Effects of Primary Percutaneous Coronary Intervention on P Wave Dispersion

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Background: Several studies demonstrated that P wave dispersion (PWD) increased after coronary occlusion. The effect of primary percutaneous coronary intervention (PCI) on PWD needs to be elucidated.

Methods: The study consisted of 125 patients with acute myocardial infarction (110 men, mean age 59.8 ± 7.8 years) undergoing primary PCI. The patients were divided into three groups according to thrombolysis in myocardial infarction myocardial perfusion grade (TMPG) after successful PCI. Groups 1 (n = 12), 2 (n = 9), and 3 (n = 104) included the patients with TMPG 0/1, 2, 3, respectively. Electrocardiograms were obtained before and approximately 66 ± 18 minutes after PCI.

Results: PWD and $P_{maximum}$ after PCI were significantly lower than the preintervention values ($P < 0.001$ for both). When PWD and $P_{maximum}$ values after PCI were compared among groups, PWD and $P_{maximum}$ in groups 1 and 2 were found to be higher than those of group 3 ($P < 0.001$ for PWD and $P_{maximum}$). Atrial fibrillation (AF) occurred in 14 patients. $P_{maximum}$ and PWD in patients with AF were higher compared to those of the patients without AF ($P < 0.001$ for both P wave parameters). Also more frequent AF attacks were observed in group 1 compared to group 3 ($P < 0.001$).

Conclusions: PWD and $P_{maximum}$ after primary PCI were lower compared to the preintervention values. Prolonged PWD in patients with poor myocardial perfusion can contribute to increased mortality, and also it can can be combined with ST segment resolution to predict clinical reperfusion and might help in predicting AF. **A.N.E. 2005;10(3):342–347**

P wave dispersion; primary percutaneous coronary intervention

P wave dispersion (PWD) constitutes an important contribution to the field of noninvasive electrocardiology and is defined as the difference between the longest and shortest P wave duration (P_{dur}) recorded from surface electrocardiogram (ECG) leads. PWD has been thorougly examined in a number of diseases including hypertension, angina pectoris, coronary artery bypass surgery, and paroxysmal atrial fibrillation (AF).[1–4]

Acute myocardial infarction (AMI) is the leading cause of death in North America and Europe.[5] The primary goal in the management of AMI is to institute reperfusion therapy as quickly as possible. Catheter-based strategies for reperfusion of the occluded infarct-related artery (IRA) in patients with AMI is a rapidly evolving field.[6] Several studies revealed that primary percutaneous coronary intervention (PCI) has more favorable effects than those of classical therapy including thrombolytic therapy.

Although acute effects of elective PCI on atrial conduction abnormalities manifested by increased PWD and P maximum values were shown in a well-designated clinical study,[7] the effects of primary PCI on PWD in patients with ST segment elevation myocardial infarction (STEMI) and the clinical significance of P_{dur} changes have remained to be elucidated.

In this clinical study, we aimed to investigate the effects of primary PCI on atrial conduction properties defined simply as PWD and its clinical sequela in patients with STEMI.

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Table 1. Exclusion Criteria

1. Severe valvular heart disease of hemodynamic significance (Mitral valve disease, aortic insufficiency, etc.)
2. Severe pulmonary hypertension
3. History of asthma or chronic obstructive lung disease
4. Atrial fibrillation, flutter, or any other atrial tachyarrhythmias requiring antiarrhythmic theraphy
5. History of taking antiarrhythmic drugs within 1 month including digoxin
6. Hypertrophic, restrictive and dilated cardiomyopathy with any etiology
7. Lower than TIMI flow grade 3 after primary PCI
8. Severe renal or hepatic failure
9. Hyperthyroidism
10. History of coronary artery bypass surgery

METHODS

Patients

The study population consisted of 125 patients presenting with STEMI (110 men, mean age 59.8 ± 7.8 years) undergoing successful primary PCI. The study group was divided into three groups according to thrombolysis in myocardial infarction (TIMI) myocardial perfusion grade (TMPG) immediately after primary PCI. Group 1 comprised patients with TMPG 0/1; group 2, TMPG 2; and group 3, TMPG 3. Exclusion criteria were shown in Table 1. Written informed consents were obtained from all the patients eligible for the study.

The diagnosis of AMI was established using American College of Cardiology/European Society of Cardiology criteria.[8]

Adjuntive Therapy

On admission, all the patients received aspirin 300 mg a day, heparin, clopidogrel with a starting dose of 300 mg and a maintenance dose of 75 mg, and nitroglycerine. Primary PCI was performed as quickly as possible (average door to first balloon time 52 ± 18 minutes).The use of other medications, including GpIIb/IIIa receptor antogonists, was at the discretion of the attending operator.

Coronary Intervention and Analysis of TMPG

Primary angioplasty and stenting procedure was performed according to standard techniques. The technical aspects of the procedure, including choice of stents, duration, and pressure of inflation, were determined by individual operators. To achieve maximal dilatation, each coronary angiogram was preceded by intracoronary injection of 125 μg nitroglycerin. All angiographic analyses (Siemens HICOR T.O.P Image System, Forchheim, Germany) were performed off-line by two cardiologists blinded to all data of the patients at our catheter laboratory.

Successful coronary intervention was defined as TIMI grade 3 flow and residual stenosis of less than 30% after the angioplasty procedure. Unsuccessful angiographic percutaneous transluminal coronary angioplasty (PTCA) was defined when TIMI flow was scored 0 or 1 at any level of residual stenosis.

TMPG was graded densitometrically based on visual assessment of relative contrast opacification of the myocardial territory subtended by the infarct vessel in relation to the epicardial density as described by van't Hof et al.[9] Blush score 0 was defined as the absence of contrast opacification in the myocardial infarct zone or persistent stain without washout; blush 1, minimal contrast opacification; blush 2, reduced but clearly evident blush in the infarct zone compared to the ipsilateral or contralateral noninvolved epicardial vessel(s); blush 3, myocardial contrast filling equal to or greater than that seen in the noninvolved epicardial vessel(s). To allow blush grading, the length of the angiographic run was kept long enough to see the venous phase of the contrast medium passage. These angiographic runs were made using identical views according to the IRA and thus assuring comparable evaluations in all patients. When the left coronary artery was involved, the final angiogram was obtained in the left lateral view. If the IRA was the right coronary artery, the final angiogram was obtained in the right oblique view. Blush scores were analyzed by two different interventional cardiologists blinded to patients' clinical data. Intra- and interobserver variability were obtained from random sample of 50 patients. Intra- and interobserver variability for blush score 0/1 were 8.5% and 11.5%, respectively. While intra- and interobserver variability for blush score 2 were 1.5% and 2.5%, respectively, and both intraobserver and interobserver variability for blush score 3 was 0%.

Transthoracic echocardiography was performed using ESAOTE 2.5 MHz probe (ESAOTE, Genova, Italy) at the left lateral decubitis position before primary PCI.

Surface ECG

Twelve-lead surface ECG was recorded from all patients before and at an average of 66 ± 18 minutes after primary PCI procedure (Hewlett Packard M1700A, Houston, TX, USA). The ECG recordings were obtained at a paper speed of 50 mm/s and signal size of 10 mm/mV at sinus rhtym.

P Wave Duration Analyses

The P wave duration (P_{dur}) measurements were calculated from 12-lead surface ECGs recorded simultaneously. Manual measurements of P_{dur} were performed with digital ECG recordings on a high-resolution screen by two cardiologists not aware of the patients' clinical data and outcomes. The P-wave onset was defined as the first atrial deflection from the isoelectric line and the offset was the return of the atrial signal to baseline. Mean P_{dur} was calculated as the mean value of P duration in each lead. The difference between the maximum and minimum P wave duration was defined as PWD: (PWD (ms) = $P_{maximum} - P_{minimum}$). Two investigators blinded to patients' clinical and outcome data calculated P-wave durations. Intra- and interobserver variability were obtained from random ECG recordings of 50 patients. While intra- and interobserver variability for $P_{maximum}$ were 3.5% and 4%, respectively; intra- and interobserver variability for PWD were 2.5% and 3.3%, respectively.

Statistics

Results are expressed as the mean ± SD and percents. The Levene's test was used to analyze the distribution characteristics of variables. The differences between groups were tested for significance by chi-square, one-way analysis of variance and Kruskal–Wallis test. Two-tailed paired *t*-test was used to compare the mean values of ECG measurements of P_{dur} before and after primary PCI. Independent samples *t*-test and Mann–Whitney *U* test were used to compare P wave duration values between patients with AF and without AF after primary PCI. The relationship between variables was analyzed with Kendall's tau-b and Spearman correlation test. Differences and correlations were considered at $P < 0.05$. Statistical analyses were performed by using SPSS 10.0 Statistical Package Program for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

The study included 125 consecutive patients (110 men, mean age 59.8 ± 7.8 years). Group 1 consisted of 12; group 2, 9; and group 3, 104 patients. When clinical, angiographic, and echocardiographic variables were compared with each other among groups, no statistically significant difference was found (Table 2).

When preintervention P_{dur}, PWD, and heart rates were compared to postintervention values, $P_{maximum}$ and PWD values after primary PCI were found significantly lower than the values of preintervention as shown in Table 3 ($P < 0.001$ for both of them).

When PWD and P_{dur} after primary PCI were compared to those of other groups each, statistically significant difference was seen among groups. PWD and $P_{maximum}$ in groups 1 and 2 were higher than those of group 3 as shown in Table 4 ($P < 0.001$ for PWD and $P_{maximum}$).

When the patients were subdivided into groups according to IRA, P wave measurements before and after primary PCI were not different among groups.

Fourteen patients suffered from AF in-hospital follow-up period (mean in-hospital stay 7 ± 2 days). AF was electrically converted to sinus rhythm in 2 patients and pharmacologically converted to sinus rhythm in 6 patients. AF spontaneously converted to sinus rhythm in 6 patients. Eight patients suffered from AF in group 1, 2 patients in group 2, and 1 patient in group 3. Values of $P_{maximum}$ and PWD in patients with AF in-hospital follow-up period were higher compared to those of the patients without AF as shown in Table 5 ($P < 0.001$ for both $P_{maximum}$ and PWD).

When in-hospital AF frequencies were analyzed, significantly higher frequency of AF was found in group 1 compared to group 3 ($P < 0.001$ for group 1 vs 3).

Strong negative correlation was found between AF and TMPG 1($r = -0.975$, $P < 0.001$). Additionally, moderate negative correlation was seen between AF and PWD after primary PCI ($r = -0.55$, $P < 0.001$).

DISCUSSION

It has been shown that P wave duration changes can occur in acute coronary syndromes, induced myocardial ischemia,[10–12] and after elective

Table 2. Basic Clinical, Angiographic, and Echocardiographic Characteristics of the Patients

	Group 1 (n = 12)	Group 2 (n = 9)	Group 3 (n = 104)	P Value
Mean age (years)	61.9 ± 7.3	56.4 ± 8.3	59.9 ± 7.8	0.25[a]
Sex (M), n (%)	10 (83)	8 (80)	92 (89)	0.59[b]
Hypercholesterolemia, n (%)	4 (33)	1 (11)	37 (35)	0.25[b]
Diabetes mellitus, n (%)	5 (41)	3 (30)	22 (21)	0.26[b]
Hypertension, n (%)	8 (66)	2 (22)	63 (60)	0.15[b]
FHPCAD, n (%)	4 (33)	3 (33)	19 (18)	0.36[b]
Smoking, n (%)	8 (66)	4 (44)	49 (47)	0.38[b]
Time from symptoms onset to first balloon inflation (minutes)	216 ± 94	234 ± 78	198 ± 98	0.54[a]
LVEF (%)	51.5 ± 3.6	54.0 ± 4.0	54.1 ± 4.5	0.18[a]
LA (mm)	41.9 ± 1.9	41.6 ± 1.1	42.0 ± 1.3	0.67[a]
HR (bpm)	73.6 ± 7.9	72.5 ± 8.1	72.9 ± 9.7	0.95[a]
IRA, n (%)				
LAD	7 (58.3)	3 (30)	24 (23)	0.13[b]
CX	1 (8.3)	1 (10)	18 (17.3)	
RCA	4 (33.3)	6 (60)	61 (58.6)	

M = male; FHPCAD, family history of premature coronary artery disease; LVEF = left ventricular ejection fraction; LA = left atrium; HR = heart rate; LAD = left anterior descending coronary artery; CX = circumflex coronary artery; RCA = right coronary artery.
Values are mean ± SD or n (%).
[a]One-way ANOVA test.
[b]Chi-square test.

coronary angioplasty.[5] Rapid restoration of patency by catheter-based percutaneous intervention can result in excellent outcomes in patients presenting with STEMI.[13] However, the changes in P wave duration have not been thoroughly studied in patients with STEMI undergoing primary PCI. We found that the values of $P_{maximum}$ and PWD decreased significantly after primary PCI compared to the preintervention values. Most importantly, the patients having poor myocardial perfusion, which correlates with high mortality rates even after adjusting for the presence of TIMI grade 3 flow or a normal TIMI frame count, had significantly higher values of $P_{maximum}$ and PWD compared to those of the patients with good myocardial perfusion grades after primary PCI. Moreover, the values of $P_{maximum}$ and PWD in patients with in-hospital follow-up period were higher compared to those of the patients without AF.

In spite of the fact that the flow in epicardial IRA in patients with STEMI can be accomplished by catheter-based interventions in most of the patients; unfortunately, adequate myocardial perfusion may not be achieved in all the patients with TIMI grade 3 flow.[14,15] TMPG is a multivariate predictor of a 30-day mortality independent of age, gender, admission pulse, anterior myocardial infarction location, corrected TIMI frame count, or TIMI flow grade.[16] Patients with TIMI 3 flow in the IRA after PCI and poor myocardial perfusion (TMPG 0 or 1) have a mortality of 5.4%, which is significantly higher than that in patients with TIMI 3 flow and TMPG 2 (4.4%) or TMPG 3 (2%, $P < 0.01$).[16] We considered that in our study poor

Table 3. P Wave Dispersion, $P_{maximum}$ and $P_{minimum}$, and Heart Rate Values after Primary Percutaneous Coronary Intervention (PCI) Procedure

	Before PCI (n = 125)	After PCI (n = 125)	P Value[a]
P maximum (ms)	117.08 ± 11.00	100.44 ± 15.22	<0.001
P minimum (ms)	45.56 ± 10.21	48.00 ± 10.10	0.06
P dispersion (ms)	69.52 ± 14.61	52.44 ± 18.75	<0.001
Heart rate (bpm)	72.90 ± 9.41	71.62 ± 11.21	0.18

Values are presented as mean ± SD.
[a]Paired *t*-test.

Table 4. Comparison of P Wave Duration Values Among Groups before and after Primary Percutaneous Coronary Intervention

	Group 1 (n = 12)	Group 2 (n = 9)	Group 3 (n = 104)	P Value
PWD (ms)				
Before	70.0 ± 6.7	75.0 ± 9.4	68.9 ± 15.6	0.46[a]
After	89.1 ± 6.6$^{\lambda}$	76.0 ± 13.7$^{\lambda\lambda}$	45.8 ± 12.2$^{\lambda\lambda\lambda}$	<0.001[b]
P maximum (ms)				
Before	114.1 ± 9.9	119.0 ± 5.16	117.2 ± 11.5	0.61[a]
After	133.3 ± 7.7$^{\gamma}$	123.2 ± 4.6$^{\gamma\gamma}$	94.4 ± 6.5$^{\gamma\gamma\gamma}$	<0.001[b]
P minimum (ms)				
Before	44.1 ± 5.1	44.0 ± 8.4	48.3 ± 10.6	0.32[a]
After	44.2 ± 5.2	46.9 ± 8.2	48.5 ± 10.7	0.53[a]

PWD, P wave dispersion.
Values are presented as mean ± SD.
[a]Kruskal–Wallis test.
[b]Bonferroni adjusted Mann–Whitney *U* test.
P = 0.02 for λ versus $\lambda\lambda$, P < 0.001 for λ versus $\lambda\lambda\lambda$ and $\lambda\lambda$ versus $\lambda\lambda\lambda$.
P = 0.005 for γ versus $\gamma\gamma$, P < 0.001 for γ versus $\gamma\gamma\gamma$ and $\gamma\gamma$ versus $\gamma\gamma\gamma$.

myocardial perfusion grade after primary PCI can cause PWD and $P_{maximum}$ prolongation. Probably, the increased PWD and $P_{maximum}$ in patients with poor myocardial perfusion after primary PCI is a result of the ongoing tissue ischemia inducing in homogeneous and discontinuous atrial conduction. We speculated that high PWD values in patients with poor myocardial perfusion after primary PCI might have a role in high mortality rates encountered in this group of patients.

ST segment resolution on the surface 12-lead ECG is a strong predictor of outcome in AMI patients; its absence is a better predictor of an occluded rather than patent IRA.[14,17,18] Resolution of ST segment elevation by more than 70% is correlated with effective tissue level reperfusion. We consider that PWD when it is combined with ST segment resolution can provide additive data about tissue perfusion in patients STEMI undergoing primary PCI. We hope that future large-scale studies will shed light on the role of PWD on myocardial tissue level reperfusion.

Atrial fibrillation occurs in 10–20% of patients with AMI.[19] AF in AMI is associated with increased mortality and stroke particularly in patients with acute anterior wall infarction.[20] PWD has been proven to be a sensitive and specific ECG predictor of AF in the various clinical settings such as hypertension, coronary artery disease, and coronary artery bypass surgery. Concordantly, we observed

Table 5. Comparison of P Wave Duration Values between the Patients with and without Atrial Fibrillation before and after Primary Percutaneous Coronary Intervention

	AF (n = 14)	No AF (n = 111)	P VALUE
PWD (ms)			
Before	71.4 ± 8.1	69.2 ± 15.2	0.79[a]
After	80.7 ± 17.8	48.8 ± 15.6	<0.001[b]
P maximum (ms)			
Before	117.8 ± 8.1	116.9 ± 11.3	0.86[a]
After	129.2 ± 16.3	96.2 ± 10.5	<0.001[b]
P minimum (ms)			
Before	46.2 ± 7.4	47.7 ± 10.5	0.91[a]
After	48.5 ± 6.3	47.9 ± 10.4	0.31[b]

AF, Atrial fibrillation; PWD, P wave dispersion.
Values are mean ± SD.
[a]Mann–Whitney *U* test.
[b]Independent samples *t*-test.

that the patients with AF had higher PWD and $P_{maximum}$ values compared to those of the patients without AF. Therefore, PWD might help in the prediction of AF in patients with AMI undergoing primary PCI. In our study, the patients with poor myocardial perfusion showed more frequent AF compared to the patients with good myocardial perfusion. It has been shown that AF increases mortality and morbidity in AMI patients. We speculated that high PWD values in patients with poor myocardial perfusion after primary PCI might have a role in high mortality rates encountered in this group of patients by increasing of frequency of in-hospital AF.

CONCLUSION

PWD and $P_{maximum}$ values after primary PCI were lower compared to the preintervention values. Postprocedure prolonged PWD in patients with poor myocardial perfusion can contribute to increased mortality, can be combined with ST segment resolution to predict clinical reperfusion and might help in predicting of AF in patients with STEMI undergoing primary PCI.

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