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A practical predictor for postoperative atrial fibrillation in patients with coronary artery bypass graft surgery: P-wave peak time in lead-V1

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ABSTRACT

Objectives: The study aimed to examine the relationship between P-wave peak time (PWPT) and postoperative atrial fibrillation (POAF) in electrocardiograms recordings before the coronary artery bypass graft (CABG) surgery.

Patients and methods: The retrospective study was conducted with 203 patients who underwent CABG surgery between January 2015 and January 2023. Patients were divided into two groups: those who developed POAF (n=40; 30 males, 10 females; mean age: 68.1±8.7 years; range, 18 to 85 years) and those who did not (n=163; 122 males, 41 females; mean age: 62.9±9.7 years; range, 18 to 85 years). The PWPT was calculated on the patients' preoperative electrocardiograms.

Results: The PWPT in lead V1 (PWPT-V1) and age were identified as strong predictors of POAF in CABG patients. In the receiver operating characteristic curve analysis, it was found that a PWPT-V1 value >41.5 had 79% sensitivity and 73% specificity for the prediction of the POAF (area under the curve=0.806, p<0.001).

Conclusion: The PWPT-V1 can predict the development of POAF in patients undergoing CABG surgery. Thanks to this parameter, necessary prophylactic treatments can be performed in these patients before surgery. As a result, mortality and morbidity can be reduced in these patients.

Keywords: Atrial fibrillation, coronary artery bypass graft, P-wave indices, P-wave peak time

One of the common complications after cardiac surgery is atrial fibrillation (AF), and it is the most common type of arrhythmia after surgery.[1] In a study, it was found that postoperative AF (POAF) developed in 25 to 50% of patients depending on the surgical procedures.[2]

Although years have passed, developing surgical methods or preoperative treatments have not caused a decrease in the number of POAF in operated patients.[3] Postoperative AF still causes increased morbidity and mortality today. It is also among the important causes of health care costs.[4] Atrial fibrillation is more common in patients with POAF compared to patients in postoperative sinus rhythm.[5]

A study has shown that POAF is associated with an increased incidence of short-term complications after coronary artery bypass graft (CABG).[6] Additionally, it has been shown in a study that POAF is associated with the risk of death and thromboembolic complications in the long term.[7]

It is known that P-wave-related parameters reflect atrial reorganization, and it is associated with an increased risk of AF in CABG patients.[8] P-wave peak time (PWPT), a new electrocardiogram (ECG) parameter, shows that the conduction time in the interatrial and interatrial area increases, and a study has shown a relationship with AF.[9]

The study aimed to examine the relationship between PWPT and POAF in ECG recordings before

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CABG surgery. If a relationship is found, PWPT could be used to identify patients at high risk for POAF and allow close monitoring of these patients after surgery, reducing mortality and morbidity in these patients.

PATIENTS AND METHODS

The retrospective study was conducted with 203 patients who underwent CABG surgery at the Bakırçay University Çiğli Training and Research Hospital, Department of Cardiology, between January 2015 and January 2023. The patients were in sinus rhythm on the ECG taken before CABG. The patients were divided into two groups: those who developed POAF (n=40; 30 males, 10 females; mean age: 68.1±8.7 years; range, 18 to 85 years) and those who did not (n=163; 122 males, 41 females; mean age: 62.9±9.7 years; range, 18 to 85 years). Electrocardiogram parameters, demographic characteristics, and blood parameters of the groups were compared. A written informed consent was obtained from each patient. The study protocol was approved by the İzmir Bakırçay University Ethics Committee (date: 18.10.2023, no: 1246). The study was conducted in accordance with the principles of the Declaration of Helsinki. The inclusion criteria were having no previous diagnosis of AF and having a documented sinus ECG before surgery. The exclusion criteria were as follows: patients with electrolyte disorders, patients without a preoperative ECG taken on the same day as the CABG surgery, patients with severe heart valve diseases and chronic renal failure, patients with pacemakers, patients using antiarrhythmic drugs, and patients with metabolic disorders.

Electrocardiograms taken on the day of the surgery were examined. The definition of POAF was made as follows: arrhythmia lasting more than 10 min and resolving spontaneously or after being treated with electrical/medical cardioversion.[8] Patients were closely monitored for arrhythmia throughout their hospital stay. An ECG was also taken when cardiac symptoms, such as palpitations, occurred. Patients who developed AF before discharge were included in the study.

Electrocardiograms were recorded in 12 leads, at 10 mm/mV and 25 mm/sec settings. Electrocardiograms were transferred digitally and

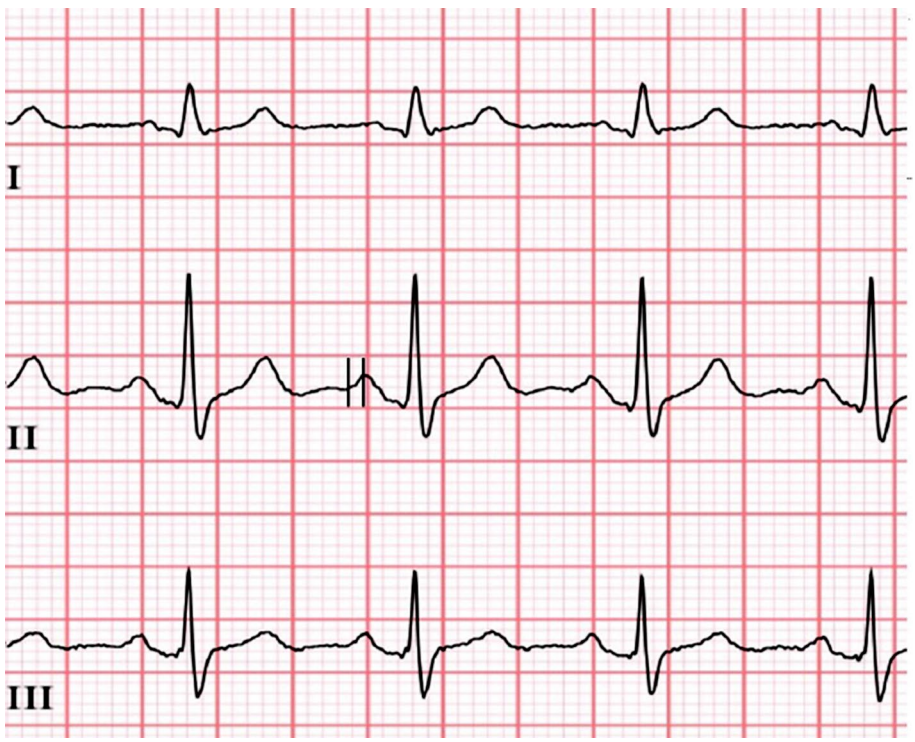

Figure 1. Calculation of P wave peak time on electrocardiographic.

loaded into software. Once the images were enlarged sufficiently, after the ECGs were evaluated by a cardiologist, they were evaluated again by another cardiologist to reduce bias. The PWPT was measured in leads D2 (PWPT-D2) and V1 (PWPT-V1; Figure 1). The beginning of the P-wave deflection determined the starting position of the measurement area. The peak of the P wave formed the last region of the measurement region. The PWPT was defined as the time between the onset of positive deflection and the peak of negative deflection during which P waves were biphasic in lead V1.

Statistical analysis

Data were analyzed using IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Histograms, Q-Q plots, and the Shapiro-Wilk test were used to evaluate whether the data met normality assumptions. A two-sample t-test and the Mann-Whitney U test were performed to compare quantitative variables between groups. The chi-square test was used to evaluate the relationship between categorical variables. The continuous data were presented as mean ± standard deviation (SD) based on the data distribution. The categorical variables were expressed as the frequency (n) and percentage (%). Logistic regression analysis was used to determine the risk factors affecting POAF status. Variables that were found to be statistically significant as a result of logistic regression analysis were evaluated with multiple logistic regression analysis. Receiver

Table 1
The baseline clinical and laboratory characteristics

	POAF (–) group (n=163)			POAF (+) group (n=40)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			62.9±9.7			68.1±8.7	**<0.001**
Sex							
Female	41	25.1		10	25		0.247
Body mass index (kg/m^2)			26.94±3.47			27.59±3.72	0.153
Hypertension	128	78.5		31	77.5		0.076
Diabetes mellitus	79	48.4		18	45		0.519
Hyperlipidemia	126	77.3		32	80		0.428
Cerebrovascular event	6	3.6		3	7.5		**0.023**
Smoking	62	38		12	30		0.152
Systolic blood pressure (mmHg)			143.73±20.8			147.4±19.52	0.154
Diastolic blood pressure (mmHg)			79.9±8.6			81.38±7.58	0.141
Gensini score			71.33±31.12			68.2±31.38	0.437
Creatinine (mg/dL)			0.93±0.44			0.85±0.29	0.36
Na (mmol/L)			140.2±3.4			138.6±2.5	0.853
K (mmol/L)			4.12±0.43			4.43±0.35	0.25
AST (U/L)			19.2±11.5			21.2±7.5	0.45
ALT (U/L)			16±14.1			20.1±16	0.17
Total cholesterol			193.54±48.03			180.93±46.17	0.06
LDL (mg/dL)			125.36±42.25			115.81±43.81	0.090
HDL (mg/dL)			34.1±5.7			32.9±4.8	0.07
White blood cell (10^3/uL)			8.2±2.4			8.1±2.2	0.30
Hemoglobin (g/dL)			10.9±1.8			11.4±2.1	0.81
Platelet (10^3/uL)			251.3±69.2			245.8±70.9	0.37

POAF: Postoperative atrial fibrillation; SD: Standard deviation; ALT: Alanine transaminase; AST: Aspartate transaminase; LDL-C: Low density lipoprotein cholesterol; HDL: High-density lipoprotein.

operating characteristic (ROC) analysis was performed to evaluate the predictive value of PWPT-V1 and age for POAF. The area under the curve (AUC) and the cutoff value were calculated for each parameter. Sensitivity and specificity were calculated to determine the diagnostic power of the scores. A p-value <0.05 was considered statistically significant.

RESULTS

When the baseline clinical and demographic characteristics of both groups were compared, the age of the patients in the POAF group was higher compared to the other group (p<0.001). The number of cerebrovascular events was also higher in the POAF group than in the other group (3 (7.5) *vs.* 6 (3.6), p=0.023). Total cholesterol count was observed at lower levels in the POAF group compared to the other group (180.93±46.17 *vs.* 193.54±48.03, p=0.037). There was no significant difference between the groups, except for age and cerebrovascular events (Table 1).

When the results of echocardiographic and electrocardiographic parameters of both groups were examined, partial interatrial block (IAB; 10 (25) *vs.* 7 (4.3), p<0.001), advanced IAB (8 (20) *vs.* 1 (0.6), p<0.001), PWPT-V1 (45.04±3.95 *vs.* 40.12±4.01, p<0.001), and PWPT-D2 (49.72±5.29 *vs.* 43.69±4.93, p<0.001) were higher in the POAF group compared to the other group (Table 2).

According to multiple logistic regression analysis, age (odds ratio [OR]=1.044, 95% confidence interval [CI]: 1.009-1.081, p=0.014), PWPT-V1 (OR=1.177,

Table 2
The echocardiographic and electrocardiographic results

	POAF (–) group (n=163)			POAF (+) group (n=40)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
LVEF (%)			53.63±9.72			52.86±9.81	0.475
Left atrium diameter (mm)			44.7±5.4			49.6±5.2	0.082
LVEDD (mm)			49.5±4.2			52.9±3.8	0.128
P-IAB	7	4.3		10	25		**<0.001**
A-IAB	1	0.6		8	20		**<0.001**
PWD (msec)			92.57±9.1			99.49±12.8	0.065
PWPT-V1 (msec)			40.12±4.01			45.04±3.95	**<0.001**
PWPT-D2 (msec)			43.69±4.93			49.72±5.29	**<0.001**

POAF: Postoperative atrial fibrillation; SD: Standard deviation; LVEF: Left ventricular ejection fraction; LVEDD: Left ventricular end-diastolic diameter; IAB: Interatrial block; PWD: P wave duration; PWPT: P wave peak time.

Table 3
The univariate and multivariate analysis for predicting POAF

	Univariate			Multivariate		
	OR	%95 CI	*p*	OR	%95 CI	*p*
Age	1.064	1.032-1.096	**<0.001**	1.044	1.009-1.081	**0.014**
PWPT-V1	1.318	1.229-1.414	**<0.001**	1.177	1.053-1.316	**0.004**
PWPT-D2	1.236	1.167-1.308	**<0.001**			
Cerebrovascular event	2.990	1.242-7.199	**0.015**			
A-IAB	26.500	7.443-94.355	**<0.001**	8.470	2.074-34.589	**0.003**
P-IAB	6.925	3.260-14.711	**<0.001**			

POAF: Postoperative atrial fibrillation; OR: Odss ratio; CI: Confidence interval; PWPT-V1: P-wave peak time in lead V1; PWPT-D2: P-wave peak time in lead D2; A-IAB: Advanced interatrial block; P-IAB: Partial interatrial block.

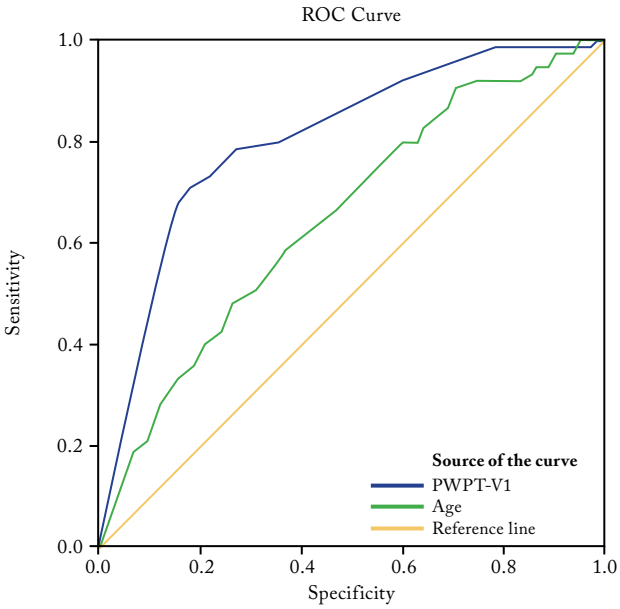

Figure 2. The ROC curve of POAF predictors in patients who underwent CABG surgery.

ROC: Receiver operating characteristics; POAF: Postoperative atrial fibrillation; CABG: Coronary artery bypass graft; PWPT: P wave peak time.

95% CI: 1.053-1.316, p=0.004), and advanced IAB (OR=8.470, 95% CI: 2.074-34.589, p=0.003) were strong independent predictors of POAF after CABG surgery (Table 3).

In ROC analysis, a PWPT-V1 >41.5 (AUC=0.806, 95% CI: 0.751-0.861, p<0.001) was found to be an independent predictor for the development of POAF after CABG surgery, with 79% sensitivity and 73% specificity. Additionally, age >66.5 years (AUC=0.653, 95% CI: 0.586-0.721, p<0.001) was identified as another independent predictor, with 59% sensitivity and 63% specificity (Figure 2).

DISCUSSION

This comprehensive study investigated the relationship between CABG surgery and POAF. The most important finding in this study was that PWPT-V1, an ECG parameter, was an independent predictor of POAF.

In the past, AF was not considered a significant complication after heart surgery. However, a study has revealed that POAF affects mortality and morbidity.[10] In a study conducted with CABG patients, patients with POAF were examined. A prolonged need for ventilation and longer stays in the intensive care unit and hospital were observed in patients with POAF.[11] It has also been revealed that POAF is associated with an increased risk of mortality and stroke in the long term.[12]

Since it is understood that POAF developing after cardiac surgery can lead to significant complications, it becomes important to identify patients at high risk for AF. For this purpose, conduct comprehensive studies on POAF have been conducted.

Some factors may lead to the development of POAF. A study found a relationship between hypoxemia and POAF.[13] In another study, a relationship was found between different surgical techniques and POAF.[14] The multitude of risk factors that can lead to AF can lead to the development of POAF. In a meta-analysis with 36,834 participants, advanced age, increased left atrium diameter, low ejection fraction, chronic obstructive pulmonary disease, hypertension, myocardial infarction, and diabetes were found to be associated with the development of POAF.[15]

In the ECG, the wave associated with atrial depolarization is the P wave. Structural changes and arrhythmias in the atria can cause changes in the P wave. Therefore, studies have examined whether there is a relationship between P-wave changes and POAF. An ECG taken before undergoing surgery is the simplest method that can be used to predict POAF.

In recent studies, the relationship between PWPT, a new ECG parameter, and AF has been examined. In a study conducted with patients in sinus rhythm with acute ischemic stroke, a significant relationship was found between paroxysmal AF detected in Holter ECG and P-wave duration, dispersion, and terminal force in ECGs.[26] In another study on acute ischemic stroke patients, it was examined whether there was a relationship between PWPT and paroxysmal AF, and it was determined that there was a relationship between PWPT and AF.[16] Another study found PWPT-D2 and PWPT-V1 to be strong markers predicting POAF in patients.[17] Unlike our study, it was found that only PWPT-V1 could be associated with POAF. Furthermore, the AUC, sensitivity, and specificity values of PWPT-V1 in our study in the ROC curve analysis were higher compared to the previous study.[17] We did not have information about the coronary lesions of the CABG patients

included in the study. In a study, PWPT-V1 was found to be significantly longer in the multivessel slow flow group than in the single-vessel group.[18] It was stated that these findings may be related to ischemia being affected by a larger myocardial area and multivessel slow flow.[18] The significant results observed in PWPT-V1 in our study may be due to these reasons.

In IAB, the activation time between the atria is longer than normal. Therefore, the P-wave duration of patients with IAB is ≥120 msec.[19] It was demonstrated that IAB may lead to AF.[20] In one study, IAB was found to be a predictor of AF in patients with coronary artery disease and carotid artery disease.[21] Interatrial block is important because it is commonly found in the elderly population and has previously been associated with AF.[22] In a study, it was found that IAB detected the emergence and recurrence of AF.[23] Bachmann's area is the largest interatrial conduction pathway. It is thought that fibrosis in this region may lead to IAB.[21] The fact that IAB was statistically significant in our study can be explained by this mechanism.

Age is an independent risk factor for the development of AF.[24] It is estimated that AF observed in elderly patients in the European Union will be more than twice as common after 50 years.[25] With this study, we determined the relationship between age and AF and found that one of the most important risk factors for POAF is advanced age.

Atrial fibrillation is a high-risk disease group in terms of ischemic events. Therefore, cerebrovascular events may occur more frequently in these patients. This may explain the higher incidence of cerebrovascular events in the AF group in our study.

The most important limitation of the study was the retrospective design. Lack of sufficient knowledge about the surgical techniques applied was also a significant limitation since the surgical techniques applied may have affected PWPT-V1 values. The data on the anesthetic drugs given to patients before surgery were also absent. The anesthetic agents given may also have influenced PWPT-V1 values. Multicenter, prospective, randomized controlled studies are needed to better understand whether this parameter is predictive of POAF.

In conclusion, PWPT-V1 can predict the development of POAF in patients undergoing CABG. Utilizing this parameter, necessary prophylactic treatments can be performed in these patients before surgery, reducing mortality and morbidity.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, design, control/supervision, analysis and/or interpretation, literature review, writing the article, critical review, materials: İ.K., E.K.; Data collection and/or processing: İ.K.

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