PREDICTION AND STRATIFICATION OF THE FUTURE CARDIOVASCULAR ARRHYTHMIC EVENTS: SIGNAL AVERAGED ELECTROCARDIOGRAPHY VERSUS EJECTION FRACTION*

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Abstract: Cardiac arrhythmias as cause of sudden cardiac death remains an important public health problem. The availability of effective treatment in terms of the implantable defibrillator makes it critical to identify individuals at risk. An essential step in this process is the use of non-invasive techniques to screen patients and identify those at risk. The detection of ventricular late potential using the SAECG as a non-invasive technique is being explored for this purpose. The objective of the study was to stratify the future cardiovascular events including life threatening cardiac arrhythmias, in different cardiac diseases through positive and negative predictive values of SAECG and comparing with EF% another mechanical determinant. The study was conducted on 152 subjects selected from the OPD and admitted case of the New Civil Hospital and Govt. Medical College, Surat; between 25 to 75 years of age group, from August 2001 to June 2004. 80 healthy subjects free from any major acute/chronic illness were selected as a control using our own normative values for SAECG. The statistical analysis was performed using SPSS package. The results obtained were analyzed for significance by using Chi square and Independent ‘t’ test. When we compared the cardiac arrhythmic events on 6 month follow-up study, based on SAECG and EF% separately we found that negative predictive value of SAECG was more (99.1%) than negative predictive value of EF% (93.6%). However positive predictive values for cardiac arrhythmic events of SAECG were less (28.9%) compare to EF% (42.9%).

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When both the parameters SAECG and EF% are considered together the negative as well as positive predictive values of these tests were quite high (100% and 50% respectively). In this study conducted on 152 patients we found that SAECG and EF% together were an accurate predictor of the cardiac arrhythmic events in terms of positive and negative predictive value while SAECG or EF% alone were not. However SAECG has got a more negative predictive value compared to EF%. In this study SAECG compared favorably or even better than EF% for risk stratification. SAECG and EF% together (and not separately) may be considered as a better investigational tool to stratify future cardiovascular arrhythmic events.

**Key words**: cardiovascular arrhythmic events ejection fraction signal averaged electrocardiography

**Abbreviations**: EF% = Percentage Ejection Fraction, SAECG = Signal Averaged Electrocardiography, LP = Late Potential.

**INTRODUCTION**

A signal-averaged electrocardiogram, (SAECG) is a specialized ECG which may identify areas of delayed electrical conduction of the heart. Signal-averaged electrocardiogram (SAECG) reveals presence of late potentials that are low-amplitude high-frequency waveforms within the terminal portion of the QRS complex (1). Delayed conduction, which usually occurs near cardiac scar tissue, is often associated with certain abnormal heart rhythms. Late potentials in the SAECG reflect the presence of slow conduction within the ventricular myocardium that may serve as a substrate for arrhythmogenesis. Late potentials (LP) detected on the signal-averaged electrocardiogram (SAECG) predict arrhythmic events after acute myocardial infarction (2, 5). Park et al (3) found that late potentials has a more positive predictive value than ejection fraction.

Fatal or near-fatal arrhythmic events can be predicted by many risk stratification methods, especially by heart rate variability and reduced left ventricular ejection fraction (LVEF ≤ 40%) after AMI (4). In another recent study by Gang et al (5) concluded that long-term monitoring in a population of post-AMI patients with left ventricular ejection fraction ≤ 40% showed that VT/VF and bradyarrhythmia each accounted for half of the recorded events at the time of death. Time domain signal averaging is applicable to a limited study group since late potentials are not detectable in the presence of intraventricular conduction abnormalities such as bundle branch block. With signal averaging very low amplitude electrical potential, generated by the sinus node, AV node, Bundle of His and Bundle branches are detectable at the body surface (6). Risk stratification of patients recovering from acute myocardial infarction is one of the most important functions for subsequent management and rehabilitation. Identifying patients at risk for serious ventricular arrhythmia is as important in this. Late potential at SAECG are said to suggest presence of electric instability and slowed conduction velocity, a pre-requisite for re-entrant ventricular tachyarrhythmia (7). Progressive increase in delayed ventricular conduction by SAECG not associated with significant echocardiographic changes (8).
Therefore, the conduction disturbance seems to increase independently from anatomical alterations. The baseline SAECG and echocardiographic parameters, more than their modifications during follow-up, appear to be useful in identifying patients with sustained ventricular tachycardia (8).

The 2006 American College of Cardiology, American Heart Association and European Society of Cardiology guidelines for management of patients with ventricular arrhythmias and prevention of sudden death list SAECG with a Class IIb recommendation (Class IIb noted as usefulness/efficacy is less well established by evidence/opinion). The report notes that SAECG may be useful to improve the diagnosis and risk stratification of patients with ventricular arrhythmias or at risk for life-threatening ventricular arrhythmias (9).

A recent consensus document from the American Heart Association, American College of Cardiology Foundation and Heart Rhythm Society indicates that SAECG may identify patients with prior MI at risk for sudden cardiac death and that further studies are required to assess the utility of this test (10).

One study from Japan (11) did evaluate the use of SAECG in a study of 222 hospitalized patients found to have non-sustained ventricular tachycardia (NSVT). Forty-three patients had ischemic heart disease and 50 had non-ischemic cardiomyopathy. These patients were evaluated using an algorithm for risk-stratification. The algorithm included left ventricular ejection fraction, signal-averaged electrocardiography (in 69 patients), programmed ventricular stimulation, and family history of sudden cardiac death (SCD); programmed stimulation was done in follow-up to all positive SAECG studies. The authors concluded that this proposed algorithm for risk-stratification of patients with NSVT may be feasible for appropriate selection of candidates for prophylactic ICD implantation.

Sudden cardiac death remains an important public health problem. The availability of effective treatment in terms of the implantable defibrillator makes it critical to be able to identify individuals at risk. An essential step in this process is the development of non-invasive techniques to screen patients who may be at risk. The detection of ventricular late potential using the SAECG has been a non-invasive technique for this purpose. Although it has a low positive predictive value, SAECG has also been shown to predict susceptibility to ventricular arrhythmias (7, 12). The aim of the study was to predict and stratify the future cardiovascular events including life threatening cardiac arrhythmias in different cardiac diseases through positive & negative predictive values of SAECG and EF%.

MATERIALS AND METHODS

All the patients/guardians were informed about the study protocol and informed written consent was obtained from them to participate in the study prior to examination and investigation. The study was approved by the Ethical Committee of Govt. Medical College and New Civil Hospital, Surat. 210 subjects were selected from the OPD and admitted case of the New Civil Hospital and Govt. Medical College, Surat between 25 to
75 years of age group, from August 2001 to June 2004. Out of the 210 only 152 patients were included in the study group based on the inclusion and exclusion criteria. The patients were divided into the following groups:

1. **Acute Coronary Syndrome (ACS)** from the last 6 to 10 weeks (n=58):
   Patients with chest pain at rest with increasing frequency and severity which included the patients with ST elevation MI, non ST elevation MI and unstable angina. ECG suggestive of MI or unstable angina with cardiac enzymes to confirm the diagnosis.

2. **Chronic Ischemic Heart Disease (CIHD)**, (n=46):
   In this group patients selected, having chronic history of IHD with stable angina with ECG supportive of ischaemia as well as 2D Echocardiography is suggestive of regional wall motion abnormality.

3. **Dilated Cardiomyopathy (DCM)**, (n=21):
   In this group patients selected, having sign and symptoms of biventricular failure clinically, ECG suggestive of non-specific ST-T changes. QS pattern, low voltage complexes, sinus tachycardia, chamber enlargement, intraventricular conduction defects. X-ray chest PA view and 2D echocardiography reports suggestion of generalized cardiomegaly with severe wall motion abnormality with low ejection fraction.

4. **Systemic Arterial Hypertension (SAH)**, (n=27):
   In this group patients selected, having long standing systemic arterial hypertension (JNC-6) with ECG and 2D echocardiography suggestive of LVH.

5. **Control group**:
   Eighty healthy subjects free from any major acute/chronic illness, having no history of any cardiac disease, with normal ECG, were selected as a control. If the individuals in this group were >35 years of age, then 2D echocardiography was performed to rule out any cardiac disease. RBS, S.cholesterol, Blood urea, Serum creatinine and Haemoglobin was done to rule out other illnesses in all (young and middle age) study population.

SAECG was taken using HIPEC HA-200 system analyzer with Butterworth double filter of 40-250 Hz from AIREL-RENOLDS, Israel (1999). 36 leads were used to obtain three different leads (X,Y and Z) and a mini computer averaged them into one single complex for analysis. After temporal averaging the complexes are filtered to eliminate low frequency components of QRS complex (plateau or repolarization phase). Interferences from low frequency with 20-50 Hz and is stable at 10 Hz filter. Filtering enhances detection of high frequency, low amplitude signals corresponding to disorganized wave-fronts of activation. The computer selected a part of the down slope of the ‘R’ wave that first dropped to an arbitrary point (usually 40 μV); this signaled the beginning of “late potential”. Three measurements were then made.

1) QRS duration (QRSd) which includes Late Potential.
2) Duration of Late Potential (LP) and
3) Root mean square voltage of the terminal 40 ms of the QRS complex (RMS_{40}).

Out of the three parameters of SAECG at least two parameters should be abnormal to diagnose SAECG as abnormal.

Defining the normative values of different parameters of SAECG.

We have established our own normative values of SAECG. Eighty subjects free from any cardiac illness or any major acute/chronic illness, were selected for SAECG to established normative values.

The parameters of SAECG and their normal values are:

1. QRS Duration \( \leq 110 \text{ ms} \).
2. RMS_{40} > 25 \mu V.
3. Late potential (LP) duration < 40 ms.

The 5th and 95th percentile of each parameter was decided.

**QRS duration:** Upper limit is important so 95th percentile was considered as cut of point.

**RMS_{40}:** Lower limit is important so 5th percentile was considered as cut of point.

**Late potential (LP) duration:** Upper limit is important so 95th percentile was considered as cut of point.

These values are matching with the normal values decided by American Heart Association (AHA) and also by other investigators (6). SAECG is said to be positive only if \( \geq 2 \) parameters of SAECG are abnormal. 2D Echocardiography was performed in all the study population to support the diagnosis and also on the control group age > 35 years to rule out asymptomatic cardiac illness.

Preparation of the patients before electrode placement is very important for SAECG analysis. Shave the chest and the areas where the leads are to be placed followed by rubbing of the skin by gauze pad. Clean the area with alcohol pad and then dry the skin. Place the electrode on the flat bony areas and not on muscle or fat. Connect the patient with SAECG analyzer.

2D echocardiograms were recorded using MEGAS CVX and MEGAS GPX equipped with ADV4 software from ESAOTE s.p.a. Firenze, Italy (1999). Echocardiographic variables were calculated according to the American Society of Echocardiography (ASE) guidelines. Left ventricular internal dimensions at systole and diastole (LVIDs and LVIDd), interventricular septal dimension and posterior wall thickness (IVSd and PWT) were measured. Stroke volume (SV), cardiac output (CO), percentage ejection fraction (EF\%) and Left ventricular mass were calculated from the measured dimension by the following formula of ASE convention –

\[
\text{S.V.} = (\text{LVIDd})^3 - (\text{LVIDs})^3
\]

CO (L/min) = stroke volume (SV) \times heart rate (HR)

\[
\text{EF\%} = \frac{(\text{LVIDd})^3 - (\text{LVIDs})^3}{(\text{LVIDd})^3} \times 100
\]

Left ventricular mass (LVM) were measured using ASE conventions by the following equation (13):

\[
\text{LVM} = \frac{1}{1 - \text{EF\%}} \times \frac{\pi}{6} \times (\text{LVIDd})^3 - (\text{LVIDs})^3
\]
LVM (ASE) = 0.8[1.04(IVS + LVIDd + PWT) 3 – (LVIDd) 3] + 0.6 g.

Follow up visits were done for at least 6 months at an interval of 15 days for the symptomatic patients while an interval of one month for asymptomatic cases. For all patients, an arrhythmic event was considered only if a patient had a documented arrhythmia in the hospital (Holter monitoring). For most of the patients the time of first recording after the event was between 24–48 hours. The statistical analysis was performed using SPSS package (version 13.0). The results obtained were analyzed for significance by using Chi square and ‘t’ test.

RESULTS

Table I shows general characteristics of the study population. It has shown that mean age is similar in the study subgroups, but it was significantly higher (P<0.05) in the cardiovascular disease subgroups compared to control. The BMI of acute coronary syndrome (ACS) and systemic arterial hypertension (SAH) subgroups were significantly higher (P<0.05) than control and dilated cardiomyopathy (DCM) sub group. Systolic and diastolic blood pressure were significantly higher (P<0.001) in SAH sub group compared to control and other subgroups (ACS, CIHD, DCM). The number of cases with SAECG positivity was quite high in patients with ACS (50%) than other groups (CIHD 23.7%, DCM 18.4% and SAH 7.9%, Table III). This result is similar to the study by previous investigators (6, 14). Table IV shows that out of the total 38 patients with SAECG positive (i.e. ≥ 2 parameters of SAECG are abnormal), 11 patients demonstrate abnormal

**Table I**: General parameters, basal heart rate (BHR), systolic blood pressure (SBP) and diastolic blood pressure of the study population.

<table>
<thead>
<tr>
<th>Group</th>
<th>Status</th>
<th>Age (years)</th>
<th>RMS 40 μV</th>
<th>QRSdms</th>
<th>LPms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>n=80</td>
<td>48.0±8.1</td>
<td>78.44±5.4</td>
<td>123.2±9.03</td>
<td>87.6±3.8</td>
</tr>
<tr>
<td>ACS (n=58)</td>
<td>54.7±8.8*</td>
<td>23.2±8.6</td>
<td>53.9±6.7*</td>
<td>122.8±5.5</td>
<td>23.9±5.4</td>
</tr>
<tr>
<td>CIHD (n=46)</td>
<td>53.9±8.8*</td>
<td>1.6±0.15</td>
<td>1.6±0.2</td>
<td>1.6±0.3</td>
<td>80.6±4.4</td>
</tr>
<tr>
<td>DCM (n=21)</td>
<td>52.2±4.4</td>
<td>76.3±4.9</td>
<td>124.7±5.5</td>
<td>119.4±8.6</td>
<td>78.6±4.5</td>
</tr>
<tr>
<td>SAH (n=27)</td>
<td>54.6±10.1*</td>
<td>74.1±6.4</td>
<td>23.3±2.8</td>
<td>158.4±19.2***</td>
<td>95.6±6.7***</td>
</tr>
</tbody>
</table>

Values are mean±SD; BMI- body mass index, BSA- body surface area, ACS-Acute coronary syndrome, CIHD-Chronic ischemic heart disease, SAH-Systemic arterial hypertension, DCM- Dilated cardiomyopathy; the star mark(*) depicts comparisons between control and cases (ACS,CIHD,DCM,SAH) and has (#) mark depicts comparison of ACS,SAH with DCM. The analysis of data was done by one-way ANOVA. *P<0.05, ***P<0.001.

**Table II**: Group statistics and SAECG in the study population.

<table>
<thead>
<tr>
<th>Group</th>
<th>Status</th>
<th>Age (years)</th>
<th>RMS 40 μV</th>
<th>QRSdms</th>
<th>LPms</th>
</tr>
</thead>
</table>
| Cases N=152|        | 53.9±9.8    | 49.8±44.8 | 97.7±21.3 | 32.6±20.5
| Control N=80|        | 48.0±8.1    | 87.5±49.6 | 93.1±12.4 | 23.9±7.7
| P Value    | <0.05  | <0.0001     | <0.05     | <0.001  |

Values are expressed as mean±SD; Cases (n=152) includes acute coronary syndrome (ACS) from the last 6–10 weeks –58 Patients, Chronic ischemic heart disease (CIHD) –46 Patients, Systemic arterial hypertension (SAH) –27 Patients, Dilated cardiomyopathy (DCM) –21 Patients; RMS 40 = Root mean square voltage of terminal 40 second of QRSd, QRSd = QRS duration, LP = Late potential.
TABLE III: SAECG abnormality in different cardiovascular diseases.

<table>
<thead>
<tr>
<th>Study groups</th>
<th>SAECG Positive</th>
<th>SAECG Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS (n=58)</td>
<td>19 (50)</td>
<td>39</td>
</tr>
<tr>
<td>CIHD (n=46)</td>
<td>09 (23.7)</td>
<td>37</td>
</tr>
<tr>
<td>SAH (n=27)</td>
<td>03 (7.9)</td>
<td>24</td>
</tr>
<tr>
<td>DCM (n=21)</td>
<td>07 (18.4)</td>
<td>14</td>
</tr>
<tr>
<td>Total (n=152)</td>
<td>38</td>
<td>114</td>
</tr>
</tbody>
</table>

Figures in parenthesis indicates % of the number of total SAECG positive ACS-Acute coronary syndrome, CIHD-Chronic ischemic heart disease, SAH-Systemic arterial hypertension, DCM-Dilated cardiomyopathy.

TABLE IV: Correlation of SAECG positivity to abnormal cardiac arrhythmic events (arrhythmias) on 6 months follow-up in various cardiac diseases.

<table>
<thead>
<tr>
<th>Group status</th>
<th>Cardiac arrhythmic events positive on 6 month follow-up</th>
<th>Cardiac arrhythmic events negative on 6 month follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Positive (n=19)</td>
<td>07 (36.8)</td>
<td>12</td>
</tr>
<tr>
<td>ACS Negative (n=39)</td>
<td>00 (100)</td>
<td>39</td>
</tr>
<tr>
<td>CIHD Positive (n=09)</td>
<td>01 (11.1)</td>
<td>08</td>
</tr>
<tr>
<td>CIHD Negative (n=37)</td>
<td>00 (100)</td>
<td>37</td>
</tr>
<tr>
<td>SAH Positive (n=03)</td>
<td>01 (25)</td>
<td>03</td>
</tr>
<tr>
<td>SAH Negative (n=24)</td>
<td>00 (100)</td>
<td>24</td>
</tr>
<tr>
<td>DCM Positive (n=07)</td>
<td>02 (28.5)</td>
<td>05</td>
</tr>
<tr>
<td>DCM Negative (n=14)</td>
<td>01 (92.9)</td>
<td>13</td>
</tr>
<tr>
<td>Total Positive (n=38)</td>
<td>11 (28.9)</td>
<td>27*</td>
</tr>
<tr>
<td>n=152 Negative (n=114)</td>
<td>01 (99.1)</td>
<td>113**</td>
</tr>
</tbody>
</table>

This table shows that out of the total 38 SAECG positive patients, 11 patients demonstrate abnormal cardiac events (cardiac arrhythmias) on 6 month follow-up (Positive predictive Value 28.9%); while out of the total 114 SAECG negative patients only one patient presented with cardiac arrhythmia on 6 month follow-up (negative predictive value 99.1%). This indicates that SAECG has more negative predictive value than positive predictive value. Figures in parenthesis indicate percentage of positive and negative predictive Value; Cardiac arrhythmic events = ventricular tachycardia/ventricular fibrillation/sudden cardiac death, ACS-Acute coronary syndrome, CIHD-Chronic ischemic heart disease, SAH-Systemic arterial hypertension, DCM-Dilated cardiomyopathy. *P<0.005, **P<0.0005.

TABLE V: Correlation between abnormality of EF% and cardiac arrhythmic events in the study population.

<table>
<thead>
<tr>
<th>Study group based on EF%</th>
<th>Cardiac arrhythmic events</th>
<th>No cardiac arrhythmic events</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF&lt;40% (n=42)</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>EF ≥40% (n=110)</td>
<td>03</td>
<td>107</td>
</tr>
</tbody>
</table>

Positive predictive value=23.8%, Negative predictive value=97.3%. Cardiac arrhythmic events = ventricular tachycardia/ventricular fibrillation/sudden cardiac death, EF% = Percentage ejection fraction.

TABLE VI: Cardiac arrhythmic events on 6 month follow-up in the study population based on EF%.

<table>
<thead>
<tr>
<th>Study group based on EF%</th>
<th>Cardiac arrhythmic events on 6 month follow-up</th>
<th>No cardiac arrhythmic events on 6 month follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF &lt;40% (n=42)</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>EF ≥40% (n=110)</td>
<td>07</td>
<td>103</td>
</tr>
</tbody>
</table>

Positive Predictive Value = 42.9%, Negative predictive Value = 93.6%. Cardiac arrhythmic events = ventricular tachycardia/ventricular fibrillation/sudden cardiac death, EF% = Percentage ejection fraction.
have the advantage of being non-invasive methods of assessment also both have positive as well as negative predictive value of the future ventricular arrhythmic events. This study conducted on 152 patients. We found that SAECG and EF% together were accurate predictors of the cardiac arrhythmic events in terms of positive and negative predictive value (Table VII) and not SAECG or EF% alone (Table IV, V and VI). However, SAECG has got a more negative predictive value compare to EF% (Table III). Our study is well supported by Bailey, et al. (16) of the utility of non-invasive tests for risk stratification and prediction of cardiovascular arrhythmic events was found to be helpful. The authors concluded that combinations of tests in stages allowed the authors to stratify 92% of patients as either high-risk or low-risk. A report from the 2006 American College of Cardiology, American Heart Association and European Society of Cardiology guidelines for management of patients with ventricular arrhythmias and prevention of sudden death list SAECG with a Class IIb recommendation (Class IIb noted as usefulness/efficacy is less well established by evidence/opinion). However the report noted that SAECG may be useful to improve the diagnosis and risk stratification of patients with ventricular arrhythmias or at risk for life-threatening ventricular arrhythmias (9).

In a study of Sussex et al (14) post myocardial infarction patients it was found that SAECG was a statistically significant predictor of arrhythmic events during 1–2 year follow up with a sensitivity of 65% and a specificity of 68.4%. Various previous studies (15, 18) with non-sustained ventricular tachycardia states that SAECG was a predictor of ventricular tachycardia, with specificity in the range of 71% to 89%.

### DISCUSSION

In recognizing potentially useful markers, late potentials spotted on SAECG appeared to be the most useful tool for identifying prospective patients at risk for future ventricular arrhythmic events and sudden cardiac death.

We compared SAECG with EF%; as both have the advantage of being non-invasive methods of assessment also both have positive as well as negative predictive value of the future ventricular arrhythmic events. This study conducted on 152 patients. We found that SAECG and EF% together were accurate predictors of the cardiac arrhythmic events in terms of positive and negative predictive value (Table VII) and not SAECG or EF% alone (Table IV, V and VI). However, SAECG has got a more negative predictive value compare to EF% (Table III). Our study is well supported by Bailey, et al. (16) of the utility of non-invasive tests for risk stratification and prediction of cardiovascular arrhythmic events was found to be helpful. The authors concluded that combinations of tests in stages allowed the authors to stratify 92% of patients as either high-risk or low-risk. A report from the 2006 American College of Cardiology, American Heart Association and European Society of Cardiology guidelines for management of patients with ventricular arrhythmias and prevention of sudden death list SAECG with a Class IIb recommendation (Class IIb noted as usefulness/efficacy is less well established by evidence/opinion). However the report noted that SAECG may be useful to improve the diagnosis and risk stratification of patients with ventricular arrhythmias or at risk for life-threatening ventricular arrhythmias (9).

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<table>
<thead>
<tr>
<th>Study group based on EF% and SAECG</th>
<th>Cardiac arrhythmic events</th>
<th>No cardiac arrhythmic events</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAECG +ve &amp; EF &lt; 40% (n=8)</td>
<td>04</td>
<td>04</td>
</tr>
<tr>
<td>SAECG -ve &amp; EF &lt; 40% (n=12)</td>
<td>00</td>
<td>12</td>
</tr>
<tr>
<td>SAECG +ve &amp; EF ≥ 40% (n=7)</td>
<td>01</td>
<td>06</td>
</tr>
<tr>
<td>SAECG -ve &amp; EF ≥ 40% (n=31)</td>
<td>00</td>
<td>31</td>
</tr>
<tr>
<td>Total (n=58)</td>
<td>05</td>
<td>53</td>
</tr>
</tbody>
</table>

Positive Predictive Value = 50%, Negative predictive Value = 100%. Cardiac arrhythmic events = ventricular tachycardia/ventricular fibrillation/sudden cardiac death, EF% = Percentage ejection fraction, SAECG = signal averaged ECG.
comparing well with the values of specificity (92% to 99%) for SAECG alone in our study. In some of the larger studies, SAECG achieved statistical significance with moderate values of sensitivity and very high specificity (17).

One study from Japan (11) did evaluate the use of SAECG for stratification and prediction of arrhythmic events for selection of candidates for prophylactic ICD implantation and they found it feasible. Goldberger et al in 2008 (10) observed that SAECG may identify patients with prior MI at risk for sudden cardiac death and that further studies are required to assess the utility of this test.

Thus the significance of positive as well as negative predictive value of SAECG to stratify the risk of future cardiovascular arrhythmic event is similar to the values obtained in other studies. But several other studies have confirmed that abnormal SAECG was not a strong predictor of sudden cardiac death. Bauer et al. in 2005 (19) reported on reduced prognostic power of ventricular late potentials in patients who received revascularization therapy. The authors retrospectively analyzed the predictive values of late potentials, left ventricular ejection fraction, and heart rate turbulence in a cohort of patients who survived a recent myocardial infarction from January 1996 to December 2000. The majority of these patients received contemporary post-myocardial infarction treatment, namely, revascularization, beta-blockers, aspirin, ACE inhibitors, and statins. The authors found that the incidence of late potentials were low (9.3%) and that the presence of late potentials was not predictive of cardiac death and serious arrhythmic events. However, in their study left ventricular function was mostly preserved but depressed in our study. This study was a retrospective analysis and some patients were lost to follow-up. Park et al in 2009 (3) found that late potentials has a more positive predictive value than EF%. However, they also observed that there was no significant correlation between parameters of the SAECG and two-dimensional ECG for the entire patient population.

Amongst the three components of SAECG namely QRS duration, RMS40, and late potential (LP) duration prevalence of late potentials is high in cardiovascular disease like acute coronary syndrome, dilated cardiomyopathy, chronic ischemic heart disease and systemic arterial hypertension. SAECG has very high negative predictive value for risk stratification of future Cardiac Arrhythmic events. SAECG and EF% together (and not separately) may be considered as a better investigational tool to stratify future Cardiovascular Arrhythmic events.

In summary, SAECG appears to be a useful new technique for identifying individuals at risk for cardiac arrhythmic events. In this study, SAECG compared favorably or even better than EF% for risk stratification. It looks ostensibly remarkable to consider these two measures (SAECG and EF%) because SAECG measures electrophysiological properties while EF% is a measure of contractile properties or mechanical properties of the heart. Thus, we can expect that these two measures would provide independent information on the risk of ventricular arrhythmias.

Limitations

The study population size was small. All the arrhythmia were documented only at hospital. Follow-up was incomplete, but this is common in such type of studies because of drop out and the study participants came
from a small city and rural population. However, it is imaginable that the patients attending post arrhythmic evaluations may have been more aware of their general health than those not returning.

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