncope	8.3%	4.8%	.09
Fatigue	53.2%	40.8%	.003
History of medication			
Warfarin	82.1%	2.2%	.000
ASA	17.3%	24.5%	.059
ACE-inhibitor/ARB	41%	41.9%	.90
B Blocker	55.1%	17.7%	.000
Digoxin	10.9%	0.5%	.000
Statin	55.1%	40.1%	.000
Irregular of self-pulse assessment	67.9%	31.7%	.000
MENARI plus score ≥7	84%	12.1%	.000

TABLE 3 2×2 Table for MENARI Plus. Shows the 2×2 table for evaluating validation of MENARI Plus score confirmed with ECG for detecting AF.

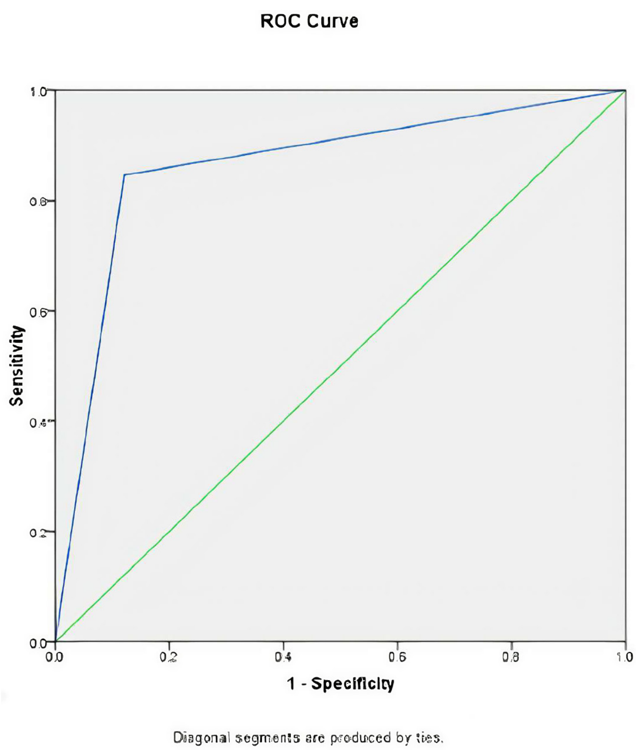
	ECG	
Variable	AF (156)	Non AF (1229)
MENARI plus ≥7	132 (84.6%)	149 (12.1%)
MENARI plus <7	24 (15.4%)	1080 (87.9%)

TABLE 4 2×2 Table for self-pulse palpation (MENARI). Shows the 2×2 table for evaluate validation of self-pulse palpation confirmed with ECG for detecting AF.

Variable	ECG AF (156)	ECG Non AF (1229)
Irregular self-pulse palpation (MENARI)	106 (67.9%)	389 (31.7%)
Regular self-pulse palpation (MENARI)	50 (32.1%)	840 (68.3%)

TABLE 5 Comparison of MENARI plus validation and self-pulse palpation for diagnosing atrial fibrillation. Shows the comparison of validity between self-pulse palpation (MENARI) and MENARI Plus score for detecting atrial fibrillation.

	Self-pulse palpation (MENARI)		MENARI plus ≥7	
Variable	Estimate	95% CI	Estimate	95% CI
Sensitivity	67.9%	63%–73%	84.6%	81%–87%
Specificity	68.3%	63%–74%	87.9%	84%–90%
Positive predictive value	21.4%	18%–27%	46.8%	43%–49%
Negative predictive value	94.4%	91%–96%	97.7%	93%–99%
Likelihood ratio (+)	2.14	1.8–2.7	6.9	6.4–7.4
Accuracy ratio	67.8%	64%–72%	87.5%	82%–92%



PICTURE 3 AUC of MENARI plus for validation test of atrial fibrillation. Shows the validation score of MENARI Plus score ≥7 showing a good discrimination with an area under the receiver operating curve (AUC) of 0.86 (95% CI: 0.82–0.89).

3 | DISCUSSION

3.1 | Detection rate of AF

The detection rate of AF in this study was higher (11.5% of the sample) compared to other studies; for example, in the STROKESTOP study (2015) with a population aged >65 years, the prevalence of AF was 3%.[12] In other studies, the detection rate of AF ranged from 1.4% to 5.5%.[11,12] In this study, the number needed to screen (NNS) those newly diagnosed with AF was 26, and the results of this study were lower than those of other studies by Nicole et al[13] with an NNS of 69 in patients aged 65 years. The high detection rate and low NNS in patients were due to samples taken from high-risk population groups with CHA_2DS_2-VASc scores ≥2. Anat et al[14] reported that AF detection reached 6% at age ≥50 years with CHA_2DS_2-VASc values >1. This study was also conducted on patients aged 50–75 years because according to OneAF registry data, it is said that the average age of AF patients in Indonesia is 57.52 (50.6 ± 78.2) years.[15]

In addition, a high detection rate is also associated with a high proportion of other cardiovascular comorbidities such as hypertension (45.7%), history of stroke or TIA (10.8%) diabetes mellitus (43.7%), and heart failure (17.2%). So, this figure cannot be generalized to the general prevalence of AF in Indonesia. In this study, AF was more common in patients aged ≥65 (74.4% vs. 53.5%, $p < .001$) with comorbid hypertension (67.9% vs. 42.9%, $p < .001$) compared to younger patients and with no hypertension. European data reveal that the incidence of AF ranges from 3.7% to 4.2% of those aged 60–70 years. and increases to 10%–17% at older ages.[8]

3.2 | Clinical comorbidity and clinical manifestation

Hypertension and AF often occur together. In the Framingham study, hypertension increased the risk of AF by 50% in men and 40% in women, because of the higher prevalence of hypertension in the population. Hypertension accounted for more cases of AF than other risk factors such as heart failure and valvular heart disease.[16] In the ARIC study (risk of atherosclerosis in the community), hypertension was the main contributor to AF and was thought to be the cause of 20% of patients diagnosed with AF for the first time.[17]

The main symptoms in AF patients in this study included palpitations (68.6%), shortness of breath (39.1%), chest pain (34.6%), easy fatigue (29.5%), and dizziness, with or without syncope (8.5%). The results obtained in this study are similar to several other studies including the study by Saleh et al, 2011. In a study of 720 patients with AF, the majority of symptoms were shortness of breath (59.3%), palpitations (24.5%), chest pain (13.4%), and dizziness, with or without syncope (6.25%). The study by Levy et al (1999) on 756 subjects, palpitations were the most common symptom complained of by AF patients with 54.1%, while other complaints were easy fatigue (14.3%), chest pain (10.1%), and syncope (10.4%).[18]

Palpitations are significantly more common in newly diagnosed AF, whereas shortness of breath is significantly more common in patients with chronic AF.[19] According to research by Smitha et al (2020), the most common clinical presentations of AF patients with hypertension were palpitations (42.5%) and fatigue (35%). Both symptoms were statistically significant compared with patients without AF. The same thing happened in this study. There was a significant difference in the proportion of palpitations ($p<.001$) and fatigue ($p<.003$) between the AF and non-AF groups. Several sociodemographic characteristics of AF have also been associated with variations in the symptoms experienced by AF patients, such as fatigue. Women are more likely to experience most of the symptoms of AF, and to a greater degree of severity than men. In particular, women experience more frequent palpitations, shortness of breath, dizziness, fatigue, and chest pain.[20]

Palpitations are defined as an increase in the perception of the heartbeat. The sensory and mechanistic pathways underlying the palpitations are unknown. Interestingly, previous studies have reported that the neural excitability for palpitations may not originate in the myocardium. Barsky et al. demonstrated that although there is no innervation of the heart, one-third of heart transplant recipients are accurately aware of their resting heart rate. Further research is needed to identify the afferent neural pathways that transmit sensory information so that palpitations can be perceived by the brain.[21]

In general, exercise performance depends on several factors including cardiac output and oxygen transport, which in turn depend on respiratory function. In AF, cardiac output may be decreased because of impaired diastolic filling secondary to a rapid ventricular rate. Diastolic dysfunction in AF may also increase left-sided intracardiac pressure and predispose the patient to episodes of subclinical pulmonary edema. Loss of atrial kick during diastole, short diastolic filling time (in AF with rapid ventricular response), and increased mitral and tricuspid regurgitation are believed to be responsible for the decrease in cardiac output. In another study, decreased exercise capacity causing fatigue in AF patients was thought to be related to stroke, which is one of the most common complications in AF patients.[22] Sub-analysis in this study found, without a history of stroke, that there was still a significant difference in the proportion of easily fatigued patients with AF (31.1%) compared to non-AF patients (18.2%, $p<.001$).

3.3 | Validity of MENARI plus

In this study, the sensitivity of self-palpation was 67.9% (95% CI: 63%–73%) and specificity was 68.3% (95% CI: 63%–74%). The results in this study are the same as the results of a preliminary study conducted on 461 patients 50–75 years old, with a sensitivity of 66% and a specificity of 69.1%.[23] The results of another study on self-palpation in 1010 subjects by Ghazal et al (2020) found a sensitivity of 56% (95% CI: 35%–75%) and specificity of 81% (95% CI: 78%–83%). The values of sensitivity and specificity were higher when the pulse was measured by nurses with a sensitivity of 80% (95% CI: 28%–99%) and a specificity of 98% (95% CI: 97%–99%).[11] However, the sensitivity test results from pulse palpation performed by medical personnel are between 87% and 97% and specificity is between 70% and 81%. Increased knowledge about the manner and interpretation of palpating the pulse is thought to be the cause of the increased sensitivity and specificity.[11]

The sensitivity and specificity test of MENARI Plus in this study are not different from the results when the derivation test was carried out in the preliminary study which obtained a sensitivity of 84% (95% CI: 82%–94%) and specificity of 80% (95% CI: 79%–84%). The results of the sensitivity test to MENARI Plus with a score of 7 obtained 84.6% (95% CI: 81%–87%). The results of this sensitivity test were found to be lower compared to AF detection studies using photoplethysmography on mobile phones with ranged between 87% and 98%.[8,24–30] However, the results of the sensitivity test in this study were better than the results of the sensitivity test on the detection of AF using a smartphone by Chan et al., with 10 735 patients with a mean age of 78.6 ± 8.1 years, and a sensitivity of 75% was obtained. In a study by Tison et al., with a total of 1617 patients with a mean age of 42 ± 12, a sensitivity of 67.7% was obtained.[30,31]

The specificity test for MENARI Plus was 87.9% (95% CI 84%–90%). The results of this specificity test were found to be lower than research on AF detection using a photoplethysmography device on a mobile phone ranging between 93.5% and 98.2%.[24–29] However, the results of the specificity test in this study were better than the results of the specificity test on the detection of AF by Bumgarner et al. using a smartwatch on 100 subjects, and the specificity was 84%.[32] Chan et al, with 10 735 patients, whose mean age was

8.6±8.1 years, obtained a sensitivity of 75% and a study by Tison et al, with a total of 1617 patients with a mean age of 42±12 obtained a sensitivity of 67.7%.[30,31]

Compared with photoplethysmography-based wearable devices, in general, MENARI Plus 7 has lower sensitivity and specificity, but lower costs with a target range that can reach more subjects. This study included a sample of 1385 subjects with CHA2DS2-VASc 2. There are limitations in detecting paroxysmal AF based on one-time measurements of the MENARI Plus. The problem of decreased cognitive function in AF patients can also reduce the sensitivity and specificity of the screening method which in MENARI Plus is based on the ability to use a smartphone and memory of the symptoms felt.

In this study, to reduce this bias, the MMSE examination was carried out to determine the patient's previous cognitive function. The results of the MMSE test did not show a significant difference between subjects with AF and non-AF with a good MMSE average value (29.2±0.8). So, it did not cause a decrease in the accuracy of MENARI Plus. In this study, the selection of health facilities was not done randomly, so it is very likely to affect the reproducibility of the research results when applied to other places. In this study, ectopic heart rate, both premature ventricular complex (PVC) and premature atrial complex (PAC) can cause irregular palpation which then leads to reduced specificity in this study. However, multi-centre studies with larger samples and duration of serial measurements, and confirmation of ECG in real time are needed to increase the sensitivity and specificity of MENARI Plus.

4 | CONCLUSION

MENARI Plus has a good validation test result for detecting AF compared to the previous derivation test results in high-risk patients based on CHA2DS2-VASc score ≥2. It is therefore useful for ruling out AF. It may also be a useful screen to apply opportunistically for previously undetected AF.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

ETHIC APPROVAL

All of the protocols in this research have already been approved by the Ethical Committee of Universitas Brawijaya Malang, Indonesia (no.400/79/K.3/302/2018).

PATIENT CONSENT STATEMENT

All of consent statements in this research have already been approved by the Ethical Committee of Universitas Brawijaya Malang, Indonesia (no.400/79/K.3/302/2018).

CLINICAL TRIAL REGISTRATION

N/A.

ORCID

Ardian Rizal https://orcid.org/0000-0002-9104-5022

Mohammad S. Rohman https://orcid.org/0000-0001-6461-2223

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