

# Diagnostic accuracy of P-wave dispersion in prediction of maintenance of sinus rhythm after external cardioversion of atrial fibrillation

*Atrial fibrilasyonun eksternal kardiyoversiyondan sonra sinüs ritminin korunmasını öngörmeye P dalga dispersiyonunun tanısal değeri*

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## ABSTRACT

**Objective:** P-wave dispersion (PWD) is an electrocardiographic measurement, which reflects a disparity in an atrial conduction. In this study, we aim to demonstrate the diagnostic accuracy of PWD in predicting recurrence of atrial fibrillation (AF) in patients with sinus rhythm restoration after external cardioversion.

**Methods:** This prospective, observational study consists of 26 patients, who underwent external cardioversion for non-valvular persistent AF and successfully cardioverted to sinus rhythm (13 men, mean age 58.1±11 years). Twelve-lead surface electrocardiogram of each patient was recorded immediately after the external cardioversion process to measure the P-wave duration. Recurrent AF was assessed for each patient during the 12-month follow-up after restoring the sinus rhythm. Patients were divided into the 2 groups with respect to the AF recurrence (recurrent AF group, (n=19), and sinus rhythm group, (n=7)) and variables that can affect AF development were compared between the two groups. Stepwise logistic regression analysis was used to identify the independent predictors of AF recurrence and ROC curve analysis was performed to determine the cut-off value of independent factors.

**Results:** The two groups have similar demographic, clinical and echocardiographic features. Patients with recurrent AF had significantly higher PWD than those who continued to have a sinus rhythm (80±21 msec vs 53±11 msec, p=0.001, respectively). There is a positive correlation observed between the increase in PWD and the risk of AF recurrence (r=0.643; p<0.001). In logistic regression analysis, PWD was found to be an independent predictor of AF recurrence (OR 1.192 (95% CI 1.032-1.375), p= 0.013). Receiver operating characteristic analysis revealed that the best cut-off value of PWD for maintenance of sinus rhythm was 58 msec (sensitivity: 86%, specificity: 95%, AUC=0.917, 95% CI=0.785-1.05, p=0.001).

**Conclusion:** This study suggests that PWD analysis after successful external cardioversion has diagnostic accuracy to predict the recurrence of AF (*Anadolu Kardiyol Derg 2011 1: 34-8*)

**Key words:** Atrial fibrillation, cardioversion, electrocardiography, P-wave dispersion, predictive value of tests, diagnostic accuracy

## ÖZET

**Amaç:** P dalga dispersiyonu (PWD) atriyal iletimdeki farklılığı gösteren elektrokardiyografik bir ölçümdür. Bu çalışmanın amacı, eksternal kardiyoversiyon sonrası sinüs ritminde olan hastalarda PWD'nin atriyal fibrilasyon (AF) rekürrenslerini öngörmeye tanısal değerini göstermektir.

**Yöntemler:** Bu prospektif gözlemsel çalışmaya, başarılı eksternal kardiyoversiyonla sinüs ritmi sağlanmış, kapak hastalığı dışı persistan AF'si olan 26 hasta dâhil edildi (13 erkek, yaş ortalaması 58.1±11 yıl). Eksternal kardiyoversiyondan hemen sonra, P dalga süresini ölçmek için tüm hastaların 12 derivasyonlu yüzeysel elektrokardiyografileri çekildi. Sinüs ritmi sağlandıktan sonraki 12 aylık takip süresinde tüm hastaların tekrar eden AF'leri değerlendirildi. Hastalar AF rekürrens gelişimine göre 2 gruba ayrıldı (AF rekürrens grubu (n=19) ve sinüs ritim grubu (n=7)) ve bu gruplar, AF rekürrenslerini etkileyebilecek değişkenler açısından karşılaştırıldı. Atriyal fibrilasyon rekürrenslerinin bağımsız öngördürücülerinin belirlenmesinde basamaklı lojistik regresyon analizi ve bağımsız öngördürücülerin kestirim değerinin belirlenmesinde ROC eğrisi analizi kullanıldı.

**Bulgular:** Her iki grubun demografik, klinik ve ekokardiyografik özellikleri benzerdi. Atriyal fibrilasyonu tekrarlayan hastaların PWD değerleri sinüs ritmi devam eden hastalara göre anlamlı olarak daha yüksekti (sırasıyla 80±21 msn ve 53±11 msn, p=0.001). P dalga dispersiyonundaki artış ile AF'nin tekrarlama riski arasında pozitif korelasyon izlendi (r=0.643; p<0.001). Lojistik regresyon analizinde PWD AF rekürrenslerinin bağımsız

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öngördürücüsü olarak bulundu (OR 1.192 (%95 CI 1.032- 1.375),  $p= 0.013$ ) ve sinüs ritminin korunmasında en iyi kestirim değeri 58 msn olarak tespit edildi (duyarlılık: %86, özgüllük: %95, AUC=0.917, %95 CI=0.785- 1.05,  $p=0.001$ ).

**Sonuç:** Bu çalışmada, P dalga dispersiyonunun başarılı eksternal kardiyoversiyon sonrası AF rekürrensini öngörmeye tanısıl değere sahip olduğu gösterilmiştir. (*Anadolu Kardiyol Derg 2011 1: 34-8*)

**Anahtar kelimeler:** Atriyal fibrilasyon, kardiyoversiyon, elektrokardiyografi, P dalga dispersiyonu, testlerin öngördürücü değerleri, tanısıl değer

## Introduction

Atrial fibrillation (AF) is the most common continuous cardiac arrhythmia and occurs in the progression of heart failure, hypertensive cardiac disease and coronary artery disease, which all affect the atriums. Two electrocardiographic markers, maximum P-wave duration (P max) and P-wave dispersion (PWD) are simple electrocardiographic (ECG) markers that have been reported to be associated with inhomogeneous and discontinuous propagation of sinus impulses (1). Prolonged P-wave duration and increased PWD have been reported to be associated with an increased risk for atrial fibrillation (2). Furthermore, the maximum duration and dispersion of the P-wave have been reported to be predictors of recurrence of AF in patients with symptomatic episodes of AF (1, 3). After the restoration of sinus rhythm, determination of predictors of AF recurrence will be beneficial in treatments and follow-ups. Nowadays, the P-wave dispersion and the longest P-wave duration, which are simple ECG parameters, are suggested to be useful in the early diagnosis of AF.

In this study, we aim to demonstrate the diagnostic accuracy of PWD in predicting recurrence of AF in patients with sinus rhythm after an external cardioversion process.

## Methods

### Patients

This prospective, observational study consists of 26 patients who underwent elective cardioversion for non-valvular persistent AF and were successfully cardioverted to a desired sinus rhythm (13 men, 13 women, mean age  $58.1\pm 11$  years). Patients with left atrial thrombus and valvular heart disease were excluded from the study. A written informed consent was obtained from all patients.

### Electrocardiography

Twelve-lead surface electrocardiogram, which was performed manually by two of the investigators, was recorded for each patient at a rate of 50 mm/s immediately after the external cardioversion to measure the P-wave duration. The onset of the P-wave was defined as the junction between the isoelectric line and the beginning of the P-wave deflection and the offset of the P-wave as the junction between the end of the P-wave deflection and the isoelectric line (4, 5). P-wave dispersion was defined as the difference between maximum and minimum P-wave duration (3, 5).

### Echocardiography

All patients underwent routine transthoracic and transesophageal echocardiographic examination (Aloka SSD-550, Aloka Co,

Japan). Left atrial (LA) diameter, left ventricular end-diastolic and end-systolic diameters and left ventricular ejection fraction (LVEF) were determined by transthoracic echocardiographic examination before cardioversion. Presence of a left atrial thrombus was determined by a transesophageal echocardiographic examination.

### Study protocol

All patients underwent anticoagulation with warfarin for 4 weeks after the cardioversion. Amiodarone (200mg/day) or sotalol (160 mg/day) were prescribed to all patients until to the 1<sup>st</sup> AF recurrence time (in AF recurrent group) or during the whole study period (in sinus rhythm group).

The study period was limited to 12 months after conversion to a sinus rhythm. There were no withdrawals at follow-up. Control electrocardiograms were performed routinely once for every month. Each patient was warned to go to the hospital, whenever a symptom related to AF relapse occurred. Review of the patients' records and ECGs were used to document AF recurrence.

### Statistical analysis

Data were analyzed using SPSS software version 12.0 for Windows statistical package (SPSS Inc., Chicago, IL, USA). Statistical analysis was performed using a Mann-Whitney U test and a Chi-square test wherever appropriate. Pearson correlation analysis was used to analyze the relationship of AF recurrence with clinical, electrocardiographic and echocardiographic variables. Stepwise logistic regression analysis was performed to identify the independent predictors of AF recurrence. The independent variables include: clinical and electrocardiographic features that have been identified as predictors of AF (age, LA diameter, LVEF and PWD) (6-11). Receiver operating characteristic (ROC) curve analysis was used to identify optimal cut-off values of PWD level to identify maximum sensitivity and specificity for detection of recurrent AFs. Differences were considered to be statistically significant if the  $p$  value was  $<0.05$ .

## Results

Recurrent AF was observed in 19 patients (73.1%) at an average of  $3.0\pm 2.6$  months. There was no difference between the groups of patients with and without AF recurrence in terms of gender, presence of hypertension, diabetes mellitus, hypercholesterolemia, smoking habits, coronary artery disease history, lone AF and LA diameter and LVEF. There was no significant difference between the two groups in type of medications used after cardioversion (Table 1).

Maximum P-wave duration and PWD of patients with recurrent AF were found to be significantly higher than in those who continued to have a regular sinus rhythm ( $p=0.02$  and  $p=0.001$ , respectively) (Table 2). However, there was no statistically significant difference between the two groups regarding minimum P-wave duration ( $p=0.9$ ). There is a positive correlation between the increase in PWD and the risk of AF recurrence ( $r=0.643$ ;  $p<0.001$ ).

In stepwise logistic regression analysis, only PWD was found to be an independent predictor of AF recurrence (OR 1.192 [95% CI 1.032-1.375],  $p=0.013$ ).

ROC analysis revealed that the best cut-off value of PWD for maintenance of sinus rhythm was 58 msec (sensitivity: 86% [95% CI 42-99%], specificity: 95% [95% CI 72-99%], positive predictive value: 86% [95% CI 42-99%], negative predictive value: 95% [95% CI 72-99%] [AUC=0.917, 95% CI=0.785-1.05,  $p=0.001$ ] (Fig. 1).

## Discussion

In the present study, we investigated whether P-wave duration and PWD analysis could provide a non-invasive way of predicting recurrences of atrial fibrillation after a successful external cardioversion. Our results suggest that P-wave dispersion has diagnostic accuracy to predict the recurrence of atrial fibrillation.

External cardioversion is a safe and effective treatment modality in arrhythmias originating from the atrium. Unfortunately, most patients usually relapse to AF within a few weeks of cardioversion and only about 25% of the patients remain in a desired sinus rhythm during the year after post-cardioversion (12-14). In the literature, a number of clinical and demographic features have been suggested to be associated with increased risk of AF recurrence. In Stroke Prevention in Atrial Fibrillation (SPAF) trial, age, presence of heart failure, myocardial infarction and left atrium size were found to be clinical and echocardiographic predictors of recurrent AF (6). In Atrial Fibrillation Follow-up Investigation of Rhythm Management (AFFIRM) trial the risk factors for the recurrence of AF were reported as no coronary artery disease, longer PWD, second or greater episode of AF, LVEF  $<0.50$ , and mitral valve thickening, however the overall sensitivity and specificity of these parameters for recurrence and repeated cardioversion were found to be low (7). Therefore, it remains unclear which parameters exactly predict clinical recurrence of AF.

Interatrial conduction delays have been implicated in initiating and maintaining AF (15-17). Prolongation of intraatrial and interatrial conduction times and the inhomogeneous propagation of sinus impulses are well-known electrophysiological characteristics of the atrium, which is prone to fibrillate and has been evaluated by two simple electrocardiographic markers, P maximum and PWD (3). P-wave dispersion is defined as the difference between maximum and minimum P-wave durations. In the present study, maximum P-wave duration and PWD were

**Table 1. Clinical and echocardiographic characteristics of patients with respect to atrial fibrillation recurrence**

Variables	Sinus rhythm group (n= 7)	AF recurrence group (n= 19)	p*
Gender: female, n (%)	4 (57.1)	9 (47.3)	NS
male, n (%)	3 (42.9)	10 (52.6)	
Age, years	51.7±14.4 51 (33-75)	60.4±9.1 60 (40-74)	*NS
Hypertension, n (%)	3 (42.9)	11 (57.9)	NS
Diabetes mellitus, n (%)	1 (14.3)	3 (15.8)	NS
Hypercholesterolemia, n (%)	5 (71.4)	5 (26.3)	NS
Smoking history, n (%)	1 (14.3)	3 (15.8)	NS
CAD, n (%)	2 (28.6)	9 (47.3)	NS
LVEF, (%)	50±17 40 (32-75)	44±15 44 (30-75)	*NS
Left atrial diameter, mm	4.17±0.30 4.3 (3.6-4.4)	4.27±0.55 4.3 (3.3-5.5)	*NS
Lone AF, n (%)	2 (28.6)	3 (15.8)	NS
Warfarin, n (%)	3 (42.9)	8 (42.1)	NS
Aspirin, n (%)	6 (85.7)	17 (89.4)	NS
ACE inhibitors, n (%)	4 (57.1)	11 (57.9)	NS
Beta-blocker, n (%)	4 (57.1)	10 (52.7)	NS
Statin, n (%)	3 (42.9)	7 (36.8)	NS
Post-cardioversion medication			
Amiodarone, n (%)	4 (57.1)	12 (63.1)	NS
Sotalolol, n (%)	3 (42.9)	7 (36.8)	NS

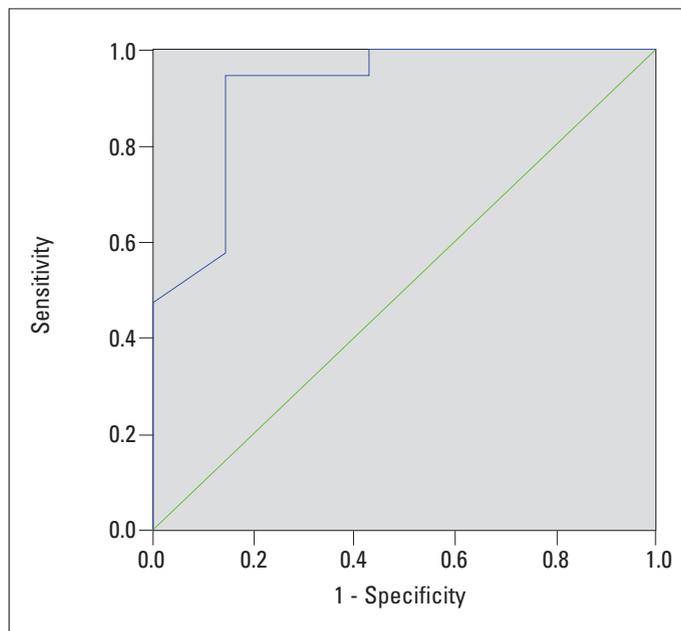
Data are presented as mean±SD, median (min-max) values and proportions/percentages  
\*Chi - square test and Mann - Whitney U test  
ACE - angiotensin converting enzyme, AF - atrial fibrillation, CAD - coronary artery disease, LVEF - left ventricular ejection fraction, NS - nonsignificant

**Table 2. Electrocardiographic parameters immediately after external cardioversion to sinus rhythm with respect to atrial fibrillation recurrence**

Variables	Sinus rhythm group (n= 7)	AF recurrence group (n= 19)	p*
Maximum P-wave duration, msec	131.42±14.68 124 (120-152)	158±26.03 152 (112-210)	0.02
Minimum P-wave duration, msec	77.71±11.04 76 (64-100)	78±15.66 80 (49-105)	0.9
P-wave dispersion, msec	53.71±11.51 52 (42-76)	80±21.78 76 (54-148)	0.001

Data are presented as mean±SD and median (min-max) values  
Mann-Whitney U test  
AF- atrial fibrillation

detected to be significantly higher in patients with AF recurrence compared with patients remained in sinus. Although the predictive value of P-wave dispersion has been demonstrated by previous studies (10, 18, 19), the data on diagnostic accuracy



**Figure 1. Receiver operating characteristic (ROC) curve for P-wave dispersion values and AF recurrence (ROC curve analysis - AUC=0.917, 95% CI=0.785-1.05, p=0.001)**

AF - atrial fibrillation, AUC - area under curve, CI - confidence interval

of the PWD in prediction of AF recurrence has not been well defined. Lin et al. (18) demonstrated that the mean duration of a P-wave of >125 ms is the only significant predictor of clinical recurrence of AF after patients with AF go through an electrical cardioversion. Perzanowski et al. (10) has shown that PWD greater than 80 msec correlates with a higher risk of AF after cardioversion. Furthermore, in another study, PWD <46 msec ( $p<0.001$ ) was found to be an independent predictor of sinus rhythm maintenance, with a sensitivity of 96% (19). In the present study, increased PWD values were found to be correlated with recurrent AF and a PWD <58 msec was found to be an independent predictor of sinus rhythm maintenance, with a sensitivity of 86% and a specificity of 95%.

P-wave dispersion is a useful and simple method in prediction of recurrent AFs and shows the prolonged interatrial conduction independent from LA enlargement (20). Likewise, Dilaveris et al. (1) and Ishimoto et al. (21) reported that there was no correlation between P maximum duration and PWD and the LA diameter. There are contradictory results about the LA enlargement, which may play a role in maintenance of sinus rhythm in patients with an AF. Volgman et al. (11) has shown that patients with LA dimension greater than 65 mm were associated with an AF recurrence. Similar results by Flaker et al. (6) and Ökçün et al. (22) demonstrated that an enlarged LA predicted recurrence of an AF after cardioversion. However, Omran et al. (23) and Lin et al. (18) found no correlation between LA diameters and recurrence of AFs. In the present study, there was no statistically significant difference of baseline atrial sizes between patients with and without an AF recurrence. Furthermore, there was no association of PWD with LA diameters.

### Study limitations

The small sample size and the unavailability of data about definite duration of an AF before external cardioversion are the main limitations of the study.

### Conclusion

Our results suggest that P-wave dispersion analysis after external cardioversion is an inexpensive, noninvasive and simple method, which has diagnostic accuracy to predict the recurrence of atrial fibrillation after the restoration of the sinus rhythm.

**Conflict of interest:** None declared.

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