SIGNAL-AVERAGED P-WAVE ECG AS A MARKER OF ATRIAL ELECTRICAL INSTABILITY IN PATIENTS WITH RIGHT VENTRICULAR DYSFUNCTION

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Severe pulmonary hypertension (PAH) leads to right ventricular dysfunction and is associated with different atrial arrhythmias. In PAH patients, the echocardiographic Tei-index is used for monitoring right heart function. The P-wave signal-averaged ECG (SA-ECG) has been shown to have a potential role in identifying patients at risk of developing paroxysmal atrial fibrillation and those likely to change from paroxysmal to chronic atrial fibrillation. The aim of the present study was to define the correlation of the Tei-Index with parameters of P-wave triggered and bidirectional P-wave SA-ECG. A total of 18 patients (14 men, 4 women) with normal sinus rhythm and a mean age of 67 ±10 years (BMI 27.6 ±5.1 kg/m²) were included into the study. Right ventricular (RV) Tei-index was calculated from the sum of isovolumetric contraction time and relaxation time divided by ejection time. Furthermore, P-wave triggered P-wave signal averaged ECG was performed from an X, Y, and Z lead system. The results show that there was a statistically significant correlation between Tei-index and filtered P-wave duration (r=0.53; P=0.023). Tei-index did not correlate with the root mean square voltage of the last 20 ms of the P wave (r=−0.16; P=0.52). In conclusion, a correlation of RV Tei index with P-wave duration indicates that this echocardiographic measurement is not only a marker of right heart function, but also an indicator of electrical instability that could be useful to detect patients at risk for atrial arrhythmias.

Key words: P-wave signal-averaging technique, pulmonary hypertension, Tei index
INTRODUCTION

P-wave signal-averaging (SA) is used for the detection of low amplitude and high frequency signals in surface Electrocardiogram (ECG) (1). P-wave SA-ECG has been shown to predict the risk for the development of atrial arrhythmias in patients with structural heart disease (2). In this context filtered P-wave duration (FPD) from Frank’s orthogonal leads is calculated after P-waves are sampled and filtered using the Fast Fourier transformation.

Ehrlich et al (3) have found that the filtered P-wave duration in normal healthy subjects is 114 ±13 ms and the root mean square voltage of the last 40 ms of the P-wave duration is 5.2 ±2.5 µV. These authors have shown that there is a significant correlation between the P-wave duration and the age of the patients. Furthermore, an excellent reproducibility of the measurement of the FPD has been described.

The myocardial performance index (Tei) is a doppler echocardiographic index for the assessment of the global right ventricular (RV) function (4). It is measured by the sum of the isovolumetric contraction time and isovolumetric relaxation time divided by the ejection time (5). Tei et al (4) have compared doppler intervals between normal subjects and patients with primary pulmonary hypertension (PPH) and found that the isovolumetric contraction and relaxation time are prolonged in patients with PPH. On the other hand, the ejection time was shortened in patients with PPH compared with normal healthy subjects. Moreover, they have found that the myocardial performance index is markedly prolonged in patients with PPH.

In view of those findings, we conducted the present study to define the correlation between the RV Tei index and parameters of P-wave signal averaging in patients with mild pulmonary hypertension. Our hypothesis was that a longer filtered P-wave duration would be associated with a higher myocardial performance index.

PATIENTS AND METHODS

A total of 18 patients (14 men, 4 women) with a mean age of 67 ±10 years and a systolic pulmonary arterial pressure >30 mmHg in sinus rhythm were included into the study. Exclusion criteria were: pacemaker stimulation, acute cardiac or noncardiac illness, atrial fibrillation and atrioventricular block.

Echocardiography, SA-ECG

Comprehensive echocardiographic examinations were performed in all patients to determine left ventricular (LV) size, pulmonary arterial systolic pressure, ejection time, and right ventricular myocardial performance index. Tei-index was calculated from the sum of isovolumetric contraction time and relaxation time divided by ejection time. For the analysis of Tei index the tricuspid inflow was recorded from the apical four chamber view with the doppler sample volume between the tips
of the tricuspid leaflets. The right outflow velocity was recorded from the parasternal short axis with the sample volume right below the pulmonary valve. Furthermore, P-wave triggered P-wave signal averaged ECG was performed from an X, Y, and Z lead system (Predictor-ECG-System, Dr. Kaiser Medizintechnik, Bad Hersfeld, Germany).

**Brain natriuretic peptide (BNP)**

Blood was drawn into EDTA-containing plastic tubes after a standardized period of rest (10 min) in the supine position. BNP was measured using the Triage BNP-Test (Biosite Diagnostik, Willich, Germany).

**Statistics**

All variables are given as means ±SD. Correlation between variables was determined using Pearson’s correlation test. A level of statistical significance was defined as a P value < 0.05. Data were analyzed using the Statistical Package for Social Sciences (SPSS 11.0 for Windows, Munich, Germany).

**RESULTS**

Demographic characteristics of the study population are presented in Table 1. Echocardiographic findings were a mean pulmonary arterial systolic pressure of 45.6 ±12.1 mmHg, a normal left ventricular end-diastolic diameter and an ejection time of 313 ±28.4 ms (Table 2). Tei index in our study population was 0.36 ±0.18. The filtered P-wave duration in our cohort was 124.6 ±25.6 ms.

There was a significant correlation between Tei index, on the one hand, and the filtered P-wave duration, on the other hand (Fig. 1). Tei index did not correlate with the RMS20 (Fig. 2). Brain natriuretic peptide was 89 ±51 pg/dl.

**Table 1.** Demographic characteristics.

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<tr>
<th>Age (yr)</th>
<th>67 ±10</th>
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<tbody>
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<td>Gender (M/F)</td>
<td>14/4</td>
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<tr>
<td>Weight (kg)</td>
<td>86.6 ±18.9</td>
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<tr>
<td>Height (m)</td>
<td>177.2 ±7.3</td>
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<td>BMI (kg/m²)</td>
<td>27.6 ±5.1</td>
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**Table 2.** Echocardiographic findings and filtered P-wave duration.

| PA systolic pressure (mmHg) | 45.6 ±12.1 |
| Ejection time (ms)          | 313 ±28.4  |
| LVEDD (mm)                  | 50.8 ±5.2  |
| Tei index                   | 0.36 ±0.18 |
| Filtered P-wave duration (ms)| 124 ±25.6 |
Neither Tei index \( (r=0.83; \ P=0.75) \) nor the filtered P-wave duration \( (r=0.3; \ P=0.24) \) showed a significant correlation to BNP values.

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DISCUSSION

In the present study we investigated the association of the echocardiographic myocardial performance index (Tei) and the filtered P-wave duration. Our principal finding was that there was a significant positive correlation between these two parameters. Since P-wave signal averaged ECG has been used to detect atrial late potentials, which are seen in patients with paroxysmal atrial fibrillation, our finding might indicate that a higher Tei index could be associated with an increased electrical instability. This result is supported by the finding that the myocardial performance index correlates negatively with the RV ejection fraction and with the central venous oxygen saturation and stroke volume, whereas it is positively correlated with the central venous pressure (6). In conclusion, an impaired RV function due to pulmonary hypertension seems to be associated with a slow conduction in the atrium by means of P-wave signal averaging.

Surprisingly, Tei index did not correlate with the root mean square voltage of the last 20 ms of the P-wave. Budeus et al (7) have shown that a lower RMS20 in patients with atrial fibrillation is a sign for the recurrence of atrial fibrillation after electrical cardioversion. They found that a cut-off point of <3.1µV for the RMS20 achieved a specificity of 69%, a sensitivity of 74%, a positive predictive value of 68%, and a negative predictive value of 75% for the prediction of the recurrence of atrial fibrillation. In this context, a lower RMS20 reflects a delayed atrial conduction, possibly due to fibrosis of the atrium, ischemia or disarray of the myocytes. However, in our study we could not see that a higher Tei index, indicating a more accentuated RV dysfunction, was associated with a lower RMS20.

In chronically overloaded right ventricles, elevated myocardial performance index and BNP values have been observed (8). In contrast, we could not detect a significant
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In chronically overloaded right ventricles, elevated myocardial performance index and BNP values have been observed (8). In contrast, we could not detect a significant correlation between the Tei index and BNP values. This difference with respect to the results in chronically overloaded right ventricles, as mentioned above, may possibly be explained by the durability of the RV dysfunction.

Several limitations of the present study deserve attention. First of all, there were only mild forms of pulmonary hypertension and right ventricular dysfunction. Therefore, correlations might be strengthened in patients with severe pulmonary hypertension and cor pulmonale. Furthermore, sample size was small so that a Type II error might be a possible explanation for some of our results. Another limitation refers to the study design, which did not allow to verify causal relationships.

In summary, the P-wave signal averaged ECG was used as a predictor of atrial arrhythmias. Tei index is a rapid, feasible, and simple noninvasive method of assessing the right ventricular function. In the present study we found a significant correlation between these two measurements. Therefore, Tei index possibly is not only a marker of right heart function, but could also be an indicator
of atrial electrical instability. Further prospective investigations in larger trials are necessary to corroborate these results.

REFERENCES


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