ORIGINAL ARTICLE

CHANGES OF SIGNAL-AVERAGED ECG IN NORMAL SUBJECTS AFTER ONE YEAR

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Summary: Repeated signal-averaged electrocardiograms (SA ECG) were recorded twice with a mean interval of 13 months in 11 healthy volunteers in order to acquire basic information on long-term changes of SA ECG. After one year the duration of filtered QRS remains the most stable parameter of SA ECG on the contrary to parameters describing end of fQRS - i.e. both HFLA and RMS. Moreover fQRS seems to have better specificity in comparison to HFLA and RMS. An estimation of significant long-term changes in individual parameters of SA ECG was obtained. According to our results, only changes in QRS ± 13 ms, fQRS ± 8 ms, HFLA ± 22 ms and RMS ± 17 μV should be considered significant when found in a long-term follow-up of patients with a heart disease.

Key words: *Signal-averaged electrocardiography (SA ECG); Late potentials; Long-term changes; Healthy volunteers*

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Introduction

Late potentials appear to be a hallmark for sustained ventricular arrhythmias (1). Signal-averaged electrocardiography (SA ECG) helps in stratifying the risk of developing a sustained ventricular arrhythmia in patients who are recovering from myocardial infarction (2). With the present knowledge, it appears that late potentials seem to be more closely related to the underlying morphological substrate for arrhythmias than the clinically occurring arrhythmia per se. Abnormal signal-averaged ECG reflects abnormalities in ventricular activation caused by separation of myocardial bundles and the distortion of their parallel orientation by fibrosis (3).

There are several studies on the long-term changes in SA ECG in patients after myocardial infarction (4,5) and one study of patients with right ventricular dysplasia (6). But assessment of changes of SA ECG was not based on a comparison with a control group. Moreover there has been no study of the long-term changes in SA ECG in normal subjects. In order to acquire such basic information we performed a prospective study of signal-averaged ECG in 11 normal subjects. Such a study should be, in our opinion, the first step in evaluating long-term changes of SA ECG in different group of patients.

Materials and methods

11 men of relatively young age 32±6 years were studied. For inclusion into the study, each subject had to feel healthy and be active. All patients had to have a history and a physical examination neither of which was suggestive of cardiac disease, and a normal surface standard electrocardiogram. Repeated signal-averaged surface electrocardiograms were recorded with a mean interval of 13±1 months.

The recording and signal averaging and processing was performed with a system from Arrhythmia Research Technology, model 1200 EPX, based on the method previously described by Simson (1). Standard orthogonal bipolar X, Y, and Z leads were used to manalyse 250 cycles with a noise ≤0,4 μV. The recorded signals were amplified, averaged and filtered with a Butterwoth bidirectional filter (range 40 to 250 Hz). The signal obtained from the 3 leads were then combined to form a vector magnitude ($V= \sqrt{X^2+ Y^2 + Z^2}$), a measure that sums the high-frequency content from all three leads, termed „the filtered QRS complex". Three indices were measured: 1. the duration of the filtered QRS (fQRS), 2. the root mean square of the terminal 40 ms of the filtered QRS (RMS) and 3. the period for which the filtered QRS remains <40 μV (HFLA). Abnormal values for these three parameters were defined according to current recommendation as fQRS >114 ms, RMS <20 μV, and HFLA >38 ms (2). Abnormal late potentials were defined by presence of two criteria out of the three.

All data were expressed as mean ± one standard deviation (SD). In order to gain criteria for significant changes for all measured parameters we doubled and rounded up standard deviation of mean change of each of the parameters. Any change in case of QRS, mfQRS, HFLA higher by 1 ms and in case of RMS higher by 1 μV was considered to be significant (table 1.).

Results

On the basis of the previously defined criteria, late potentials were found in 2 out of 11 volunteers (18%) in the first measurement. After 1 year the signal averaged ECG of both previously positive volunteers were found to be within normal limits, but one subject (9%) whose SA ECG was originally normal was classified as late potentials positive.

Interestingly, in all cases of positive SA ECG, late potentials were present due to coincident abnormal values of HFLA and RMS. fQRS was well within normal limits in all measurements. Both RMS and HFLA were in all 22 measurements 4 times abnormal.

Mean changes of measured parameters, and calculation of final values of changes considered abnormal are shown in table 1.

Table 1:

	mean change ± SD	2 SD	borderline values	abnormal changes
QRS (ms)	1,9±5,6	11,2	±12	±13
f QRS (ms)	2,3±3,1	6,2	±7	±8
HFLA (ms)	0,5±10,3	20,6	±21	±22
RMS (μV)	0,78±7,87	15,74	±16	±17

Changes of measured parameters of SA ECG after one year in healthy volunteers (n=11) and calculation of changes considered to be abnormal.

According to our results we consider as significant a change of the standard QRS duration ±13 ms, a change of fQRS ±8 ms, a change of HFLA ±22 ms and a change of RMS ±17V.

Discussion

Using the currently recommended method in 11 healthy volunteers, we found the abnormal late potentials in 2/11 (18%), which is slightly higher than reported in previous studies (7,8). This difference may be caused by the different method of detection of late potentials, but also by the small size of our group of volunteers. Interestingly, the abnormal late potentials in our group did not remain stable over the longer period, they either appeared or disappeared without any apparent changes in the health status of the study participants. An important finding is that the abnormal late potentials were always diagnosed by simultaneous abnormalities of RMS and HFLA. In addition, we observed a low long-term stability of these parameters suggesting their poor long-term reproducibility. On contrast to RMS and HFLA no abnormal value of fQRS was observed in our study. FQRS was found to be the most stable parameter over time. In this way our work gives rise to some doubts about currently recommended criteria for evaluation of SA ECG. In order to eliminate the false positive results the duration of the filtered QRS should be preferred to the other two recommended parameters of SA ECG. Our results on long-term stability of fQRS closely correspond with previous studies which found fQRS to be the most reproducible parameter of SA ECG in a short-time (6,9).

To our knowledge the estimation of the significance of long-term changes of the SA ECG parameters is the first attempt to obtain such criteria. In previous research just the occurrence of abnormal late potentials was used to describe changes in SA ECG. Such studies were done in patients after myocardial infarction (4,5). But by this simple way of evaluation changes in late potentials may be under- or overestimated. For example prolongation of fQRS from 95 ms to 113 ms is definitely a significant change without meeting defined criteria for late potentials. But a change as small as 1 ms may be sufficient to meet recommended criteria e.g. prolongation fQRS from 114 to 115 ms. Blomström-Lunqvist et al. (6) have arbitrarily defined the changes in late potentials as 10 μV or more for RMS and 10 ms or more for HFLA under 25 μV to be significant. Our results clearly show their suggested criteria to be unacceptable. The most important limitation of our study is the limited size of the group of volunteers. At the beginning of the study we considered the size to be sufficient as we expected only a small variability of the studied parameters in time. Although limited by the size of the group, the findings demonstrate that in the long-term follow-up, only rather large differences in individual parameters of SA ECG (ΔQRS ±13 ms, ΔfQRS ±8 ms, ΔHFLA ±22 ms and ΔRMS ±17 μV) are likely to be caused by myocardial damage.

Conclusion

The duration of fQRS appears to be the most stable parameter of SA ECG on analysis of the long-term changes of SA ECG parameters. The fQRS is clearly superior to both RMS and HFLA. We obtained an estimate of significant long-term changes of parameters of signal-averaged ECG which might be useful in evaluating changes of SA ECG in different groups of patients. We consider fQRS to be the most useful parameter of SA ECG for assessment of long-term changes of SA ECG.

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