FREQUENCY OF VENTRICULAR LATE POTENTIALS IN HEALTHY POPULATION

Muhammad Alamgir Khan, Muhammad Mazhar Husssain, Muhammad Aslam, Imran Majeed*, Waqas Hameed

Department of Physiology Army Medical College, Rawalpindi. *Armed Forces Institute of Cardiology, Rawalpindi.

Background: Ventricular late potentials are low amplitude signals detected on Signal averaged ECG. These potentials have been associated with the development of ventricular tachyarrhythmias. Few studies are available relating frequency of ventricular late potentials in healthy individuals but no such data is available for our population. We planned the study to determine frequency of ventricular late potentials in healthy subjects of our population. **Methods:** Thirty-seven healthy subjects with mean age 26±5 were included. All the subjects underwent ECG, Echocardiography, Exercise tolerance test, blood sugar profile and coronary angiogram to rule out all the possible confounders. Signal averaged ECG was performed on all the subjects to determine ventricular late potentials. Three parameters of SAECG, i.e., fQRS, LAS 40 and RMS 40 were measured using 1200 EPX arrhythmia research technology. **Results:** Only 1 subject out of total 37 had ventricular late potentials (2.7 %). **Conclusion:** The frequency of ventricular late potentials in healthy subjects (2.7%) indicates the magnitude of development of ventricular tachyarrhythmias that may lead to vulnerability of sudden cardiac death. However study on larger scale is needed to confirm the frequency of ventricular late potentials in our population.

Keywords: Ventricular late potentials, Signal averaged ECG, Arrhythmia.

INTRODUCTION

Signal averaged electrocardiogram (SAECG) is a very specialized type of surface ECG which involves computerized analysis of small segments of a standard ECG in order to detect abnormalities, termed as ventricular late potentials (VLP) which would otherwise be obscured by skeletal muscle and electrical noise.[1] There are various types of these low amplitude signals which can be detected by SAECG but the most important are ventricular late potentials (VLP) and the main clinical use of SAECG is to detect these VLPs. Ventricular Late Potentials are present in terminal part of QRS complex and these may extend into ST segment; hence called 'late potentials' because these arise late in ventricular activation process.[2]

Ventricular late potentials had been the pivotal point of cardiac electrophysiologic research for the last twenty-five years and they have been investigated extensively. VLPs arise in an area of myocardium where the conduction velocity of cardiac impulse is slow, e.g., peri-infarct zone. This means when depolarization in healthy myocardium is complete or almost complete, this area will still be depolarizing. It will lead to the generation of low voltage, fractionated signals towards the end of QRS complex. The same area will become substrate for the development of ventricular tachyarrhythmias through re-entry mechanism. Therefore VLPs may act as non-invasive marker for the development of ventricular tachyarrhythmias.[3] The criteria for their presence and co-relation with ventricular tachyarrhythmias are now well established.[4] Therefore identification of subjects prone to have high risk of developing ventricular arrhythmias is a major challenge for clinical research. Therefore present study has been planned in healthy subjects to assess the frequency of ventricular late potentials. The objective of this study was to determine frequency of ventricular late potentials in healthy population.

MATERIAL AND METHODS

The study was planned in 37 healthy subjects without heart disease (23 males and 17 females) ranging age between 21 and 31 years. Strict criteria were followed to rule out all the possible confounders. After general physical examination, we performed 12 lead ECG, Echocardiography and exercise tolerance test of all the subjects. Blood sugar profile of all the subjects was also done to rule out Diabetes Mellitus. All the subjects, whose Exercise tolerance test was border-line, underwent coronary angiography. We finally selected only those subjects as healthy individuals whose coronary angiogram were normal.

Signal Averaged ECG was recorded by using commercially available SAECG recording device "1200 EPX High Resolution Electrocardiograph". (Arrhythmia research technology Inc., Austin, Tx). The 1200 EPX Signal Averaging Electrocardiograph is a portable battery operated signal acquisition device. It is a microprocessor based signal averaging device which performs this task on ECG signals. It checks each incoming QRS for uniformity, aligns it with the template, add each new point to the average and increments the total number of beats. Thus a 'signal averaged recording' is built over time.

The 1200 EPX system is made up of several components that, when put together constitute a complete unit. These components are:

- The data acquisition unit.
- The plastic tray, built to house the unit and to provide battery power.
- The padded carrying pouch in which the tray and unit, along with necessary cables can be packed.
- Cables. The S-1 (9 Pin), the S-1 (25 Pin) and the patient cable.

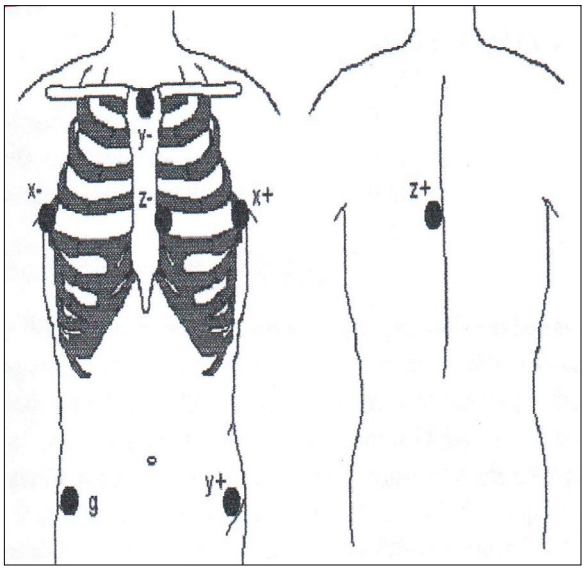
Lead placement

Three bipolar leads X, Y and Z were used to record Signal Averaged ECG as described by Micheal Simson, MD.[5] These are three orthogonal leads at right angles to each other and they cover the heart from all the three dimensions.

Lead placement for a Signal Averaged ECG is as under:

- Positive X (+X) electrode was placed at left fourth intercostal space, midaxillary line.
- Negative X (-X) electrode was placed at right fourth intercostal space, midaxillary line.
- Positive Y (+Y) electrode was placed at the left iliac crest.
- Negative Y (-Y) electrode was placed at superior aspect of the manubrium of sternum.
- Positive Z (+Z) electrode was placed at fourth intercostal space just left of the sternum
- Negative Z (-Z) electrode was placed on back of the patients directly posterior to positive Z electrode.
- A ground electrode (G) was placed on right 8th rib.

Fig-1: Positions of electrodes for signal averaged electrocardiography



Recording of SAECG

Recording of SAECG requires following four components:

- The 1200 EPX high resolution electrocardiograph.
- Arrhythmia research technology (ART) software version 4.02 for analysis of ventricular late potentials.
- The computer.
- The printer.

Recording room was made free of all other electrical devices and the extra lights were switched off to avoid electronic noise and 60 Hz interference. In some patients the noise level was very high, so all the lights were switched off and recording was done in total dark. Torchlight was used, where necessary (to see the recording display and control panel).

Patient Preparation

Preparation of the electrode recording sites is extremely important in recording signal averaged ECG because the signals are 10 to 100 times smaller than those found in conventional electrocardiograms. Inadequate preparation may produce false results. Patients were instructed to lie absolutely calm and quite to avoid electromyographic (EMG) or the physiologic noise. They were told not to speak or move their hands or legs during the recording. In fact, EMG is the most common source of noise in this setting.

Hair on the chest were shaved properly to ensure good contact of the electrodes with skin and for greater noise reduction which can be achieved with proper removal of chest hairs. The sites, on which electrodes were to be placed, were cleaned with spirit swab and then dried properly. Adhesive pregelled electrodes were placed at the above mentioned sites and then connected through leads with 1200 EPX high resolution electrocardiograph. SAECG recordings were obtained for about one thousand heart beats. All the three bipolar leads were recorded, averaged, filtered and combined into a QRS vector magnitude, called filtered QRS complex (fQRS) which is analyzed for the presence of ventricular late potentials.

SAECG is considered to be positive (presence of VLP) when at least two out of the following three criteria are fulfilled.[6]

- Duration of total filtered QRS complex (fQRS) >114 ms.
- Low amplitude signal under 40 μv (LAS 40) >38 ms.
- Root mean square voltage of last 40 ms of fQRS (RMS 40) <20 μv.

RESULTS

Thirty-seven subjects (23 males and 14 females) were studied who had mean age of 26±5 years. Signal averaged ECG was recorded at a mean noise level of 0.26±0.11 μv. Table-1 reveals duration of filtered QRS complex; 100.67±9.74 ms, duration of low amplitude signal under 40 μv as 26.94±10.01 ms and root mean square voltage of signal in last 40 ms of filtered QRS as 33.14±11.79 μv.

Table-1: Signal averaged ECG findings in healthy subjects (Mean ± SD)

Measures of SAECG	Subjects (n=37)
Duration of filtered QRS complex (ms)	100.67 ±9.74
Duration of low amplitude signal under 40 μv (ms)	26.94 ±10.01
Root mean square voltage of signal in last 40 ms of filtered QRS (μv)	33.14 ±11.79
Noise level (μv)	0.26 ±0.11

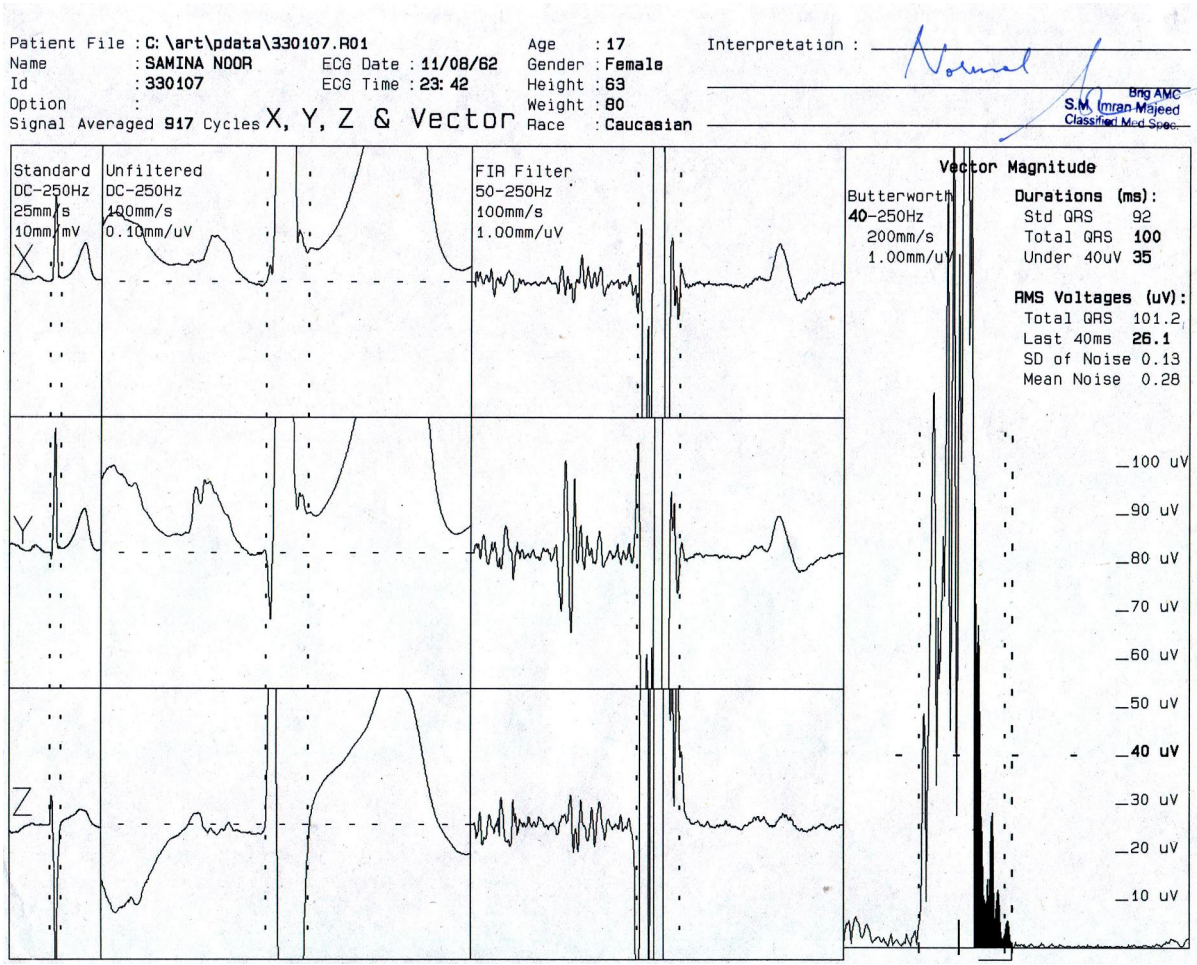
Table-2 shows the number of subjects in whom the parameters of signal averaged ECG were abnormal. fQRS was more than 114 ms in 2 individuals, duration of LAS under 40 μv was more than 38 ms in 7 subjects and root mean square voltage of signal in last 40 ms of filtered QRS was less than 20 μv in 4 individuals. Ventricular late potentials, defined as an abnormality in any two of the three parameters of SAECG were present in only one individual out of the total 37.

Table-2: SAECG Parameters and Ventricular Late Potentials

SAECG parameter	Subjects (n=37)
fQRS (>114 ms)	2 (5.40%)
LAS 40 (>38 ms)	7 (18.91%)
RMS 40 (<20 (μv)	4 (10.81%)
Ventricular late potentials	1 (2.7%)

fQRS = Filtered QRS complex,
LAS 40 = Low amplitude signal under 40 μv,
RMS 40 = Root mean square voltage of signal in last 40 ms of fQRS

Figure-2: A normal signal averaged ECG.



DISCUSSION

Non-invasive identification of patients at increased risk of developing malignant ventricular arrhythmias leading to sudden death remains a major challenge for the cardiovascular research. At present accurate prediction of patients at risk of developing ventricular tachyarrhythmias by the available non-invasive tests that is, electrocardiography and echocardiography are not promising. This necessitates to look into new tests which could correctly identify patients at risk of ventricular tachyarrhythmias. One such predictor of ventricular tachyarrhythmias, we used in our study is 'Ventricular late potentials' which can be detected on signal averaged ECG. Ventricular late potentials have been studied extensively in patients with various cardiac pathologies. Although few studies investigating presence of ventricular late potentials in healthy subjects are available, no such data is present for our own population. We conducted the study to determine frequency of ventricular late potentials in healthy individuals.

Marques[7] and colleagues determined prevalence of late potentials in healthy middle-aged men from Southwestern France. They studied 487 men from 50 to 59 years of age, without history of cardiovascular disease. They determined the prevalence of ventricular late potentials to be 21%. In our study we found the frequency of ventricular late potentials to be 2.7% which is almost the same as quoted in 'American College of Cardiology Expert Consensus Document on Signal averaged ECG'.[6]

This noticeable difference is due to the different selection criteria followed in the two studies. Marques and colleagues just relied on history to rule out any cardiac pathology and all other confounders but we in our study followed very strict criteria to define 'healthy' individuals. We performed 12 lead standard ECG, Echocardiography, blood sugar profile and exercise tolerance test of all the subjects. The final test in this prudent attempt to define healthy individuals was cardiac angiography. We recruited only those individuals whose cardiac angiography report was normal, who just underwent cardiac angiography due to equivocal exercise tolerance test. We tried to exclude as many confounders as possible. By just relying upon history many confounders could not be excluded especially in the age group 59 to 69 years, studied by Marques and colleagues, which might have led to the high prevalence of ventricular late potentials.

The other causative factor may be the age of study population. The range of age in our study was 21 to 31 years where as Marques and colleagues studied the subjects with age range 59 to 69. This is a substantial difference. Increased age increases the risk of various cardiac pathologies which can lead to appearance of ventricular late potentials on signal averaged ECG. The third factor that might have led to the difference in frequency of ventricular late potentials in the two studies may be the racial difference.

Brune[8] and colleagues performed signal averaged ECG on 20 healthy subjects with a mean age of 56 years. They performed coronary angiography on their subjects to rule out cardiac pathology like coronary artery disease. The criteria for the presence of ventricular late potentials were the same as we followed in our study. They found only one out of total 20 subjects (5%) having ventricular late potentials. Their finding is very close to what we found in our study i.e. 2.7%. The subtle difference may be due to the difference of mean age of the study population in the two studies. Brune and colleagues studied subjects with mean age of 56 years whereas we had the mean age of 26 years. The other factor leading to dissimilar results may be the racial difference.

Biffi *et al*[9] studied presence of ventricular late potentials in 35 healthy athletes on signal averaged ECG. Like our study they also followed strict criteria to define healthy subjects. Their subjects underwent cardiac physical examination, routine laboratory tests (including thyroid evaluation), resting electrocardiogram and bicycle-exercise stress test, chest X-ray examination and echocardiography. They holtered the subjects for 24 hours to rule out cardiac arrhythmias. Only those individuals who did not show abnormality on any of the tests were included in the study. The duration (mean ± SD) of fQRS complex was 104.8±8.6 ms, that of LAS 40 was 21.9±8.1 ms and the voltage (mean ± SD) of RMS 40 was 75.7±48 μv. They found late potentials to be present in only one out of total 35 (2.8%). This is exactly what we found in our study, i.e., 2.7%. There is negligible difference between the parameters of SAECG in two studies except for the values of RMS 40. This difference may be due to the fact that in our study the cut off value for RMS 40 was 20 μv whereas Biffi *et al* used a cut off value of 25 μv.

It is concluded that the presence of ventricular late potentials (2.7 %) in signal averaged ECG of healthy subjects indicates the magnitude of risk for developing ventricular tachyarrhythmias that shows the vulnerability of sudden death. The effectiveness of signal averaged ECG can be enhanced by eliminating possible confounders. However, similar study on larger scale is required to determine the frequency of ventricular late potential in our population.

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Address For Correspondence:
Muhammad Alamgir Khan, Department of Physiology, Army Medical College, Abid Majeed Road. Rawalpindi. Pakistan
Email: dralam_khan@yahoo.com, dralamgir@hotmail.com