P-wave dispersion in patients with rheumatic mitral stenosis

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It has previously been shown that maximum P-wave duration and P-wave dispersion in 12-lead surface electrocardiogram (ECG) are significantly increased in patients prone to developing atrial fibrillation. Because patients with mitral stenosis (MS) are also susceptible to developing atrial fibrillation, the present study was carried out to determine whether maximum P-wave duration and P-wave dispersion are prolonged in MS patients during normal sinus rhythm. In addition, the correlation between these P-wave variables and the left atrial size, transmitral valve gradient and mitral valve area were determined. Fifty consecutive patients (40 women and 10 men; mean age 35.76±6.59 years) with MS who were in normal sinus rhythm, and a control group of 50 age- and sex-matched healthy persons were studied.

A 12-lead ECG was obtained for each subject. All ECGs were scanned through a Cannon scanner at 300 dpi and saved as images in a personal computer. The minimum and maximum P-wave durations, as well as P-wave dispersion, were subsequently calculated. In addition, all patients were evaluated by echocardiography to measure the left atrial size, transmitral valve gradient and mitral valve area by planimetry. The P-wave parameters were compared between the two groups and the correlation between these parameters and the echocardiographic variables were determined in patients with MS. The most important findings included a significant prolongation of maximum P-wave duration in patients with MS compared with controls (P<0.001), and a strong correlation between the maximum P-wave duration and left atrial size (r=0.505, P<0.001), transmitral valve gradient (r=0.371, P=0.01) and a significant negative correlation with mitral valve area (r=–0.379, P=0.007). There was no correlation between the P-wave dispersion and echocardiographic parameters.

Key Words: *Maximum P-wave duration; Minimum P-wave duration; P-wave dispersion; Rheumatic mitral stenosis*

P-wave prolongation has been used as a marker of interatrial conduction disturbance and prolonged atrial conduction time, which has been associated with a high frequency of atrial fibrillation (AF). These atrial conduction disturbances are nonuniform and site dependent, and may result in a highly variable P-wave duration in the different leads of a 12-lead electrocardiogram (ECG). As a marker of this variation, the P-wave dispersion has been introduced as the difference between the maximum and minimum P-wave duration. Prolonged P-wave duration and P-wave dispersion have been found to be predictive of later AF in patients with idiopathic AF (1-4), and recurrence of AF following cardioversion (5,6).

Because patients with rheumatic mitral stenosis (MS) are prone to develop AF, the present study was designed to find out whether the maximum P-wave duration and P-wave dispersion are prolonged in these patients, and to find out if these variables have any correlation with the left atrial size, transmitral valve gradient or mitral valve area as an index of the severity of valvular stenosis.

METHODS

Patients and controls

Fifty consecutive patients with MS who were in normal sinus rhythm, and a control group of 50 age- and sex-matched healthy persons, were included in the study. All patients and controls were carefully examined and had an ECG. Only persons with a completely normal history, physical findings and ECG were included in the control group. None had a history of hypertension or ischemic heart disease. Chest roentgenograms and echocardiography were occasionally performed to exclude the presence of any cardiac pathology. Only persons 45 years of age or younger were included in the study to minimize the chance of the presence of associated coronary artery disease. Each subject gave informed consent for participation and the study protocol was approved by the institutional research committee of Shiraz University of Medical Sciences (Iran).

Twelve-lead surface ECG

With the patients in supine position, 12-lead ECGs were recorded at a paper speed of 25 mm/s and a gain setting of 10 mm/mV. All ECGs were scanned through a Cannon scanner (at 300 dpi) and saved as images in a personal computer. The images were subsequently analyzed electronically after 800% magnification by Adobe Photoshop software (this method was found to increase accuracy and reproducibility compared with manual measurements [7]).

The starting point of a P-wave was designated as the positive deflection crossing the isoelectric line and the end point was designated as the end of deflection crossing the isoelectric line. P-wave duration was measured from the onset to the offset of the P-wave. In each ECG lead, P-wave durations were measured for three consecutive P-waves and the mean of three measurements was considered to be the P-wave duration of that lead. P-wave measurements were made in all 12 leads.

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TABLE 1
The P-wave durations and P-wave dispersion in 50 patients with rheumatic mitral stenosis (MS) and a control group of 50 age- and sex-matched individuals

	Patients with MS (n=50)		Control group (n=50)			
	Range	Mean ± SD	Range	Mean ± SD	P	95% CI
Minimum P-wave duration, ms	34–116	64.9±17.9	31–76	54.5±10.0	0.001	4.6 to 16.2
Maximum P-wave duration, ms	94.5–157	120.7±15.0	80–126	105.9±10.4	<0.001	9.7 to 20.0
P-wave dispersion, ms	26–91	55.8±16.4	25–79	51.5±13.6	0.149	–1.6 to 10.4

When the beginning or the end of the deflection could not be clearly identified, that lead was excluded. However, subjects were included only if the P-wave could be accurately measured in nine or more leads. Once the P-wave durations were determined, the maximum and minimum P-wave durations were identified. The P-wave dispersion, defined as the difference between the maximum and minimum P wave duration, was subsequently calculated.

To increase the accuracy of final results, measurements were performed by two independent physicians who were kept blind to the patients' clinical status and echocardiographic findings. All values obtained by the two observers were averaged and reported. The mean (± SD) difference between the two measurements were 0.25±2.69 ms, 0.9±7.64 ms and 0.4±3.27 ms for minimum P-wave, maximum P-wave and P-wave dispersion, respectively.

The echocardiographic study

Transthoracic echocardiographic examination was performed for each patient. M-mode study was used to measure the left atrial dimension. To determine the transmitral valve gradient, four-chamber apical view was used with the sample volume placed at the mitral valve coaptation point. Transmitral valve gradient was defined as the mean of gradients obtained from three consecutive beats obtained by continuous wave Doppler study. Mitral valve area was measured by planimetry of the mitral valve in short axis view and the mean of three measurements in three different beats were accepted as final. Mitral valve areas of 1 cm^2 or less were considered to be very severe, 1 cm^2 to 1.5 cm^2 were considered to be moderate and greater than 1.5 cm^2 were considered to be mild cases.

Colour flow Doppler was used to detect the presence of associated valvular insufficiencies, which were additionally confirmed by Doppler studies. Patients with aortic stenosis and those with severe mitral or aortic regurgitation were excluded from the study.

Statistical methods

All numerical variables were expressed as mean ± SD. Statistical analyses were performed using *t* test and Mann-Whitney U test where appropriate; Pearson correlation test was used to determine the correlation between P-wave parameters and the echocardiographic variables in patients with MS. P≤0.05 was considered significant.

RESULTS

There were 40 women and 10 men in each group. The age range of the patient group was 22 to 45 years (mean age 35.76±6.59 years) and 19 to 45 years (mean age 35.1±7.02 years) in the control group (P=not significant). Twenty-two (44%) of the patients were on long-term propranolol therapy.

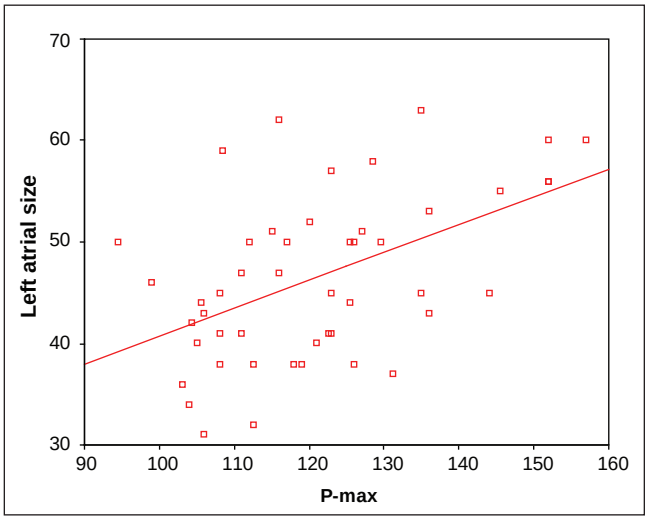

Figure 1) *The correlation between maximum P-wave duration and left atrial size*

There were 40 mild, eight moderate and two severe cases of MS in the patient study group. There was a significant difference between the maximum P-wave duration and minimum P-wave duration between the two groups, but there was no significant difference between their P-wave dispersions (Table 1).

The maximum P-wave duration showed a significant positive correlation with the left atrial size (r=0.505, P<0.001) (Figure 1) and transmitral valve gradient (r=0.371, P=0.01), and a significant negative correlation with mitral valve area (r=–0.379, P=0.007). The minimum P-wave duration showed an impressive negative correlation with mitral valve area as well (r=–0.430, P=0.002).

There was no correlation between the P-wave dispersion and the transmitral valve gradient, left atrial size or the mitral valve area.

The heart rate ranged from 60 beats/min to 100 beats/min (mean heart rate 76.9±11.59 beats/min) in the patient group, and 60 beats/min to 100 beats/min (mean heart rate 78.3±11.78 beats/min) in the control group (P=not significant). The correlation of the heart rate to the P-wave parameters are shown in Table 2. In addition, the presence or absence of associated regurgitant valvular lesions (mitral, aortic or tricuspid regurgitation) did not have any significant impact on P-wave parameters.

DISCUSSION

The most striking findings of the present study were:

1. There was significant prolongation of the maximum P-wave duration in patients with MS compared with their age- and sex-matched healthy controls (P<0.001).

TABLE 2
Correlation of heart rate with P-wave parameters in patients with mitral stenosis and a control group of 50 age- and sex-matched individuals

	Patients		Control group	
P-wave	r	P	r	P
Minimum	–0.30	0.033	0.023	0.874
Maximum	–0.53	0.715	0.134	0.353
Dispersion	0.280	0.049	0.086	0.551

2. The maximum P-wave duration in patient group had a strong correlation with the left atrial size (r=0.505, P<0.001), transmitral valve gradient (r=0.371, P=0.01) and a significant negative correlation with mitral valve area (r=–0.379, P=0.007).
3. The minimum P-wave duration showed a significant negative correlation with mitral valve area (r=–0.430, P=0.002).
4. There was no correlation between the P-wave dispersion and the left atrial size, mitral valve area or transmitral valve gradient in patients with MS.

P-wave dispersion is a new ECG marker that has been associated with inhomogeneous and nonuniform propagation of sinus impulses (3,4). It has been defined as the difference between maximum and minimum P-wave duration. Previous investigations (3,4) have shown that the prolongation of intra-atrial and interatrial conduction time, and the inhomogeneous propagation of sinus impulses, are the hallmarks of the atrium prone to fibrillation. In addition, prolonged P-wave duration and increased P-wave dispersion have been reported to be associated with an increased risk for AF (1,4).

Left atrial dilation, fibrosis within the wall of the left atrium and disorganization of the atrial muscle bundles may occur as a result of mitral valve disease and atrial inflammation due to rheumatic carditis (8). These structural changes can lead to electrical inhomogeneity, nonuniform conduction velocities and inhomogeneous refractory periods within the atrial myocardium (8,9), which can be seen on the ECG as increased P-wave duration (3,4).

There was a significant correlation between the maximum P-wave duration and the left atrial size in the patient study group. Although some investigators (10,11) have reported that the left atrial diameter is an important predictor of AF episodes, others (12) have disputed this. In addition, Ishimoto et al (12) have reported no correlation between filtered P-wave duration and atrial enlargement. Ozer et al (13) have also shown that atrial electromechanical delay is related to the left atrial size but not to the severity of MS.

The minimum P-wave duration had a strong negative correlation with the mitral valve area in our patients. The reason for this finding and its clinical relevance is unclear to us. Whether this is just an incidental finding needs further clarification. Furthermore, unlike the present study, the minimum P-wave duration has been reported to be near equal in patients with MS and the normal subjects by other investigators (14,15).

Turhan et al (14) have reported a significantly higher P-wave dispersion in patients with severe MS undergoing balloon valvuloplasty, but this was not found in our study. However, it should be mentioned that the majority of our patients had mild MS, which could partly explain the disparity between the results of the two studies. Therefore, maximum P-wave duration, rather than P-wave dispersion, could possibly be used as a predictor of subsequent AF development in patients with mild MS. Furthermore, Erbay et al (15) have shown that four weeks of oral beta-blocker therapy in patients with moderate-to-severe rheumatic MS can significantly reduce the maximum P-wave duration and the P-wave dispersion. Because 22 (44%) of our patients were already taking propranolol, the lack of significant difference between the P-wave dispersion of the two groups in our study could, therefore, be partly explained by the use of beta-blockers in almost 50% of our patients as well.

Chronic AF is associated with an increased risk of embolic events and negative impact on cardiac function and, therefore, an increased morbidity and mortality risk in patients with rheumatic MS (16). Therefore, the identification of patients who are susceptible to the development of AF will be of great value. Prolongation of maximum P-wave duration and P-wave dispersion may help detect such patients. However, further larger studies are needed to elucidate the exact association of these P-wave parameters and development of AF in patients with rheumatic MS.

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