Dispersion of signal-averaged P wave duration on precordial body surface in patients with paroxysmal atrial fibrillation


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Aims This study sought to investigate whether the spatial dispersion of signal-averaged P wave duration would be increased in patients with paroxysmal atrial fibrillation, by use of precordial mapping of the P wave signal-averaged ECG.

Methods and Results The P wave signal-averaged ECG was recorded by the P wave-triggering method from 16 precordial leads in 55 patients with paroxysmal atrial fibrillation and 57 control subjects. As an index of the dispersion of signal-averaged P wave duration, we obtained the difference between the maximum and minimum in 16 recording sites. The dispersion was significantly greater in the patients with paroxysmal atrial fibrillation than the controls (26.6 ± 9.5 vs 14.8 ± 6.7 ms, P < 0.0001). In 25 patients with symptomatic attacks of paroxysmal atrial fibrillation, the signal-averaged ECG was repeated 1 h after a single dose of orally administered pilsicainide, a new class Ic drug. These patients were prospectively followed-up for 10 ± 11 months with pilsicainide. The rate of freedom from recurrence of paroxysmal atrial fibrillation attacks was significantly (P < 0.0001) higher in patients with whom dispersion was decreased by the single dose (54% [7/13]) than in those in whom dispersion increased (8% [1/12]).

Conclusion Increased dispersion of signal-averaged P wave duration would play an important role in generating paroxysmal atrial fibrillation and would be useful in the prediction of drug efficacy to evaluate the change in dispersion by a single administration of pilsicainide.

Key Words: Atrial fibrillation, body surface mapping, P wave signal-averaged ECG, antiarrhythmic drug.

See page 171 for the Editorial comment on this article

Introduction

Electrophysiological studies by programmed atrial stimulation showed that the widened zones of repetitive atrial firing[1,2], intra-atrial conduction delay[3,4] and fragmented atrial activity[2,4] were associated with paroxysmal atrial fibrillation. It was also reported, following right atrial endocardial mapping, that prolonged and fractionated atrial endocardial electrograms were frequently observed in patients with paroxysmal atrial fibrillation during sinus rhythm[6]. These studies show that prolonged inhomogeneous intra-atrial conduction would be characteristic of paroxysmal atrial fibrillation.

We[7,8] and other investigators[9,10] reported that the electrophysiological abnormalities of the atrial muscle in patients with paroxysmal atrial fibrillation could be detected non-invasively by the P wave signal-averaged ECG. A precordial bipolar lead system was used in these studies. It thus remains unclear how such electrophysiological abnormalities of the atrium in paroxysmal atrial fibrillation during the sinus rhythm would be reflected on the spatial body surface distribution of the P wave signal-averaged ECG. The purpose of this study was to investigate by precordial mapping of the P wave signal-averaged ECG, whether the spatial dispersion of signal-averaged P wave duration would be increased in patients with paroxysmal atrial fibrillation.


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In addition, the clinical significance of dispersion in the prediction of the efficacy of the antiarrhythmic drug in paroxysmal atrial fibrillation was also determined.

Methods

Study patients

Fifty-seven consecutive patients who had paroxysmal atrial fibrillation documented on the ECG were studied. Two patients were excluded. One was excluded because of the shortness of the PQ intervals. This made deciding when the end of the signal-averaged P wave had occurred difficult. Another patient had gross noise on the P wave signal-averaged ECG. The patient group consisted of 55 patients with paroxysmal atrial fibrillation (37 men and 18 women, average age: 54 ± 18, age range: 17–78 years), of whom 26 had organic heart diseases (eight with ischaemic heart disease, eight with valvular heart disease, six with hypertensive heart disease, two with cardiomyopathy and two with congenital heart disease). The control group of 57 subjects (35 men and 22 women, average age: 48 ± 21, age range: 20–83 years) comprised 17 young healthy subjects, who had no history of heart disease, a normal physical examination and a normal standard ECG, and 40 patients without a history of heart disease between patients with paroxysmal atrial fibrillation and control subjects. Each patient gave informed consent to participate in this study, which was approved by the Osaka Prefectural Hospital Review Committee.

Precordial signal-averaged ECG recording

None of the patients in this study had taken antiarrhythmic drugs in the week before undergoing the signal-averaged ECG. In an electrically-shielded room, the signal-averaged ECG was recorded from 16 precordial unipolar leads by use of the VCM-3000 (Fukuda Denshi, Ltd.), which was recently developed for P wave-triggered signal-averaging[7]. The 16 precordial leads (V1U to V6U and V1L to V6L) were located on V1 to V6 of the standard ECG, and two intercostal spaces above and below V1 to V6 except V3. The signal-averaged ECG was also recorded from a modified X, Y and Z lead system (conventional method). The X lead was between the right and left shoulders. The AVF lead was used as the Y lead. The precordial V1 lead was used as the Z lead. The signal from each lead was amplified up to 5 μV, cm−1 and passed through a unidirectional Butterworth filter of 40 Hz (the slope; 12 dB/oct) to 300 Hz (the slope; 12 dB/oct), and was then converted from analog to digital data to a 12-bit accuracy at a sampling rate of 1 kHz.

Signal averaging

All of the digital data were stored on a floppy disk. Ventricular ectopic beats and gross noise were eliminated by a conventional QRS template-matching programme, before proceeding to the P wave recognition programme, according to the algorithm of the P wave-triggering system. A specially filtered (10–30 Hz) P wave derived from the selected dominant sinus P wave of the standard II lead served as a reference signal for all processing. After passing through a P wave recognition programme to eliminate ectopic atrial beats, the signals of more than 200 beats were averaged on a trigger point within a specially filtered P wave.

Data analysis

The signal-averaged P wave in each lead was defined as signals within the interval showing a level of more than twice the mean of the baseline noise level, which was measured every 1 ms in the optional 20 ms of the TP segment on each lead (peak noise level: 0.3 ± 0.1 μV). The onset and offset of the signal-averaged P wave was manually determined without knowledge of the patient’s clinical data. In each patient, the duration of the signal-averaged P wave was measured in all leads. In eight of 55 paroxysmal atrial fibrillation patients, the duration of the signal-averaged P wave could not be measured in one or two leads (six patients in one lead and two patients in two leads) because of relatively gross noise. As an index for dispersion of signal-averaged P wave duration, we obtained the difference (ΔAd) between the maximum and minimum and the standard deviation (SD[Ad]) of the signal-averaged P wave duration in 16 precordial recording sites in each patient. Incidentally, in patients with paroxysmal atrial fibrillation, the inter-observer and intra-observer (day-to-day) variations in measurement of ΔAd were 4.8 ± 5.4% (n=16) and 5.7 ± 3.3% (n=13), respectively. The signal from the X, Y and Z leads were combined into the vector magnitude. We also measured the duration (Ad) and the root mean square voltage (LP20) for the 20 ms of the signal-averaged P wave in the vector magnitude.

Prediction of the antiarrhythmic efficacy of pilsicainide in paroxysmal atrial fibrillation by use of precordial mapping of the P wave signal-averaged ECG: a prospective study

To elucidate the clinical significance of dispersion of signal-averaged P wave duration, as a predictor of the efficacy of the antiarrhythmic drug in paroxysmal atrial fibrillation, we performed a prospective study. The signal-averaged P wave duration in the vector magnitude was compared with the clinical data of paroxysmal atrial fibrillation patients. The duration of the signal-averaged P wave was measured in all leads. In eight of 55 paroxysmal atrial fibrillation patients, the duration of the signal-averaged P wave could not be measured in one or two leads (six patients in one lead and two patients in two leads) because of relatively gross noise. As an index for dispersion of signal-averaged P wave duration, we obtained the difference (ΔAd) between the maximum and minimum and the standard deviation (SD[Ad]) of the signal-averaged P wave duration in 16 precordial recording sites in each patient. Incidentally, in patients with paroxysmal atrial fibrillation, the inter-observer and intra-observer (day-to-day) variations in measurement of ΔAd were 4.8 ± 5.4% (n=16) and 5.7 ± 3.3% (n=13), respectively. The signal from the X, Y and Z leads were combined into the vector magnitude. We also measured the duration (Ad) and the root mean square voltage (LP20) for the 20 ms of the signal-averaged P wave in the vector magnitude.

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fibrillation, we prospectively studied 25 of 55 paroxysmal atrial fibrillation patients. These patients had symptomatic attacks more than once a month and gave informed consent to participate in this prospective study. Pilsicainide was chosen as the antiarrhythmic drug. It is a newly developed, potent class Ic drug\[11,12\], with a favourable pharmacokinetic profile. It can be administered orally, is absorbed rapidly, and is effective in the management of clinical arrhythmia\[13–15\]. At study entry, body surface mapping of the P wave signal-averaged ECG was repeated 1 h after the single orally administered dose (100 mg) of pilsicainide. (It has been reported that the time from administration to peak plasma concentration after a single dose of pilsicainide

\[\begin{align*}
\text{V2U} & : \text{Ad-max: 180 ms} \\
\text{V5L} & : \text{Ad-min: 139 ms} \\
\text{V6L} & : \text{Ad-min: 114 ms} \\
\text{V2U} & : \text{Ad-max: 180 ms} \\
\end{align*}\]

Figure 1  Representative tracings (upper panels) and maps (lower panels) of the signal-averaged P wave in patients with paroxysmal atrial fibrillation (Paf) and control subjects. \(\text{Ad-max}\)=the maximum of signal-averaged P wave duration in body surface mapping; \(\text{Ad-min}\)=the minimum of signal-averaged P wave duration; \(\Delta\text{Ad}\)=the subtraction of \(\text{Ad-min}\) from \(\text{Ad-max}\). The tracings in the leads with maximum and minimum signal-averaged P wave duration are shown in each patient. The dotted lines indicate the onset and offset of the signal-averaged P wave. Both the maximum and the minimum of the signal-averaged P wave duration are longer in paroxysmal atrial fibrillation patients than in control patients. Of note, \(\Delta\text{Ad}\), the subtraction of the minimum from the maximum signal-averaged P wave duration, is greater in paroxysmal atrial fibrillation patients. In the maps, the line step indicates 4 ms in each patient. The symbol, +, indicates the maximum lead position of signal-averaged P wave duration and, − indicates the minimum signal-averaged P wave duration. The dots indicate the lead positions. The map in a paroxysmal atrial fibrillation patient had higher intensity in the iso-duration line, compared to that in a control patient. \(\text{SD}[\text{Ad}]\), the standard deviation of signal-averaged P wave duration in all 16 leads, is greater in paroxysmal atrial fibrillation patients.
Table 1  Variables in precordial mapping of the P wave signal-averaged ECGs in patients with paroxysmal atrial fibrillation and in control subjects

<table>
<thead>
<tr>
<th></th>
<th>Paf group (n=55)</th>
<th>Control group (n=57)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ad-max (ms)</td>
<td>155·5 ± 17·7</td>
<td>129·7 ± 10·7</td>
<td>p&lt;0·0001</td>
</tr>
<tr>
<td>Ad-min (ms)</td>
<td>129·8 ± 14·1</td>
<td>144·9 ± 12·0</td>
<td>p&lt;0·0001</td>
</tr>
<tr>
<td>ΔAd (ms)</td>
<td>26·6 ± 9·5</td>
<td>148·4 ± 6·7</td>
<td>p&lt;0·0001</td>
</tr>
<tr>
<td>SD[Ad] (ms)</td>
<td>9·0 ± 6·1</td>
<td>5·3 ± 2·2</td>
<td>p&lt;0·001</td>
</tr>
<tr>
<td>Ad (ms)</td>
<td>142·6 ± 16·4</td>
<td>125·3 ± 10·2</td>
<td>p&lt;0·0001</td>
</tr>
<tr>
<td>LP20 (µV)</td>
<td>2·38 ± 0·85</td>
<td>2·88 ± 0·87</td>
<td>p&lt;0·005</td>
</tr>
</tbody>
</table>

Values are mean ± SD.
Ad-max=the maximum of signal-averaged P wave duration in precordial leads.
Ad-min=the minimum of signal-averaged P wave duration in precordial leads.
ΔAd=subtraction of the minimum from the maximum signal-averaged P wave duration.
SD[Ad]=the standard deviation of the signal-averaged P wave durations in precordial leads.
Ad=signal-averaged P wave duration measured by vector magnitude.
LP20=the root mean square voltage for the last 20 ms of signal-averaged P wave on the vector magnitude.

was approximately 60 min. ΔAd and SD[Ad] were also obtained on the P wave signal-averaged ECG 1 h after the administration. The decreased dispersion of signal-averaged P wave duration in precordial mapping was defined, in case both ΔAd and SD[Ad] decreased after the single oral administration of pilsicainide. The plasma concentration of pilsicainide was measured by high performance liquid chromatography at the same time as the signal averaged ECG was being recorded. Thereafter, these patients were followed up with pilsicainide (120 ± 32 mg·day⁻¹) for more than 1 month (10 ± 11 [1–35] months), without any knowledge of the data of the P wave signal-averaged ECG. The patients were interviewed and examined every 2 to 4 weeks by standard ECG or portable ECG monitoring to observe the cardiac rhythm. We defined the patients in whom the drug was efficacious as those who had no recurrence of paroxysmal atrial fibrillation attacks with the chronic administration of the drug. The recurrence of paroxysmal atrial fibrillation attacks were those attacks documented on the ECG, or attacks with symptoms similar to those previously documented.

Statistical analysis

Data were presented as the mean ± SD. Student’s t-test was used for the comparison of the signal-averaged ECG data in patients with paroxysmal atrial fibrillation and control subjects, in paroxysmal atrial fibrillation patients with decreased and increased dispersion of signal-averaged P wave duration and in paroxysmal atrial fibrillation patients with and without recurrence. McNemar’s test was used for comparing the sensitivity and specificity between the precordial mapping method and the conventional method for discriminating paroxysmal atrial fibrillation patients from controls. A two-factor repeated measures analysis of variance was used for the comparison of the signal-averaged ECG data before and after the single dose administration of pilsicainide. The event-(paroxysmal atrial fibrillation recurrence) free rate in patients with and without decreased dispersion due to pilsicainide administration was calculated using the Kaplan–Meier method and the difference between them was detected using the log-rank test. The level of significance was determined at a P value of 0·05.

Results

Comparison of the dispersion of signal-average P wave duration in patients with and without paroxysmal atrial fibrillation

Figure 1 depicts the original tracings and maps of the P wave signal-averaged ECG in a representative patient with paroxysmal atrial fibrillation and a control patient. In each patient, the tracings in the leads with maximum and minimum signal-averaged P wave duration are shown. Both the maximum and minimum signal-averaged P wave duration are longer in a paroxysmal
atrial fibrillation patient than in a control patient. Of note, $\Delta$Ad is greater in the paroxysmal atrial fibrillation patient than in the control patient. The map in a paroxysmal atrial fibrillation patient had higher intensity of the iso-duration line, compared to that in a control patient. SD[$Ad$] is also greater in the paroxysmal atrial fibrillation patient than in the control patient.

Table 1 summarizes data on the variables of the P wave signal-averaged ECG. The maximum and minimum signal-averaged P wave duration were significantly greater in patients with paroxysmal atrial fibrillation than in control subjects. Of note, $\Delta$Ad (26·6±9·4 vs 14·8±6·6 ms, $P<0·0001$) and SD[$Ad$] (9·0±6·1 vs 5·3±2·2 ms, $P<0·001$) were also significantly greater in patients with paroxysmal atrial fibrillation than in control subjects.

Incidentally, the dispersion of signal-averaged P wave duration in the three orthogonal bipolar leads (X, Y, Z) was also significantly greater in patients with paroxysmal atrial fibrillation than controls (19·5±10·3 vs 13·3±7·0 ms, $P<0·005$). However, in the patients with paroxysmal atrial fibrillation, the dispersion in precordial mapping leads was significantly ($P<0·0001$) greater than that in the orthogonal leads, while there was no significant difference in dispersion between the two methods in the controls.

Comparison between the precordial mapping method and the conventional method for the detection of paroxysmal atrial fibrillation patients

Figure 2 shows receiver–operator characteristic curves of variables in the P wave signal-averaged ECG. The curves of the maximum signal-averaged P wave duration (Ad-max) and $\Delta$Ad in the precordial mapping methods shifted higher and more to the right compared to those of Ad and LP20 in the conventional method. When ‘Ad-max $>135$ ms’ and ‘Ad $>130$ ms’ were considered abnormal, the sensitivity of the precordial mapping method was significantly greater than that of conventional method (93% vs 75%, $P<0·01$), while the specificity was comparable (74% vs 72%).

Comparison between patients with decreased and increased dispersion of signal-averaged P wave duration

The decrease in dispersion of signal-averaged P wave duration due to the single oral dose of pilsicainide was...
fibrillation recurrence-free rate was significantly higher in paroxysmal atrial fibrillation patients with than without decreased dispersion of signal-averaged P wave duration due to the single oral dose of pilsicainide. The bold line indicates patients with the decreased dispersion (n=13), the medium line indicates those without decreased dispersion (n=12). The paroxysmal atrial fibrillation recurrence free-rate was significantly higher in patients with than without the decreased dispersion.

observed in 13 of 25 paroxysmal atrial fibrillation patients, while dispersion increased in the remaining 12 patients. Clinical and study characteristics in patients with decreased and increased dispersion are shown in Table 2. There were no significant differences in age, sex or left atrial dimensions between the two groups. Although between the two groups there was no significant difference in ΔAd or SD[Ad] before the administration of pilsicainide, after administration ΔAd and SD[Ad] were significantly smaller in patients with decreased than with increased dispersion despite there being no difference in the plasma concentration of pilsicainide between them. On the other hand, there was no significant differences in Ad or LP20 in the vector magnitude between the two groups.

Prediction of paroxysmal atrial fibrillation recurrence by the dispersion of signal-averaged P wave duration

The recurrence of paroxysmal atrial fibrillation attacks was observed in 17 (68%) of 25 paroxysmal atrial fibrillation patients, in 14 of whom the paroxysmal atrial fibrillation recurrence was documented on the ECG. In the remaining three patients the symptoms were the same as the previous paroxysmal atrial fibrillation attacks. In six (46%) of 13 paroxysmal atrial fibrillation patients with decreased dispersion of signal-averaged P wave duration, paroxysmal atrial fibrillation attacks recurred; paroxysmal atrial fibrillation attacks also recurred in 11 (92%) of 12 paroxysmal atrial fibrillation patients with increased dispersion. Figure 3 shows the paroxysmal atrial fibrillation recurrence-free rate curve by Kaplan–Meier analysis. The paroxysmal atrial fibrillation recurrence-free rate was significantly higher in paroxysmal atrial fibrillation patients with than without decreased dispersion of signal-averaged P wave duration after the administration of pilsicainide (54% vs 8%, P<0.0001, chi-square=18.8). Accordingly, the criteria of decreased dispersion of signal-averaged P wave duration due to a single dose administration of pilsicainide, gave a sensitivity of 88%, a specificity of 65%, a positive predictive value of 54% and a negative predictive value of 92% for the prediction of drug efficacy.

Comparison between patients with and without the paroxysmal atrial fibrillation recurrence

There were no differences in age (62±13 vs 54±22 years), sex (male/female; 11/6 vs 7/1), left atrial dimension (40±6 vs 41±6 mm) or the maintenance dose of pilsicainide (126±33 vs 113±33 mg. day⁻¹) between patients with and without paroxysmal atrial fibrillation recurrence. Figure 4 shows the individual maximum and minimum changes of signal-averaged P wave duration in patients with and without the paroxysmal atrial fibrillation recurrence. In patients without paroxysmal atrial fibrillation recurrence, the minimum signal-averaged P wave duration was significantly more prolonged than the maximum, due to the single dose administration of pilsicainide (the difference between before and after administration: 15·8±9·3 vs 10·8±9·0 ms, P<0.02). On the other hand, in patients with paroxysmal atrial fibrillation recurrence, the maximum tended to be more prolonged than the minimum (19·5±15 vs 16·4±15 ms). There were no significant differences in maximum or minimum before and after the single dose administration of pilsicainide between the two groups. Figure 5 shows the individual changes of ΔAd and SD[Ad] in patients with and without paroxysmal atrial fibrillation recurrence. In patients without paroxysmal atrial fibrillation recurrence, ΔAd (23·8±6·1 vs 18·8±5·5 ms, P<0.02) and SD[Ad] (6·7±2·1 vs 5·6±1·9 ms, P<0.05) significantly decreased after the single dose administration of pilsicainide, while ΔAd (26·7±7·6 vs 28±8·7 ms) and SD[Ad] (8·0±2·1 vs 8·9±3·0 ms) tended to increase in those with paroxysmal atrial fibrillation recurrence. Although there were no significant differences in ΔAd or SD[Ad] before the single dose administration of pilsicainide between the two groups, the patients without paroxysmal atrial fibrillation recurrence had significantly smaller ΔAd and SD[Ad] after the administration than those with paroxysmal atrial fibrillation recurrence, despite there being no difference in the plasma concentration of pilsicainide (0·8±0·55 vs 0·70±0·29 µg/ml) between them. On the other hand, there was no significant difference in Ad or LP20 between patients with and without paroxysmal atrial fibrillation recurrence.
Discussion

The signal-averaged ECG has been increasingly recognized as a useful means of identifying patients at risk for ventricular tachycardia\cite{16-19}. It has been reported that the electrophysiological abnormalities of the atrial muscle in patients with paroxysmal atrial fibrillation could be detected by use of the P wave signal-averaged ECG\cite{7-10}, and prospective studies showed that the P wave signal-averaged ECG would be useful in the prediction of paroxysmal atrial fibrillation occurrence after cardiac surgery\cite{20} and in the transition of chronic atrial fibrillation in paroxysmal atrial fibrillation patients\cite{21}. It is clear that we could screen the abnormal P wave signal-averaged ECG, which in previous studies usually used recordings from bipolar lead systems, but it was difficult to investigate the spatial and temporal distribution on the body surface of the P wave signal-averaged ECG. The present study demonstrated that patients with paroxysmal atrial fibrillation had significantly increased dispersion of signal-averaged P wave duration on the precordial body surface than control subjects, which suggests that the increased dispersion of signal-averaged P wave duration would play a role in generating paroxysmal atrial fibrillation. Furthermore, this study also demonstrated that the dispersion significantly decreased after the single administration of pilsicainide in patients without paroxysmal atrial fibrillation recurrence, in comparison to those with the recurrence. This suggests that the efficacy of pilsicainide in the suppression of paroxysmal atrial fibrillation attacks might be predicted by the change in electrophysiological dispersion with the single oral dose.

Electrophysiological consideration of the dispersion of signal-averaged P wave duration

Electrophysiological studies have shown that an abnormal response by the atrium could be elicited by programmed stimulation, such as repetitive atrial firing, fragmented atrial activity and intra-atrial conduction delay. These responses have been more frequently observed in patients with than without paroxysmal atrial fibrillation\cite{1-3}. Right atrial mapping studies during sinus rhythm have shown that prolonged, fractionated atrial electrocardiograms were found more frequently and were more distributed within the entire right atrium in patients with than without paroxysmal atrial fibrillation\cite{6}. These studies show that patients with paroxysmal atrial fibrillation possess a peculiar atrial electrophysiological substrate characterized by slow inhomogeneous conduction of atrial impulse, which might be reflected on the spatial dispersion of...
signal-averaged P wave duration on the precordial body surface in this study.

Dispersion of signal-averaged P wave duration and the antiarrhythmic drug efficacy to paroxysmal atrial fibrillation

The present study is the first to evaluate the efficacy of an antiarrhythmic drug in paroxysmal atrial fibrillation by use of the P wave signal-averaged ECG. In paroxysmal atrial fibrillation patients in whom pilsicainide is efficacious (without paroxysmal atrial fibrillation recurrence), the minimum duration of the signal-averaged P wave was more prolonged than the maximum, due to the single dose of pilsicainide. On the other hand, the maximum duration of the signal-averaged P wave tended to be more prolonged than the minimum after administration in patients without drug efficacy (with the paroxysmal atrial fibrillation recurrence). Therefore, the dispersion of signal-averaged P wave duration in precordial mapping significantly decreased after the single dose of pilsicainide in patients with drug efficacy, while the dispersion increased after administration in patients without efficacy. From these findings we think that the antiarrhythmic efficacy of pilsicainide would be by correcting prolonged inhomogeneous intra-atrial conduction which might be reflected on the dispersion of the signal-averaged P wave in precordial mapping. It is also speculated that in some instances (effective group) pilsicainide may prolong conduction via the normal myocardium rather than via the diseased myocardium. This latter might lower the inhomogeneity of intra-atrial conduction. However, in other instances (ineffective group) pilsicainide may prolong conduction better via diseased atrial myocardium than via normal atrial myocardium, which might result in greater inhomogeneity.
Comparison between the conventional method and the body surface mapping of the P wave signal-averaged ECG

In the conventional method, using bipolar leads, the P wave signal-averaged ECG has been useful to detect patients at risk for paroxysmal atrial fibrillation\[17-10,20,21\]. However, in this study, we showed that body surface mapping would improve the detectability of paroxysmal atrial fibrillation patients, in comparison with conventional methods. Furthermore, the dispersion of signal-averaged P wave duration obtained by precordial mapping indicated a significant difference between patients with and without paroxysmal atrial fibrillation recurrence, while there were no differences in the parameters of the vector magnitude between patients with and without paroxysmal atrial fibrillation recurrence. These results suggest that body surface mapping of the P wave signal-averaged ECG would be superior to the conventional method in the prediction of antiarrhythmic drug efficacy and the detection of patients with paroxysmal atrial fibrillation.

Limitations of this study

This present investigation has several limitations. First, the large number of patients with valvular heart disease in the patient group may alter the signal-averaged P wave duration results, although the difference in the percentage of patients with valvular heart disease between the patient group and the controls was not statistically significant (15% vs 4%, P=0.08). Second, body surface mapping of the signal-averaged P wave was performed using 16 precordial leads in this study. It remains unclear whether the number and the location of electrodes used in the present study would be optimal for accurate estimation of body surface distribution of atrial electrograms. The more electrodes we use in mapping, the more detailed information concerning regionally selective properties of the atrial myocardium might be provided. However, extensive body surface mapping using more electrodes is cumbersome to apply and therefore may seldom be used clinically. Third, intracardiac recordings were not available to correlate atrial activation time with the P wave signal-averaged ECG measurements. However, to precisely investigate the correlation, we will need left atrial catheter mapping, which is not feasible in the usual clinical setting. Fourth, although we employed pilsicainide for drug-efficacy study, it remains unclear whether the efficacy of other antiarrhythmic drugs might be also predicted by the evaluation of the dispersion of signal-averaged P wave duration in precordial mapping. Further study will be needed to address this problem.

Conclusions

In the present study, the dispersion of signal-averaged P wave duration in precordial mapping was greater in patients with paroxysmal atrial fibrillation than in control subjects. Furthermore, the dispersion after the single dose of pilsicainide could decrease in patients in whom this drug is efficacious in the suppression of paroxysmal atrial fibrillation attacks. These results suggest that the increased spatial dispersion of signal-averaged P wave duration would play an important role in generating paroxysmal atrial fibrillation and that the efficacy of pilsicainide in the suppression of paroxysmal atrial fibrillation attacks might be predicted by evaluating the electrophysiological dispersion after the single dose administration.

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