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ORIGINAL ARTICLE

Predictive Value of P-Wave Dispersion for Paroxysmal Atrial Fibrillation in Healthy Elderly Patients

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Abstract

Background: Paroxysmal atrial fibrillation (PAF) is a common but frequently underdiagnosed arrhythmia in the elderly. Identifying noninvasive predictors in clinically low-risk individuals may enable early detection and prevention of complications such as stroke. This study aimed to evaluate the predictive value of baseline P-wave dispersion (Pd) and left atrial volume index (LAVI) in predicting PAF in healthy elderly patients.

Methods: In this retrospective study, 385 patients aged ≥65 years without structural heart disease or major comorbidities were evaluated. All underwent baseline 12-lead ECG, transthoracic echocardiography, and 24-hour Holter monitoring. Patients were grouped based on the presence (n=47) or absence (n=338) of PAF. Pd and LAVI were compared, and univariate and multivariate logistic regression analyses were performed. ROC analysis assessed the diagnostic performance of Pd.

Results: PAF patients had significantly higher Pd (48.8 ± 6.1 ms vs. 31.7 ± 5.0 ms, p<0.001) and LAVI (31.4 ± 4.4 mL/m² vs. 29.1 ± 3.8 mL/m², p<0.001). Both Pd and LAVI were significant predictors in univariate analysis; however, only Pd remained independently associated with PAF in multivariate regression (B = 0.497, p<0.001). ROC analysis showed an AUC of 0.772, with a Pd cut-off of 40.6 ms yielding 83% sensitivity and 69% specificity.

Conclusion: P-wave dispersion is an independent and practical predictor of PAF in otherwise healthy elderly patients. Incorporating Pd into routine outpatient assessments may aid in early arrhythmia risk stratification and stroke prevention.

Keywords: P-wave dispersion, paroxysmal atrial fibrillation, Holter monitoring, electrocardiography.

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INTRODUCTION

With advancing age, the prevalence of cardiac arrhythmias increases significantly. Among them, paroxysmal atrial fibrillation (PAF) stands out as a common, often silent, yet clinically serious arrhythmia in the elderly population.(1) One of the most critical and feared complications of PAF is stroke.(2) Atrial fibrillation is the leading cause of cardioembolic strokes, and in a considerable number of cases, previously undetected or overlooked PAF episodes are identified as the underlying etiology.(3)

Early identification of PAF is vital to prevent irreversible outcomes such as stroke.(4) However, because PAF episodes are often asymptomatic and brief, diagnosis can be quite challenging. For this reason, defining non-invasive, easily accessible, and reliable predictors of PAF has become a key clinical goal.

In recent years, P-wave dispersion, defined as the difference between the maximum and minimum P-wave durations recorded across different ECG leads, has emerged as a simple yet valuable electrocardiographic marker reflecting intra-atrial conduction heterogeneity.(5) An increase in P-wave dispersion may indicate delayed and heterogeneous atrial conduction, thereby suggesting a pro-arrhythmic substrate for atrial fibrillation.(5, 6) In addition, the left atrial volume index (LAVI) is considered a structural marker that reflects atrial remodeling and chronic pressure overload, both of which are implicated in the development of PAF.(7-9)

Although several studies have investigated the association between PAF and both P-wave dispersion and LAVI,(7-10) data focusing on elderly individuals (aged ≥65 years) without structural heart disease or major comorbidities remain limited. This subgroup represents a clinically relevant yet underexplored population, where subtle electroanatomical markers might play a more prominent role in arrhythmia prediction.

In this context, the present study aimed to evaluate the relationship between baseline P-wave dispersion and LAVI measurements and the presence of PAF in a cohort of elderly patients presenting solely with palpitations. By focusing on a relatively healthy geriatric group without overt cardiac pathology, we sought to clarify the independent predictive value of these accessible parameters and contribute to early risk stratification in this increasingly prevalent clinical scenario.

MATERIALS AND METHODS

Study Design and Ethical Approval

This study was conducted as a single-center, retrospective, observational analysis in a tertiary cardiology outpatient clinic. All study procedures adhered to the principles outlined in the Declaration of Helsinki and its subsequent revisions.

The study protocol was reviewed and approved by a local institutional clinical research ethics committee (Approval No: 2025-1071).

Study Population

A total of 385 patients aged 65 years and older were retrospectively identified through hospital records between January 2022 and April 2025. All patients had presented to the cardiology outpatient clinic with a primary complaint of palpitations and had undergone both a baseline 12-lead electrocardiogram (ECG) and a 24-hour Holter monitor recording within the same calendar month as part of their routine clinical evaluation.

To maintain a homogenous study population and minimize confounding variables, only patients without structural heart disease, without reduced left ventricular ejection fraction, and without major systemic comorbidities (including but not limited to hypertension, diabetes mellitus, thyroid dysfunction, chronic renal or hepatic disease, or chronic pulmonary conditions) were included. Structural heart disease was ruled out through transthoracic echocardiography.

Patients were excluded if they had a prior diagnosis of atrial fibrillation, known coronary artery disease, moderate to severe valvular heart disease, heart failure with an ejection fraction <50%, pacemaker rhythm, chronic atrial fibrillation, or were using antiarrhythmic drugs at the time of evaluation. Additionally, individuals with technically inadequate Holter recordings were also excluded from the study.

All patients had previously provided written informed consent at the time of their clinical evaluation, in accordance with institutional protocols.

Electrocardiographic Measurements – P-wave Dispersion

Baseline 12-lead ECGs were recorded at a paper speed of 25 mm/s and a calibration of 10 mm/mV in the supine position. All ECGs were obtained during sinus rhythm and analyzed digitally using calipers and magnification tools by two independent cardiologists, who were blinded to the arrhythmic outcomes, including Holter monitoring results.

P-wave duration was measured from the beginning of the P-wave deflection from the isoelectric line to its return to the isoelectric line. For each ECG, the maximum (Pmax) and minimum (Pmin) P-wave durations across all 12 leads were identified. P-wave dispersion was then calculated as the difference between these two values (P-wave dispersion = Pmax – Pmin).(11).

Echocardiographic Assessment – Left Atrial Volume Index (LAVI)

All patients underwent transthoracic echocardiographic (TTE) evaluation using standard 2D imaging protocols. Left atrial volume (LAV) was calculated using the biplane area-length method from apical four- and two-chamber views, measured at the end of ventricular systole (i.e., at the onset of the P-wave on ECG), according to the American Society of Echocardiography recommendations.(12) The volume was then indexed to body surface area to obtain the left atrial volume index (LAVI), expressed in mL/m².

Measurements were performed by experienced echocardiographers blinded to the patients' ECG and Holter findings.

Detection and Definition of Paroxysmal Atrial Fibrillation (PAF)

Each patient underwent 24-hour ambulatory Holter monitoring within the same month as their baseline ECG and echocardiographic evaluation. Recordings were reviewed by two cardiologists independently, who were blinded to other patient data.

PAF was defined as any irregularly irregular rhythm without discernible P-waves, lasting at least 30 seconds, consistent with accepted diagnostic criteria.(13) Patients were then classified into two groups: those with at least one documented PAF episode during Holter monitoring (PAF group), and those without (non-PAF group).

Holter recordings of poor technical quality or insufficient duration were excluded from analysis to maintain data integrity.

Statistical Analysis

All statistical analyses were performed using SPSS software (version 26.0, IBM Corp., Armonk, NY, USA). Continuous variables were tested for normality using the Kolmogorov–Smirnov test. Variables with normal distribution were expressed as mean ± standard deviation, while categorical variables were presented as counts and percentages.

Comparisons between the PAF and non-PAF groups were performed using the independent samples t-test for continuous variables and the Chi-square test for categorical variables. A two-sided p-value <0.05 was considered statistically significant.

To identify potential predictors of PAF, univariate logistic regression analyses were first conducted for all candidate variables. Parameters with statistical significance in the univariate analysis (LAVI and P-wave dispersion) were then entered into a multivariate logistic regression model to determine independent predictors of PAF. Prior to multivariate analysis, potential multicollinearity was assessed using correlation coefficients and variance inflation factors (VIFs). No significant collinearity was observed (all VIF values < 2). The results were reported as regression coefficients (B), p-values, and 95% confidence intervals (CI).

Additionally, the diagnostic performance of P-wave dispersion in predicting PAF was assessed using receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC), along with sensitivity, specificity, and the optimal cut-off value (determined by the Youden index), was calculated.

RESULTS

Of the 385 patients included in the study, 47 (12.2%) were found to have PAF during 24-hour Holter monitoring, while 338 (87.8%) had no documented arrhythmic events consistent with PAF. Baseline demographic, clinical, and laboratory characteristics of the two groups are summarized in Table 1.

Table 1. Baseline Characteristics of The Study Population According To PAF Status

Variable	PAF (n=47)	Non-PAF (n=338)	p-value
Age (years)	70.8 ± 4.6	72.2 ± 4.8	0.056
Female, n (%)	23 (48.9)	170 (50.3)	0.860
BMI (kg/m²)	25.8 ± 3.0	26.1 ± 3.2	0.531
Heart Rate (bpm)	76.3 ± 9.3	77.7 ± 10.2	0.345
Systolic BP (mmHg)	133.3 ± 9.3	134.5 ± 10.4	0.419
Diastolic BP (mmHg)	77.6 ± 6.2	77.7 ± 5.7	0.889
BUN (mg/dL)	20.2 ± 3.9	20.7 ± 4.9	0.398
Creatinine (mg/dL)	1.0 ± 0.2	1.0 ± 0.2	0.960
GFR (ml/min/1.73m²)	69.6 ± 13.8	70.5 ± 14.6	0.676
Sodium (mEq/L)	138.2 ± 2.3	138.0 ± 1.9	0.641
Potassium (mEq/L)	4.2 ± 0.2	4.2 ± 0.3	0.291
Ejection Fraction (%)	60.6 ± 5.5	59.7 ± 5.1	0.283
LA diameter (mm)	35.3 ± 3.3	35.5 ± 3.0	0.687
LAVI (ml/m²)	31.4 ± 4.4	29.1 ± 3.8	<0.001
P-wave dispersion (ms)	48.8 ± 6.1	31.7 ± 5.0	<0.001

Values are presented as mean ± standard deviation for continuous variables and as number (percentage) for categorical variables. p-values were calculated using the independent samples t-test for continuous variables and the Chi-square test for categorical variables, as appropriate.
Abbreviations: PAF: paroxysmal atrial fibrillation; BMI: body mass index; BP: blood pressure; BUN: blood urea nitrogen; GFR: glomerular filtration rate; EF: ejection fraction; LA: left atrium; LAVI: left atrial volume index;

There were no significant differences between the PAF and non-PAF groups in terms of age (70.8 ± 4.6 vs. 72.2 ± 4.8 years, p=0.056), sex distribution (48.9% vs. 50.3% female, p=0.860), body mass index, blood pressure, heart rate, renal function, electrolyte levels, or ejection fraction (60.6 ± 5.5% vs. 59.7 ± 5.1%, p=0.283). These findings suggest that the two groups were clinically and demographically comparable.

However, two parameters reflecting atrial structure and conduction properties demonstrated significant differences. The left atrial volume index (LAVI) was significantly higher in the PAF group compared to the non-PAF group (31.4 ± 4.4 mL/m² vs. 29.1 ± 3.8 mL/m², p<0.001). Similarly, P-wave dispersion was markedly greater among patients with PAF (48.8 ± 6.1 ms vs. 31.7 ± 5.0 ms, p<0.001) (Table 1).

In univariate logistic regression analysis, both LAVI (B = 0.165, p<0.001) and P-wave dispersion (B = 0.506, p<0.001) were identified as significant predictors of PAF (Table 2). However, in the multivariate model including both variables, only P-wave dispersion remained an independent predictor of PAF (B = 0.497, p<0.001), whereas LAVI lost statistical significance (B = 0.067, p=0.404). Correlation analysis demonstrated a weak but statisti-

Table 2. Univariate and Multivariate Logistic Regression Analyses for Predictors of PAF

Variables	B coefficient	P value	95% Confidence Interval		β* (Adjusted)	P value	95% Confidence Interval	
			Lower	Upper			Lower	Upper
Age (years)	–0.063	0.061	–0.129	0.003	—	—	—	—
Sodium (mEq/L)	0.042	0.590	–0.111	0.196	—	—	—	—
Potassium (mEq/L)	0.507	0.350	–0.556	1.570	—	—	—	—
LA diameter (mm)	–0.022	0.661	–0.122	0.078	—	—	—	—
LAVI (ml/m²)	0.165	<0.001	0.080	0.250	0.067	0.404	–0.090	0.224
EF (%)	0.035	0.252	–0.025	0.094	—	—	—	—
P-wave dispersion (ms)	0.506	<0.001	0.354	0.659	0.497	<0.001	0.344	0.649

In univariate analysis, increased LAVI and P-wave dispersion were significantly associated with the presence of PAF. In multivariate analysis including both variables (LAVI and P-wave dispersion), only P-wave dispersion remained an independent predictor of PAF. Values are presented as regression coefficient (B), p-value, and 95% confidence interval (CI).
Abbreviations: PAF: paroxysmal atrial fibrillation; EF: ejection fraction; LA: left atrium; LAVI: left atrial volume index; CI = confidence interval.

cally significant association between LAVI and P-wave dispersion ($r = 0.32$, $p < 0.001$). In addition, all variance inflation factor (VIF) values were < 2, confirming the absence of significant multicollinearity.

Finally, receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic utility of P-wave dispersion in predicting PAF. The area under the curve (AUC) was calculated as 0.772 (95% CI: 0.705–0.840). A P-wave dispersion cut-off value of 40.6 ms yielded a sensitivity of 83% and a specificity of 69%, as determined by the Youden index (Figure 1).

DISCUSSION

Early identification of PAF is of paramount importance, particularly in older adults, where it offers a critical window for stroke prevention.(13, 14) As atrial fibrillation is the most common arrhythmia in the elderly and a major cause of ischemic stroke, accessible and reliable predictors are needed.(15) However, data remain limited regarding arrhythmia prediction in older patients who are otherwise healthy, free of structural heart disease or major comorbidities, and who present solely with palpitations.

In this study, we evaluated the relationship between baseline P-wave dispersion and the presence of PAF in a well-defined cohort of 385 individuals aged 65 years and older. Our findings demonstrate that P-wave dispersion is a strong and independent predictor of PAF, retaining significance in both univariate and multivariate analyses. Notably, this association persisted even in a population without overt cardiovascular disease or systemic illness, highlighting the utility of P-wave dispersion as a noninvasive marker in low-risk elderly individuals.

Previous studies have established a link between P-wave dispersion and the risk of PAF.(5, 8) For instance, Dilaveris et al. showed that P-wave dispersion is a sensitive and specific ECG parameter for predicting paroxysmal AF, with values exceeding 40 ms significantly increas-

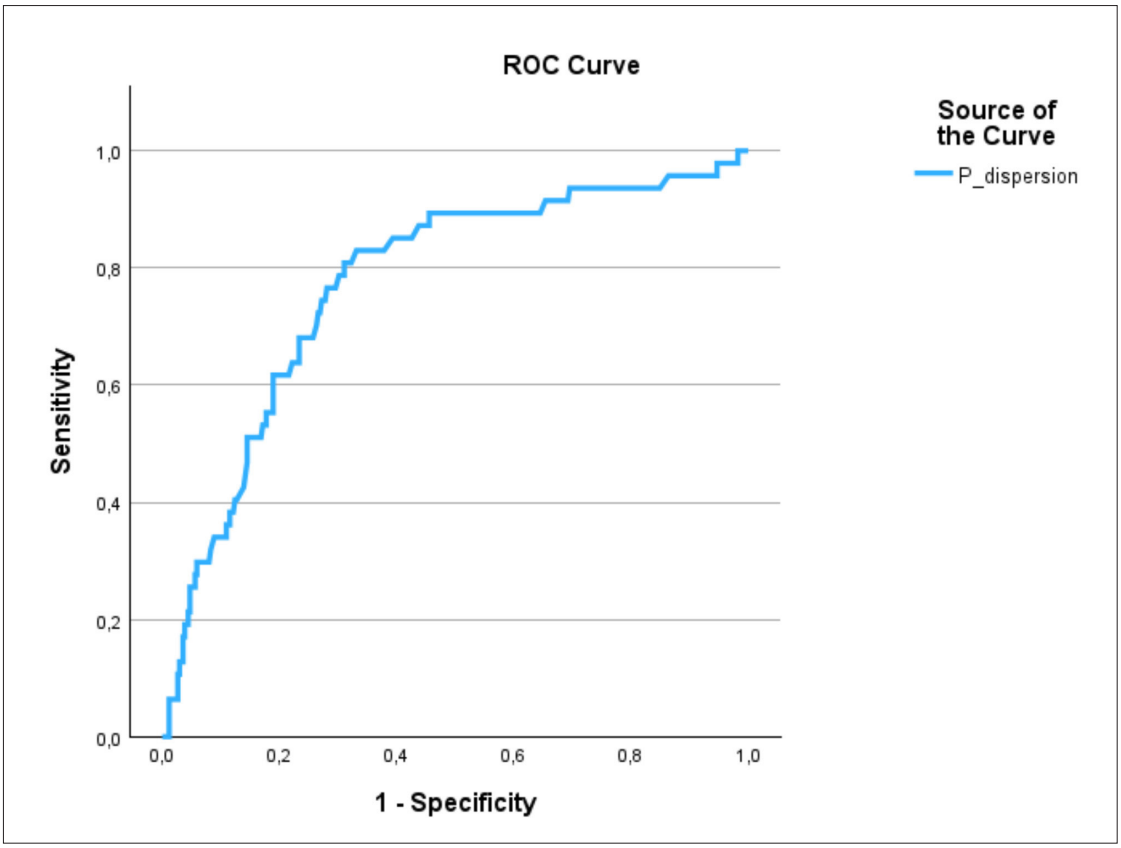


Figure 1: Receiver operating characteristic (ROC) curve of P-wave dispersion for predicting PAF.

ing the risk of arrhythmia.(5) Similarly, Dagdelen et al. found that P-wave dispersion was a valuable predictor of postoperative AF in patients undergoing coronary artery bypass grafting.(16) However, these investigations primarily involved patients with structural heart disease or those in post-surgical settings.

In contrast, the strength of our study lies in its distinct patient population. We focused exclusively on individuals without known heart disease or chronic conditions—patients who would typically be considered "healthy elderly." By isolating this population, we were able to examine the predictive value of P-wave dispersion in a context where confounding structural and systemic influences are minimal. Our results suggest that even in this relatively low-risk group, increased P-wave dispersion may reflect subtle atrial electrical remodeling and heterogeneity, serving as an early warning signal for arrhythmic potential.

Another notable observation is the initial significance of the left atrial volume index (LAVI) in univariate analysis, which did not retain statistical significance in the multivariate model. While LAVI is a well-recognized marker of structural atrial remodeling, our findings suggest that P-wave dispersion may capture electrophysiological changes that precede—or even predict structural alterations. This can be explained pathophysiologically: atrial dilatation and increased volume reflect chronic pressure or volume overload, whereas increased P-wave dispersion reflects conduction heterogeneity and electrical remodeling, which may occur earlier and predispose to arrhythmogenesis. Thus, Pd and LAVI may represent distinct but complementary dimensions of atrial vulnerability. This suggests that P-wave dispersion may be a more sensitive, early indicator of atrial vulnerability.

In summary, our study contributes novel insights into the predictive value of P-wave dispersion in a uniquely selected cohort of older adults. To our knowledge, very few studies have examined P-wave dispersion as a risk marker for PAF in healthy elderly individuals presenting with palpitations. Given the accessibility, simplicity, and non-invasive nature of ECG-based measure-

ments, P-wave dispersion may prove to be a practical tool in early risk stratification and outpatient screening strategies.

This study has several limitations. First, the retrospective and single-center design inherently limits the ability to establish causal relationships, and the findings may not be fully generalizable to other populations or clinical settings. Larger, multicenter prospective studies are needed to validate these results in broader elderly cohorts. Second, while 24-hour Holter monitoring is a standard method for detecting PAF, it may underestimate the true arrhythmia burden, especially in patients with infrequent or nocturnal episodes.(17) Longer-term monitoring approaches, such as 72-hour Holter recordings or implantable loop recorders, would likely improve detection rates and should be considered in future studies. Third, although ECG and echocardiographic measurements were performed by experienced physicians blinded to outcomes, the manual measurement of P-wave dispersion carries inherent variability. We attempted to mitigate this through repeated measurements by two independent cardiologists, but automated methods may provide greater precision in future studies. However, inter-observer and intra-observer variability statistics were not calculated, which represents a limitation of our study.

CONCLUSION

In this retrospective study of elderly patients without structural heart disease or major comorbid-ities, P-wave dispersion emerged as an independent and significant predictor of paroxysmal atrial fibrillation, while left atrial volume index did not retain predictive value in multivariate analysis. Our findings suggest that P-wave dispersion, a simple and readily available ECG pa-rameter, may reflect early atrial conduction abnormalities even in clinically low-risk individuals, and could serve as a practical tool for outpatient risk stratification.

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Abbreviations List

AF – Atrial fibrillation
AUC – Area under the curve
BMI – Body mass index
BP – Blood pressure
BUN – Blood urea nitrogen
CI – Confidence interval
ECG – Electrocardiography
EF – Ejection fraction
GFR – Glomerular filtration rate
LA – Left atrium
LAV – Left atrial volume
LAVI – Left atrial volume index
PAF – Paroxysmal atrial fibrillation
Pd – P-wave dispersion
Pmax – Maximum P-wave duration
Pmin – Minimum P-wave duration
ROC – Receiver operating characteristic
TTE – Transthoracic echocardiography
VIF – Variance inflation factor

Ethics Approval and Consent to Participate

The study protocol was reviewed and approved by a local institutional clinical research ethics committee (Approval No: 2025-1071). All procedures were carried out in accordance with the ethical standards of the responsible committee on human experimentation and with the principles outlined in the Declaration of Helsinki.

Consent for Publication

Consent for publication was obtained from all authors.

Availability of Data and Materials

Data available from the corresponding author on request due to privacy/ethical restrictions.

Competing Interests

The authors declare no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Author Contributions

YBŞ: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing original draft.
ÖS: Data curation, Formal analysis, Investigation, Supervision, Review and editing.
All authors read and approved the final version of the manuscript.

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