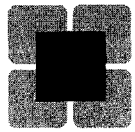

Signal-averaged electrocardiography for detection of ventricular tachycardia using fast Fourier transform filtering on a standard ECG cart

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■ Signal-averaged electrocardiography has been advocated as a technique to predict the occurrence of ventricular tachycardia, especially in patients with ischemic heart disease. We studied a heterogeneous population of 77 patients referred for electrophysiologic testing using a recently developed fast Fourier transform filtering system available as part of a standard electrocardiography cart. The sensitivity, specificity, and positive predictive accuracy of this system were consistent with those previously determined using bidirectional Butterworth filters or finite impulse response filtering techniques. This new filtering approach in generation of signal-averaged ECG data for detection of ventricular tachycardia has promise but will require use in larger groups to establish its true clinical value.

□ INDEX TERMS: SIGNAL-AVERAGED ELECTROCARDIOGRAPHY; VENTRICULAR TACHYCARDIA □ CLEVE CLIN J MED 1991; 58:510–512

SIGNAL-AVERAGED electrocardiography (SAECG) has been advocated as a predictor of ventricular tachycardia in patients prone to this arrhythmia, particularly those with ischemic heart disease.[1] The technique involves the detection of high-frequency, low-amplitude signals in the terminal QRS or early ST segment termed late potentials. The measurements commonly determined are peak-to-peak amplitude deflections of the averaged and filtered waveforms; root-mean-square of the high-frequency voltage in the terminal 40 milliseconds of the QRS (RMS-40); ventricular activation time; and duration of high-frequency, low-amplitude signals. Commercially available SAECG systems are single-use devices using bidirectional Butterworth filters or finite impulse response filters. Recently, computer software has been developed for use in a standard ECG cart system utilizing a frequency domain correlation for alignment and averaging of Frank lead x, y, and z signals and a fast Fourier transform filter for analysis of high-frequency, low-amplitude signals.[2] We tested this SAECG technique to determine the sensitivity, specificity, and positive predictive accuracy in predicting inducibility of ventricular tachycardia in the electrophysiology laboratory.

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METHODS

The patient population consisted of consecutive patients referred for electrophysiologic study for a variety

of clinical reasons. Patients with intraventricular conduction defects or bundle branch blocks were excluded. SAECG was obtained within 1 week of electrophysiologic study. Electrophysiologic status was considered abnormal if sustained monomorphic ventricular tachycardia was induced in the laboratory using a standard provocative protocol. The inducement of polymorphic ventricular tachycardia or ventricular fibrillation was classed as a nonspecific finding.

Signal-averaged tracings were generated using a standard ECG cart (Marquette Electronics) with signal-averaging analysis software. This software identifies QRS complexes and computes average P-, QRS-, and T-wave complexes that are used for analysis of late potentials. Averaged complexes for Frank leads x, y, and z are filtered using a 512 fast Fourier transform and then attenuated and reverse-transformed to obtain the filtered signals from which a vector magnitude is calculated. The filtered QRS duration (TQRS), RMS-40, and terminal duration of signal under 40 μV (LAD) are measured by the computer. Parameters for abnormality in this trial were: TQRS 120 milliseconds, RMS-40 <20 μV, and LAD > 38 milliseconds, using a 40-Hz high-pass filter. The sensitivity, specificity, and positive predictive accuracy were determined for each individual parameter.

RESULTS

Seventy-seven patients were referred for electrophysiologic testing (55 men). The mean age was 61 for the men and 60 for the women. Thirty patients were excluded because of intraventricular delays on the standard electrocardiogram. Ten patients could not be analyzed because of baseline noise; three of these had atrial arrhythmias with an atrial depolarization wave in the early ST segment. The 37 patients with "acceptable" SAECGs and without intraventricular delay made up the study population. Indication for electrophysiologic testing in these 37 patients included ventricular tachycardia (11 patients), syncope (9), sudden cardiac death (6), ventricular ectopy (5), wide complex tachycardia (4), and palpitations (2). Coronary disease was present in 22 patients (59%), and moderate to severe ventricular dysfunction in 17 (46%). The diagnostic values of the various parameters is shown in the *Table*.

TABLE
VALUE OF INDIVIDUAL SIGNAL-AVERAGED PARAMETERS IN IDENTIFYING RISK FOR VENTRICULAR TACHYCARDIA

	TQRS >120 ms	RMS-40 <20 μV	LAD (>38 ms)	Any two of three parameters abnormal
Sensitivity	68%	68%	74%	74%
Specificity	72%	83%	83%	89%
Positive predictive accuracy	72%	81%	82%	88%

TQRS = filtered QRS duration;
RMS-40 = root-mean-square voltage in the terminal 40 ms of QRS
LAD =Terminal low-amplitude duration

DISCUSSION

A sensitive noninvasive method to identify risk of ventricular tachycardia would help in deciding who should undergo invasive electrophysiologic testing. Numerous studies have shown a high sensitivity, specificity, or both, for signal-averaged electrocardiography in predicting the induction of significant arrhythmias in the electrophysiology laboratory.[1,3,4] A problem in comparing studies for overall specificity or sensitivity is the variety of criteria used to define an abnormal signal-averaged electrocardiogram, and the use of various filtering and averaging techniques. The range of test sensitivity has been reported to be between 50% and 100%, specificity 62% and 100%, and positive predictive values 28% to 95% using bidirectional Butterworth filters or finite impulse filtering techniques.[5] From a clinical point of view, the use of the technique in uniform vs mixed populations also has a significant impact on the positive predictive accuracy of the test.

In this heterogeneous population, which reflects daily clinical practice, finding any abnormality on the signal-averaged electrocardiogram had a sensitivity of 84% and a specificity of 67%. The single most sensitive (74%) and specific (83%) indicator for induced ventricular tachycardia was LAD ≥38 milliseconds. Positive predictive accuracy was between 72% and 82% for the various parameters tested.

SUMMARY

This is a preliminary report using a new filtering technique. In this heterogenous population of patients, the signal-averaged electrocardiogram produced by fast Fourier transform filtering had sensitivity and specificity values within the range reported for other filtering approaches.

SAECG is noninvasive and is easy to perform especially using cart-based analysis. It may evolve to become part of a multifaceted approach to patients in

deciding the need of further evaluation of arrhythmias. Much like stress ECG testing, standardized parameters for abnormality will need to be established and evaluated in large heterogeneous and homogeneous groups before the role of signal-averaging electrocardiography using this or any other filtering technique can be clearly stated or the result from any individual patient used in a clinically relevant fashion.

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