P Wave Amplitude and Duration may Predict Immediate Recurrence of Atrial Fibrillation After Internal Cardioversion

Bulent Gorenec, M.D., Alpaslan Birdane, M.D., Gulmira Kudaiberdieva, M.D., F.E.S.C., Omer Goktekin, M.D., Yuksel Cavusoglu, M.D., Ahmet Unalir, M.D., Necmi Ata, M.D., and Bilgin Timuralp, M.D.

From the Department of Cardiology, Osmangazi University School of Medicine, Eskişehir, Turkey

Background: Although internal cardioversion (IC) for atrial fibrillation (AF) is effective at restoring sinus rhythm, immediate recurrence (IR) of AF after IC is a major and largely unpredictable clinical problem. The purpose of the study was to determine the role of P wave duration and amplitude in prediction of IR of AF after IC. Forty-five consecutive patients undergoing IC for chronic AF were evaluated.

Material and Methods: After successful IC, 1-minute ECG recording was obtained in all patients. P wave duration and amplitude in Lead II and V₁ were measured using computer. Forty patients (88%) had successful IC. Thirteen patients experienced IR of AF within 1 minute of restoring sinus rhythm.

Results and Conclusion: As a result, the incidence of IR of AF after IC was higher in the patients with shorter P wave amplitude (for lead II $P < 0.01$, for V₁ $P < 0.01$) and larger P wave duration (for lead II $P < 0.01$, for V₁ $P < 0.05$).

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Atrial fibrillation (AF) is a major arrhythmia, which still has a high prevalence among the population. Different approaches including antiarrhythmic drug therapy and electrical cardioversion are used to convert AF to sinus rhythm (SR). External and intraatrial shocks are given in an attempt to convert AF to SR with a higher acute success rate of intraatrial shocks but similar long-term recurrence rates of AF.¹ Despite successful conversion of AF to SR, the immediate recurrence (IR) of AF after cardioversion is a major and largely unpredictable clinical problem, and little is known about the mechanisms responsible for IR of AF following the use of either one of these techniques.^{2–5} Prior studies have demonstrated that individuals with a clinical history of paroxysmal AF have a significantly longer intraatrial and interatrial conduction time of sinus impulses, which causes P wave prolongation in 12-lead ECG and signal-averaged ECG recordings.

Inhomogeneous prolongation of sinus impulses may predict the recurrence of paroxysmal atrial fib-

rillation (PAF).⁴ The heterogeneity of the structural and electrophysiological properties of the atrium prone to fibrillate, results in an inhomogeneous and discontinuous prolongation of sinus impulses.⁵ Previous studies have demonstrated that individuals with a clinical history of PAF have a significantly longer intraatrial and interatrial conduction time of sinus impulses, which has not only been electrophysiologically determined,^{6–8} but has also been shown as P wave prolongation on 12-lead surface ECG and signal-averaged ECG recordings.^{9–11} The importance of P wave dispersion in predicting the recurrence of atrial fibrillation (AF) in patients with PAF has also been elucidated.^{4,12} Although the P wave signal-averaged ECG could be useful in identifying patients at risk for recurrence of AF after internal cardioversion (IC),¹³ we do not know enough about electrocardiographic predictors of recurrence, especially IR, after cardioversion. The purpose of the study was to investigate the role of P wave properties, duration, and amplitude in the prediction of IR of AF after IC.

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Address for reprints: Bulent Gorenec, M.D., Department of Cardiology, Osmangazi University School of Medicine, Eskişehir, Turkey. Fax: 00 90 222 2395370; E-mail: bgorenec@hotmail.com

METHODS

Patients with chronic AF who were successfully converted to SR by IC were studied. Forty-five consecutive patients (29 female, mean age 57 ± 8 years) undergoing IC for chronic AF (mean duration 13 months)⁴⁻²³ were evaluated. Atrial fibrillation was defined as chronic if it was present for ≥ 1 month. Antiarrhythmic drugs were withdrawn at least five half-lives before IC. All patients underwent a work-up that included a history and physical examination, 12-lead ECG, chest x ray, M-mode, bidimensional, and color Doppler echocardiogram, laboratory tests (including creatinine serum potassium, and complete blood count), and thyroid function evaluation. Transesophageal echocardiography was performed if clinically indicated.

Patients with AF were treated with warfarin for at least 3 weeks prior to defibrillation. The dose was adjusted to maintain international normalized ratio (INR) levels up to 2.0. Warfarin was withheld 48 hours prior IC and was resumed following IC and continued for 4 weeks in those patients who successfully reverted to sinus rhythm, and indefinitely in patients who remained in AF. The long-term INR was adjusted individually to patients' characteristics.

Low energy biphasic DC shocks were delivered via electrodes placed in the right atrial appendage and coronary sinus. After successful IC, a 1-minute ECG recording was obtained in all patients. P wave duration and amplitude in Lead II and V₁ were measured using a computer.

Successful IC was defined as the presence of two or more consecutive P waves after shock delivery. Immediate recurrence of AF was defined as the resumption of AF within 1 minute after DC shock that resulted in sinus rhythm for at least two or more consecutive beats. Digitally stored ECGs were displayed on a high resolution computer screen (on-screen measurement). Leads II and V₁ were separately magnified with a magnification of 160 mm/s and 60 mm/mV. The onset and the offset of the P wave were defined as the junction between the P wave pattern and the isoelectric line and marked with the cursor. If the baseline noise was >10 mV and/or the peak of the isoelectric line P wave amplitude <15 mV, the patient was excluded from the study.

Patients were excluded from the study if they had any of the following criteria: PAF, hyperthyroidism, acute myocardial infarction, unstable

Table 1. Clinical Characteristic of the Patients

	Group A	Group B	p
Men/women	4/9	9/18	
Age (years)	59 ± 8	56 ± 7	NS
Mean heart rate (beats/min)	69 ± 8	72 ± 9	NS
Left atrial dimension (mm)	46 ± 4	48 ± 5	NS
Left ventricular ejection fraction (%)	67 ± 9	65 ± 8	NS
Duration of AF (months)	12 ± 8	13 ± 9	NS

AF: Atrial fibrillation, NS: No significant.

angina pectoris, history of thromboembolic event, left atrial or left ventricular thrombus, presence of serious ventricular arrhythmias, digitalis toxicity, significant electrolyte imbalance, and an implanted pacing device. Patients were also excluded from the study if they had signs of atrial ectopy immediately after IC, because they could disturb the atrial conduction and could induce AF relapse after cardioversion.¹⁴

RESULTS

The etiological and clinical characteristics of the patients are shown in Tables 1 and 2.

There were no differences in age, left atrial diameter, and etiology of AF between the two groups. Forty patients (88%) had successful IC. Thirteen patients experienced IR of AF within 1 minute of restoring SR. The mean P wave amplitude and duration in patients who experienced IR of AF (group A) and in patients who did not (group B), are presented in Table 3. The incidence of IR of AF after IC was higher in the patients with shorter P wave amplitude (for lead II, $P < 0.01$; for V₁, $P < 0.01$) and larger P wave duration (for lead II, $P < 0.01$; for V₁, $P < 0.05$).

DISCUSSION

Several clinical and ECG predictors of AF have been identified in previous studies. Many of these

Table 2. Etiology of Atrial Fibrillation

	Group A	Group B
Valvular heart disease	6	13
Coronary heart disease	2	5
Cardiomyopathy	3	5
Lone	2	4

Table 3. P Wave Amplitudes and P Wave Durations of the Patients

	Group A	Group B	p
P wave amplitude in Lead II	0.12 ± 0.02 Mv	0.19 ± 0.04 Mv	<0.01
P wave duration in Lead II	120 ± 28 ms	78 ± 11 ms	<0.01
P wave amplitude in V ₁	0.04 ± 0.01 Mv	0.08 ± 0.01 Mv	<0.01
P wave duration in V ₁	83 ± 12 ms	60 ± 8 ms	<0.05

studies have demonstrated that individuals with a clinical history of PAF have significantly longer interatrial conduction time of sinus impulses, both electrophysiologically documented and expressed as P wave prolongation in 12-lead and signal-averaged ECGs.^{4,8,10,15–17} Morphological differences in P wave have been associated with the inhomogeneous and discontinuous propagation of sinus impulses in the case of paroxysmal lone AF.^{4,16} Increased P wave duration and P wave dispersion are commonly found in patients with a history of PAF. P wave dispersion has already been utilized for the prediction of AF in patients undergoing coronary artery bypass surgery.¹⁸ In a study by Dilaveris et al., P wave dispersion was found to be significantly higher in hypertensive patients with a history of PAF than those without.¹⁹

The studies on the prediction of recurrence of AF by P wave analysis after cardioversion are scanty. P wave signal-averaged ECG could be useful in identifying patients at risk of recurrence of AF after external cardioversion.¹³ In a recent study, P wave dispersion detected in standard 12-lead ECG and right precordial leads is found to be an important predictor of recurrence of AF after external cardioversion.²⁰

The studies on IR after cardioversion are very limited. In one study, 26% of the patients who successfully converted to SR experienced immediate recurrence of AF within 1 minute of SR restoration after external cardioversion.²¹ Timmermans and coworkers showed that the IR after IC, which occurred in 13% of the patients was always initiated by atrial premature beat having a short coupling interval not originating from the defibrillation catheters, and was prevented by repeated shock delivery with or without the preceding administration of pharmacological agents.¹⁴ However, in order to demonstrate the effects of P wave duration and amplitude on AF relapse after IC, we exclude patients with atrial ectopic beats, which could affect atrial conduction properties.

Previous studies have revealed P wave prolongation after external cardioversion for AF.^{22,23} We demonstrate for the first time that P wave properties assessed by surface ECG are valuable in predicting the IR of AF after IC. The P wave assessment could be related to the intraatrial conduction characteristics.

The differences in P wave duration and amplitude between groups may be the sign of marked electrical remodeling. Intracellular calcium overload is considered as an important factor in the genesis of atrial electrical remodeling and recurrence of AF.²⁴ So, the prolongation of P wave duration may be related to the slowing of impulse propagation and inhomogeneity of atrial conduction in the presence of atrial remodeling in patients with AF relapse after IC.

To our knowledge only one study has investigated the role of P wave amplitude in patients with and without AF development after cardiac coronary surgery.²⁵ Authors failed to show any dependence of AF recurrence on P wave amplitude. By contrast, our findings demonstrated that patients with IR of AF have lower P wave amplitude. Why the amplitude of P wave is lower in a group of patients with AF recurrence is not yet defined, but we can only speculate that atrial stunning²⁶ after electrical cardioversion may possibly play a role in such a behavior of P wave. Further studies should address the clarification of this phenomenon.

In our report the number of patients taken for the study was limited. So it was not possible to perform subgroup analysis. Although we sometimes have difficulties in determining P wave duration, we can practically measure P waves durations in all patients. Truly, the duration of P wave may be difficult to interpret from the surface ECG, but we used a high resolution two-leads ECG computer system with the capability of storing 1-minute recordings. The measurements were made from lead II and V₁, where P wave could be more precisely analyzed and no patient was excluded from the analysis.

CONCLUSIONS

The findings of this study suggest that patients at risk of IR of AF after successful IC could be detected by P wave analysis. By P wave analysis using surface ECG without sophisticated programs it is possible to distinguish the patients in whom IR of AF will occur and in those in which it will not.

The incidence of IR is higher in patients with shorter P wave amplitude and larger P wave duration. Further studies, however, are required to determine whether these simple markers may be used as indicators of the recurrence of IR.

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