P-wave signal averaging in the management of patients with atrial fibrillation


Sowohl die signal-gemittelte P-Wellendauer als auch deren Dispersion sind reproduzierbare Parameter, die möglicherweise prognostische Informationen für das Wiederauftreten von VHF und die Effektivität verschiedener Antiarrhythmika zur Rezidivprophylaxe nach erfolgreicher Kardioversion enthalten.

Um jedoch die P-Wellensignalmittelung im klinischen Alltag als Testverfahren zu akzeptieren, sind einerseits eine internationale Standardisierung der Methodik, andererseits eine weitere systematische Forschung zur prognostischen Bedeutung im Management von Patienten mit VHF erforderlich.

Schlüsselwörter Vorhofflimmern – P-Wellensignalmittelung – EKG

Summary Atrial conduction abnormalities (delay and/or block) increase the vulnerability for atrial fibrillation (AF). AF, in turn, produces further conduction defects. These changes are reflected by P-wave changes on the surface ECG during sinus rhythm. From the available data it can be assumed that the signal averaged P-wave duration and its dispersion are reproducible parameters containing at least some prognostic information regarding both the probability of AF recurrence following cardioversion and antiarrhythmic drug efficacy for AF relapse prevention. In order to accept this test into clinical medicine both an international standardization of the P-SAECG method is required, and further systematic research elucidating the prognostic significance of this test in the management of AF patients is needed.

Key words Atrial fibrillation – P-wave signal averaging – ECG
Atrial fibrillation (AF) is the most common arrhythmia encountered in clinical practice (34). It is estimated that about 2.2 million citizens in the United States (5) and 620,000 citizens in Germany (26) suffer from AF. Epidemiologic studies have shown that its prevalence and incidence doubles with each advancing decade beyond 50 years reaching 10% in octogenarians (22, 23). In a recently conducted cross-sectional population study of Americans older than 65 years, the AF prevalence on a 24-hour Holter-ECG was about 5% (16, 17). These numbers are especially troublesome considering the growing aged population in Western countries.

The wavelength concept introduced by Moe (30) and confirmed by Allessie’s group (2) states that the induction and sustenance of AF depend on the number of reentry circuits that can be present at the same time. The number of coexisting wavelets is mainly determined by the product of conduction velocity and refractory period (wavelength). The smaller the wavelength, either by conduction slowing, refractory period shortening or both, the greater the number of possible reentry circuits and subsequently, the more easily AF is induced and maintained.

While a review by our group published in a previous issue of this journal addressed AF-induced changes in refractory periods and subsequently fibrillatory frequency (6), this review summarizes experimental and clinical findings on conduction abnormalities and their non-invasive assessment by the P-wave signal averaged ECG (P-SAECG) in patients with established AF.

Previous investigations have shown that intra-atrial or inter-atrial conduction delay or block are associated with AF and that these changes are reflected by P-wave changes on the surface ECG (28, 44), although the detailed contribution of these conduction defects, especially for the signal-averaged P-wave, are not completely identified.

Over the last 10 years numerous investigations have explored this test in order to predict AF from individuals in sinus rhythm reaching sensitivities and specificities of about 80% (19). It seems, however, that this moderately time consuming and complex technique has not been accepted into clinical practice for this purpose, especially since the diagnosis ‘AF’ can be readily reached and a failure to predict the AF development is not catastrophic (38).

Detailed reviews regarding the prediction of paroxysmal or postoperative AF were provided earlier by Rosenheck (36) and Jordaens et al. (21). Consequently, this article will focus on the possible role of the P-SAECG as an adjunct to the AF management, namely its role for prediction of AF recurrence and assessment of antiarrhythmic drug efficacy following cardioversion.

AF associated conduction abnormalities

Conduction abnormalities such as prolonged intraatrial conduction (25) or local conduction times (50) increase the vulnerability for AF. AF in turn produces further conduction defects (44).

Previous experimental studies in dogs (14, 18, 31) have shown that long-term rapid atrial pacing (RAP) induces atrial conduction slowing. The time course of conduction velocity (CV) changes has been found to be slower than that of refractory period (ERP) shortening. Gaspo et al. (18) observed a CV reduction from 109 to 82 cm/s after 6 weeks of RAP, while there was no significant reduction after 1 or 7 days, at a time when a reduction in ERP had occurred already. In a comparable experimental setting, Morillo et al. (31) noted an increase in both the P-wave duration (PWD, from 55 to 89 ms) and the PA interval (from 37 to 56 ms) also after 6 weeks of RAP. These changes are thought to be the result of an increase in atrial size and changes in atrial architecture at the microscopic level, such as fiber disarray or hypertrophy.

In contrast to the RAP model, congestive heart failure did not alter mean CV. However, an increased heterogeneity of conduction owing to discrete regions of slow conduction was observed (27). Similar to the RAP model, interstitial fibrosis with cell loss, degenerative changes, and hypertrophy was identified in these animals as a potential pathological substrate underlying these conduction abnormalities.

While the time course of CV changes associated with persistent AF in humans is not accessible, the recovery from these changes were studied in several investigations (29, 32, 49). In fact, they mirrored the time course of the electrophysiological changes (fast ERP shortening, slow CV depression) found in experimental AF models. While ERP returned to normal values within days following cardioversion of persistent AF (29, 49), P-wave duration reached control levels within 1 month when obtained from the surface ECG (29), began, however, to re-

---

**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF</td>
<td>Atrial fibrillation</td>
</tr>
<tr>
<td>CV</td>
<td>Conduction velocity</td>
</tr>
<tr>
<td>PWD</td>
<td>P-wave duration</td>
</tr>
<tr>
<td>P-SAECG</td>
<td>P-wave signal averaged ECG</td>
</tr>
<tr>
<td>RAP</td>
<td>Rapid atrial pacing</td>
</tr>
<tr>
<td>RMS</td>
<td>Root mean square</td>
</tr>
</tbody>
</table>