ORIGINAL ARTICLE

CORRELATION OF SIGNAL AVERAGED ECG PARAMETERS WITH LEFT VENTRICULAR MASS INDEX IN PATIENTS WITH SYSTEMIC ARTERIAL HYPERTENSION

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Background: Signal averaged ECG is a high-resolution electrocardiography which detects ventricular late potentials in patients susceptible to ventricular arrhythmias. Ventricular late potentials are identified on the basis of three parameters detected on signal averaged ECG. This study was planned to determine the correlation of signal averaged ECG parameters with left ventricular mass index in hypertensive patients. **Methods:** Sixty-four patients with systemic arterial hypertension were enrolled in the study. Patients with acute or old myocardial infarction, diabetes mellitus, cerebrovascular accident, heart failure, structural heart disease, bundle branch block and cardiomyopathies were excluded. Holter monitors (DMS 300 4L) were used to obtain 3 channel signal averaged ECG recording. CardioScan premium luxury software was used for analysis of ventricular late potentials. **Results:** There were 49 (76.6%) males and 15 (23.4%) female patients (n=64) with mean age of 60±11.83 years. Eleven patients (17.2%) had ventricular late potentials whereas 53 (82.8%) were without them. The mean values for filtered QRS complex, low amplitude signals, root mean square voltage, noise and left ventricular mass index were 108.52±23.63 ms, 28.81±20.78 ms, 92.17±51.02 μv, 0.29±0.26 μv and 140.48±68.26 g/m^2 respectively. Left ventricular mass index was significantly and positively correlated with filtered QRS complex (p<0.001) and low amplitude signals (p=0.03) whereas the correlation with root means square voltage was not significant (p=0.84). Left ventricular mass index had significant and positive correlation with ventricular late potentials (p=0.009). **Conclusion:** Patients with higher left ventricular mass index are at greater risk of developing ventricular late potentials which are reflective of ventricular arrhythmias. In hypertensive patients with increased left ventricular mass index the arrhythmogenesis seems to be more related to duration of the cardiac signal as compared to its voltage.

Keywords: Ventricular late potentials, signal averaged ECG, systemic arterial hypertension, left ventricular mass index

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INTRODUCTION

The term 'signal averaged electrocardiography' incorporates any technique whereby multiple electric signals from the heart are averaged to improve the signal to noise ratio in order to reveal ventricular late potentials.[1] Three bipolar orthogonal leads, XYZ are used which represent horizontal, sagittal and coronal planes respectively. The leads are recorded, averaged, filtered and combined into a vector magnitude called the filtered QRS complex. The filtered QRS complex is analysed for the presence or otherwise of ventricular late potentials. It includes filtered QRS complex duration (fQRS) greater than 114 ms, low amplitude signals (LAS) under 40 μv in the terminal QRS complex greater than 38 ms and root mean square (RMS) voltage in the terminal 40 ms less than 20 μv. Presence of any two of these three criteria confirms the occurrence of ventricular late potentials.[2]

Hypertension is a major health problem with an increasing prevalence worldwide. It is considered a silent killer because of its symptomless proceedings during pathogenesis.[3] It is a robust risk factor for left ventricular hypertrophy, a compensatory mechanism in response to increased pressure load on the heart. Systemic arterial hypertension and left ventricular hypertrophy are strong predictors of ventricular arrhythmias which may lead to sudden cardiac death.[4,5]

Knowledge about arrhythmias developing in patients with hypertension is important because it can significantly affect the prognosis and management of the disease.[6] Pathophysiological mechanisms underlying the development of left ventricular hypertrophy involves systolic and diastolic pressure overload along with neurohormonal activation.[7] Left ventricular hypertrophy results in myocardial fibrosis which through gap junctions and ion channel remodelling provokes significant electrophysiological changes which lead to delayed conduction velocity. This provides an ideal substrate for re-entry which may lead to ventricular arrhythmias.[8]

Ventricular late potentials are low amplitude, high frequency signals present in the terminal part of QRS complex that may extend up to a variable length in ST segment.[9] They are the non-invasive markers of

myocardial tissue damage.[10] Increased arterial blood pressure in hypertension results in myocardial fibrosis, a high resistivity area having delayed conduction velocity and prolonged action potential duration. This affects the electrocardiographic signals between the end of QRS complex and the initial part of ST segment thus generating these low voltage fractionated signals.[11] Detection of ventricular late potentials in hypertensive patients provides a practical and cost-effective method to identify the possible electrophysiological substrate underlying the life threatening ventricular arrhythmias which may result in sudden cardiac death.[12] In-depth knowledge about ventricular late potentials can give an insight about ventricular arrhythmogenesis in patients with systemic arterial hypertension.[13]

The current study was planned to determine the correlation of signal averaged ECG parameters with left ventricular mass index in hypertensive patients. Results of the study would provide an insight into the probable mechanisms of disturbed electrical activity within ventricular myocardium which may lead to arrhythmias.

PATIENTS AND METHODS

This correlational study was conducted at the department of Cardiac Electrophysiology, Armed Forces Institute of Cardiology (AFIC) in collaboration with Army Medical College, Rawalpindi. An official approval was obtained prior to commencement of the study from Ethical Review Committee of Army Medical College. Written and informed consent was taken from all the patients included in the study. Sample size was calculated using the software G-Power. Considering the values of alpha as 0.05, beta as 0.1 and the difference for correlation coefficients between null and alternative hypothesis as 0.4, a sample size of 61 was calculated. However, we included 64 patients of systemic arterial hypertension through non-probability convenience sampling. Patients with acute or old myocardial infarction, diabetes mellitus, cerebrovascular accident, heart failure, structural heart disease, bundle branch block and cardiomyopathies were excluded.

Signal averaged ECG of all the patiens was recorded using Holter monitors (DMS 300 4L) as per the standardized protocol.[14] CardioScan premium luxury software was used for analysis of ventricular late potentials in time domain.

Data were analysed using SPSS-22. Qualitative variables were presented as frequency and percentages whereas quantitative variables as mean and standard deviation. Bivariate correlation was calculated using Pearson Correlation. Alpha value was kept at 0.05 at confidence level of 95%.

RESULTS

There were 49 (76.6%) males and 15 (23.4%) females with a mean age of 60±11.89 years. Eleven (17.2%) patients had ventricular late potentials whereas 53 (82.8%) were without them (Table-1).

Table-1: Frequency of ventricular late potentials in patients with systemic arterial hypertension

		Frequency	Percentage
Ventricular late potentials	yes	11	17.2
	no	53	82.8

Table-2 shows mean values of left ventricular mass index and various signal averaged ECG parameters. The table also shows mean noise level at which signal averaged ECG was recorded.

Table-2: Descriptive statistics of signal averaged ECG parameters and left ventricular mass index

SAECG parameters	Mean	SD
fQRS (ms)	108.52	23.63
LAS (ms)	28.81	20.78
RMS (µv)	92.17	51.03
Noise (µv)	0.29	0.26
LVMI(g/m^2)	140.48	68.26

(fQRS: filtered QRS, LAS: low amplitude signals, RMS: root mean square, LVMI: left ventricular mass index)

Table-3 shows correlation between left ventricular mass index and each variable of signal averaged ECG. It also shows correlation between left ventricular mass index and ventricular late potentials.

Table-3: Correlation between left ventricular mass index and signal averaged ECG parameters

	fQRS	LAS	RMS	VLPs
r	0.44*	0.27*	-0.025	0.32*
p	<0.001*	0.03*	0.84	0.009*

*significant (p<0.05); (fQRS: filtered QRS, LAS: low amplitude signals, RMS: root mean square, LVMI: left ventricular mass index)

DISCUSSION

Results of our study showed that filtered QRS complex and low amplitude signals were significantly higher in patients with greater left ventricular mass index whereas root mean square voltage was lower although not significant statistically. The study also showed that left ventricular mass index was strongly associated with ventricular late potentials. This information provides an inkling towards pathogenesis of ventricular arrhythmias in hypertensive patients. The association of left ventricular mass index with filtered QRS complex and low amplitude signal on one side whereas with ventricular late potentials on the other side provides reasoning to think that filtered QRS complex and low amplitude signals are perhaps involved in the genesis of late potentials in hypertensive patients. Systemic arterial hypertension leads to an increase in left ventricular mass index which alters electrocardiographic properties of the cardiac muscle leading to establishment of re-entry circuits resulting in re-entrant ventricular arrhythmias.

Palatini *et al* studied ventricular late potentials in hypertensive patients.[15] One hundred and seven hypertensive patients were enrolled in their study and

the correlation between signal averaged electro-cardiographic parameters and left ventricular mass index was determined. They reported a positive correlation between left ventricular mass index and filtered QRS duration (p=0.03) which was similar with our findings. However, their study found no association between low amplitude signals and left ventricular mass index (p=0.06). Whereas, in our study we found a significant positive correlation between them (p=0.003). Although, results of Palatini *et al*[15] are not very far from the statistical significance, however, the difference in results of the two studies might be due the reason that Palatini *et al*[15] registered hypertensive patients with mild to moderate left ventricular hypertrophy while in our study patients with severe left ventricular hypertrophy were also included. In cases with severe left ventricular hypertrophy, the increased left ventricular mass index disturbs the electrical activity to the greater degree which might have become the basis for its significant correlation with low amplitude signals. Results of our study showed the inverse correlation of root mean square voltage with left ventricular mass index (p=0.84). Whereas, Palatini *et al*[15] found weak association between these two parameters (p=0.04). This might be due to the fact that the mean blood pressure of patients enrolled in Palatini's study was 127.6 mmHg compared to 114 mmHg in our study. Higher systemic arterial blood pressure by increasing left ventricular mass index perhaps reduced root mean square voltage of filtered QRS complex. This might have further scrutinized their results by having an increased number of patients with root mean square voltage less than 20 μv as compared to our study. Secondly, it might be attributable to the exclusion criteria followed by Palatini *et al*[15] as they excluded only patients with myocardial infarction whereas we excluded all the patients suffering from myocardial infarction, diabetes mellitus, cerebrovascular accidents, heart failure, structural heart diseases, bundle branch blocks and cardiomyopathies.

Akdeniz *et al* studied ventricular late potentials in 99 hypertensive patients to evaluate the association of left ventricular mass index with ventricular late potentials.[16] They reported association of left ventricular mass index with duration of filtered QRS complex and low amplitude signal whereas no association with root mean square voltage. These results are comparable to the findings of our study. Similar inclusion/exclusion criteria and cut off values for signal averaged ECG parameters seemed to be the bases for comparable results of the two studies. This implies that perhaps filtered QRS complex and low amplitude signals have higher contributions than root mean square voltage towards the pathogenesis of ventricular late potentials in hypertensive patients with increased left ventricular mass index. Filtered QRS complex and low amplitude signals are related to duration of the cardiac signal whereas root mean square voltage is related to voltage of the signal. This suggests that electrophysiological modifications pertaining to duration of the cardiac signal are probably involved to greater extent in generation of ventricular late potentials in patients with increased left ventricular mass index.

Schillaci *et al* reported significant association of left ventricular mass index in hypertensive patients with ventricular late potentials and ventricular arrhythmias.[17] They reported that increased left ventricular mass index was the significant predictor of higher frequency of ventricular arrhythmias in hypertensive patients (p<0.003). In our study as we demonstrated that left ventricular mass index had a significant association with ventricular late potentials (p<0.001) which are the substrates for development of arrhythmias.

Koren *et al* found a significant association between left ventricular mass index and ventricular late potentials with a p<0.01.[18] Bayes *et al* determined the effect of left ventricular mass index on ventricular late potentials in patients with systemic arterial hypertension and proposed that the relation between left ventricular mass index and ventricular late potentials was graded and continuous.[19] Wojszwiłło *et al* conducted a study to evaluate the prevalence of ventricular late potentials in hypertension in relation to left ventricular mass index.[20] They enrolled 109 hypertensive patients in their study and documented a significant positive correlation between left ventricular mass index and ventricular late potentials. They suggested that the left ventricular structural remodelling and enhanced sympathetic activity were significant predictors of ventricular late potentials in hypertensive patients. Perings *et al* assessed the arrhythmia risk in hypertensive patients with increased left ventricular mass index.[21] The risk of developing ventricular arrhythmias was 10 times higher in hypertensive patients with increased left ventricular mass index. They also proposed that increased left ventricular mass index further enhanced the chances of developing ventricular late potentials by 7 to 18 percent. Thus, findings of all these studies are suggestive of developing ventricular late potentials in patients with systemic arterial hypertension which is perhaps related to slowness of conduction velocity due to increased left ventricular mass index.

CONCLUSION

Hypertensive patients with higher left ventricular mass index are at greater risk of developing ventricular late potentials which are reflective of ventricular arrhythmias. In hypertensive patients with increased left ventricular mass index the arrhythmogenesis seems to be more related to duration of the cardiac signal as compared to its voltage.

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