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Early Diagnosis of Left Ventricular Hypertrophy by ECG Signal Processing

[1]Manjusha Sanjeev Joshi, [2]Kamalakar Dinkar Desai, [3]Dr. Shashi Menon, [4]Rohan Joshi, [5]Snehal Bhagat, [6]Manjusha Sanjeev Joshi

[1]M.E. (Electronics), MPSTME /NMIMS Deemed to be University, India
[2]Ph.D. in biomedical Engineering, Maharshi Parashuram College of engineering, Mumbai University, India
[3]M.B.B.S. M.D., Fortis-S.L. Raheja Hospital, Mahim –W, Mumbai, India
[4]B.E. (Electronics), MPSTME /NMIMS Deemed to be University, India
[5]B.E. (EXTC), MPSTME /NMIMS Deemed to be University, India
[6]Electronics and telecommunication department, MPSTME, Bhakti Vedant Marg,Vile Parle Mumbai-w.Mumbai-400056.
Fax-912226717779

Abstract : **Left ventricular hypertrophy(LVH) is maladaptive response and risk factor in chronic pressure overload. Increased myocardium results in diastolic and/or systolic failure, atrial fibrillation and sudden death. As hypertrophic growth slow and clinically invisible, early diagnosis is essential to control the mortality and morbidity. Literature Survey on proposed method could not fetch any search results on Google Scholar.**

Study aims at establishing indices for diagnosis of LVH by using safe and non invasive techniques and to indicate modification in autonomous nervous system in hypertensive subjects.

Methods and subjects: Conformative diagnostic indices obtained from 2-lead ECG sample collected for 3-5 minutes duration. Novel algorithm computs an index That provides a guideline to the echo-cardiologist to conduct echo cardiographic study.

Study was carried out with 26 normal subjects varying in age.sex and economic class, 25 hypertensive and LVH subjects and 27 hypertensives. All the cases were recorded at Fortis-S.L.Raheja hospital Mahim(W).

Essential Results: The values of heart rate, heart rate variability, sympathetic power, total power are significantly higher for hypertensive patients with LVH than the hypertensive and control group.

Principle conclusion: Early diagnosis of LVH by ECG signal Is possible. The p-value was found to be in the range below 0.001.

Keywords: **Left ventricular hypertrophy (LVH), heart rate variability (HRV), nonlinear HRV tool, Poincare plot and standard descriptor.**

1. INTRODUCTION

The paper proposes safe, noninvasive and novel method to diagnose the LVH and recommends a routine practice for hypertensive and diabetic patients. The hardware and software requirements of the system are any Pentium processor with MATLAB/C compiler making the technique is deployable at a low cost. The test can be performed by paramedical personnel saving the echo-cardiologist's time.

2. PATHOPHYSIOLOGY OF LVH

Renin-angiotensin-aldosterone is the hormone complex that maintains homeostatic condition in body. Angiotensinn-I is a vasoconstrictor required to maintain the lumen dimension of arteries. Angiotensin-II that is required to hydrolyze Angiotensin-I is found to have profibrotic effect on myocardium.[1] The Left Ventricular Hypertrophy muscle mass growth can be clearly observed in figure-1.

The typical ECG can be observed in figure-2. Since the ECG signals are highly subjective, they cannot be ECG signal is not confirmatory diagnostic test. The echocardiogram of the normal and left ventricular hypertrophic heart is shown in figure-3.

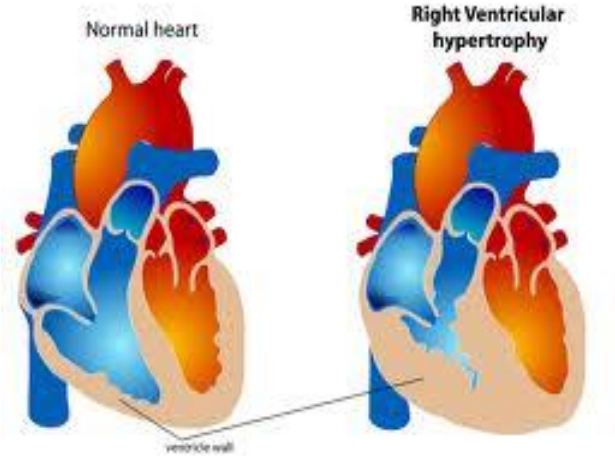

Figure-1Normal and hypertrophic myocardium

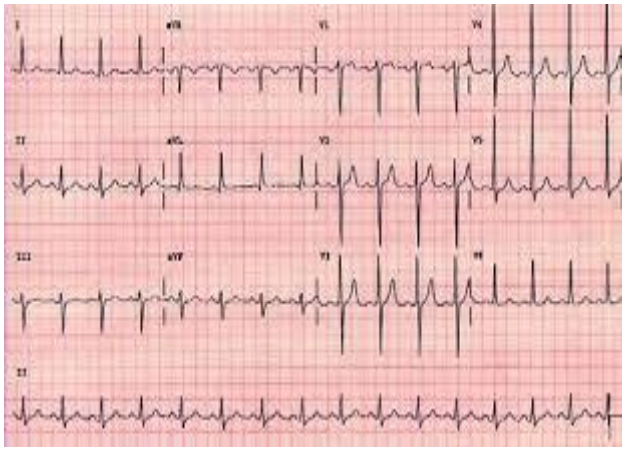

Figure-2 ECG showing sharp R-R peaks of LVH subject

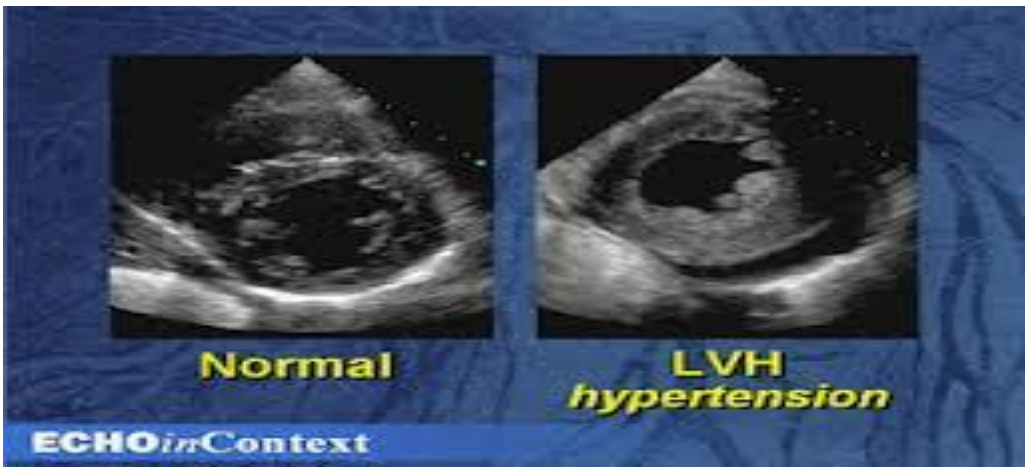

Figure-3 Echocardiogram of normal and LVH subject.

The echocardiogram evaluates the left ventricular mass and the wall thickness for the diagnosis. The normal and abnormal values are given in table-1.

Table 1 Echocardiogram indices

	Normal	LVH
Intra ventricular septum Dimension	<=12 mm	>12 mm
Posterior Wall Dimension	<=12 mm	>12 mm
Left Ventricular Mass Index	<=250	Between 250-300.

3. HRV ANALYSIS

A healthy heart is sensitive to humoral, physiological, physical and psychological changes in the body and it modifies the heart rate accordingly. [2] It has been observed that the impaired heart has reduced variation in the heart rate as the demanded by afore mentioned changes in the body Figure-4 shows the HRV and the power spectral density distribution in case of sympathetic and parasympathetic power spectral density of a normal heart and an impaired heart.

The orthostatic stress index derived from HRV analysis indicates higher value for the normal heart and lower values for impaired heart. This test is a popularly used in literature of research though not used clinically.

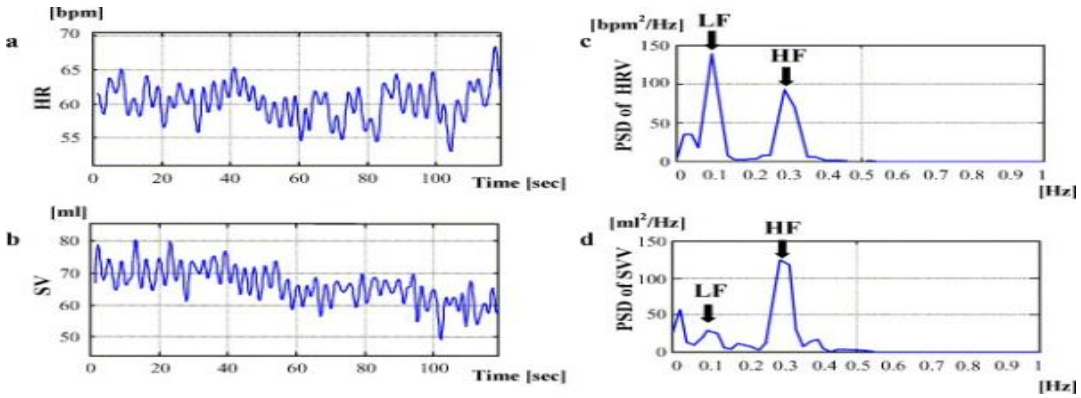

Figure 4 RR intervals and its frequency analysis of normal and reduced HRV subject.

The Poincare plot is a visual tool and uses the ratio between standard descriptors for short term correlation (SD1) and long term correlation (SD2) between RR intervals to assess the health of the heart. The successive RR intervals correlate closely to the natural rhythm of heart as a combined response to many different complex closed loop systems controlling the heart.[3] The shape of the R-R interval distribution shows an elliptical pattern and the ratio of SD1/SD2 should be higher for a healthy person. The shape of R-R interval distribution is non- elliptical pattern and ratio is much lower for a subject with impaired heart or reduced HRV. The typical cases of normal and impaired subject are as shown in the right panels of the figure-4. Their corresponding HR variations are also shown in the left panel of the figure-5.

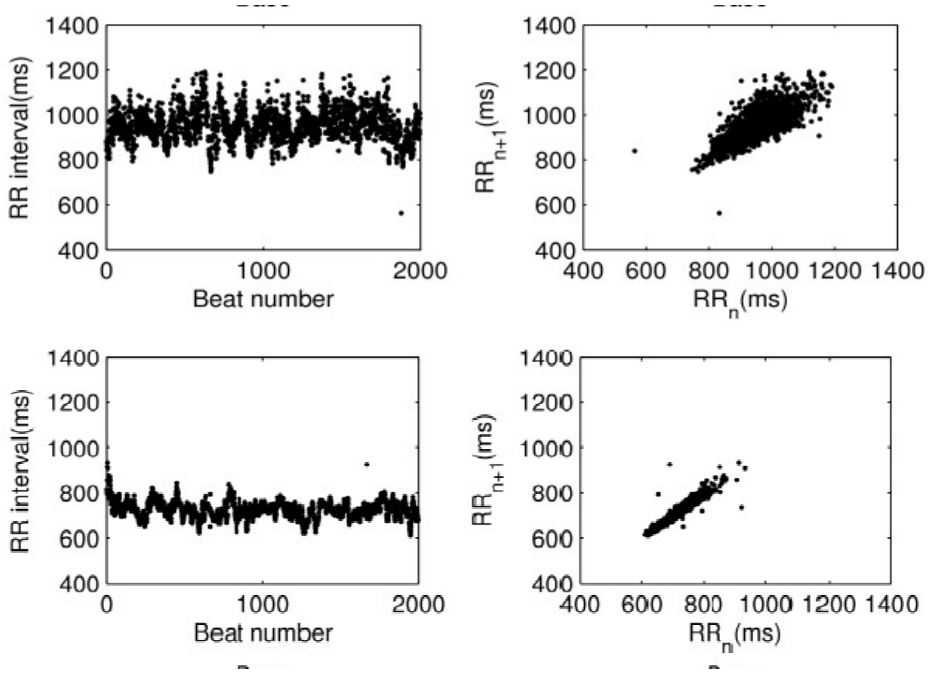

Figure 5 RR plot Vs .time and Poincare plot of normal and reduced HRV subject.

4. MODIFIED POINCARE ANALYSIS

The paper proposes further division of SD1 into two new descriptors $SD1_{up}$ and $SD1_{down}$ that represent decelerations and accelerations of R-R interval respectively. The line of $\pi/4$ slope i.e. y=x line in the Poincare plot represents the equal R-R intervals. The R-R interval points with increased heart rate are represented below the line and The RR interval points with decreased heart rate are represented above the line. Path physiologically, sympathetic power is in the decreasing order in hypertensive subjects with LVH, hypertensive subject without and control group.

4.1 Algorithm for the method used:

1. Compute R-R interval from the ECG sample acquired from the data acquisition equipment.

2. Compute the average R-R interval.

3. Compute the deviation from the average value for all the RR interval values.

4. If the corresponding R-R interval is greater than average the resulting value is negative. Store it in array1.

5. Else if the value is positive, store it in array2.

6. Compute the average of the two arrays. The average of first array is the $SD1_{up}$ and the average of the second array is $SD1_{down}$

7. Compute the difference of value of $SD1_{up}$ and $SD1_{down}$ from the average R-R interval..

8. Store the sum of all the values for the given data set of R-R interval sum_ $SD1_{up}$ and sum_ $SD1_{down}$..

9. Denote sum_ $SD1_{up}$ and sum_ $SD1_{down.}$ As average sympathetic power and parasympathetic power respectively.

5. MATERIAL AND METHODS

Study was carried out with 26 subjects of control group varying in age.sex and economic class, 25 hypertensive subjects with recorded evidence of LVH and 27 hypertensive subjects. All the cases were recorded at Fortis-S.L.Raheja hospital Mahim(W). Care was taken to ensure a vertical cross section of economic class and age group. Male and female, both sexes were included in the study group. It was ensured that there was at least five years of recorded hypertensive prevalence. Duration of prevalence of LVH was not recorded.

2-lead ECG sample collected for 3-5 minutes duration using LABVIEW as interface. The ECG signal is preprocessed, separated from DC drift, noise and EMI. R-R samples file is analyzed from a software simulator.

SDNN and HR of the subjects are recorded. Sympathetic, parasympathetic and total power was computed from the novel algorithm explained in the upcoming sections.

6. RESULTS AND DISCUSSION

Table-2-HRV indices

	Average Hear Rate. (From FDM tools)	Average HRV(SDNN) (From TDM tools)	Average Sympathetic Power. (From the proposed algorithm.)	Average Para sympathetic Power. (From the proposed algorithm.)	Average Total Power. (From the proposed algorithm.)
Control group	63.84 (+/- 2.92)	45.72(+/-13.41)	111.19 (+/-33.45)	93.48 (+/-22.74)	200 (+/-52.39)
Hypertensive subjects	68.95 (+/- 7.63)	45.43(+/-18.03)	130.07(+/-41.20)	123.00(+/-46.83)	244.89 (+/-71.32)
Hypertensive subjects with LVH	69.8848(+/-8.29)	52.254 (+/-17.28)	155.40 (+/-57.93)	124.64 (+/-36.87)	262 (+/-102.91)

Table-3-t-table with the p-value

	sympathetic power for hypertension with LVH	sympathetic power for hypertension without LVH	parasympathetic power for hypertension with LVH	parasympathetic power for hypertension without LVH
p-value one tailed test	0.000954742	0.000562989	0.033618632	0.002408206
Critical value of one tailed test	1.685954461	1.674689	1.684875122	1.684875

6.1 The list of observations that are deduced from the results and their physiological analogy can be stated as

6.1.1 It has been observed from the results shown in table-2 that the average heart rate is in decreasing order of hypertensive and hypertrophic subject, hypertensive subject and control group. The findings are consistent with the physiology since the hypertensive and hypertrophic heart has to pump at a faster rate to fulfill the demand of blood against the elevated systolic pressure that restricts the blood flow.

6.1.2 It has been observed from table-2 that heart rate variability is found to be in the decreasing order hypertensive and hypertrophic subjects, hypertensive subjects and the control group. This is due to the pharmacological intervention for treatment of hypertension and/or LVH. It has been recorded in literature that SDNN on average has no effect in case of LVH subjects. It has been also been recorded that SDNN is found increased during morning and night for LVH subjects. The ECG data samples were collected in the morning from 9.00 a.m. to 11.30 a.m.

6.1.3 It has been found that from the results shown in table-2 that total average electrical power of is in decreasing order in hypertensive and hypertrophic subject, hypertensive subjects and control group. This is consistent with the physiology that the electrical power of hypertensive and hypertrophic heart is more to work against the constricted artery lumen and reduced ventricular filling due to elevated systolic pressure or mitral regurgitation or to compensate an infracted myocardium as the case may be. In comparison hypertensive heart has to overcome the constricted artery lumen only.

6.1.4 The sympathetic power is the decreasing order in case of hypertensive and hypertrophic subjects, hypertensive subjects and control group. This observation shown in table-2 finds analogy with the physiological condition that in case of hypertensive subject, heart rate is found to be higher to supply the inadequacy of blood supply. Hence sympathetic power also increases as a compensatory mechanism. When the subject is hypertensive and hypertrophic the sympathetic power increases further more.

7. STATISTICS

It has been ascertained that the data within the groups is statistically independently performing a t-test. The results of t test are shown in table-3. To ascertain that variances within group do not differ significantly, t-test is conducted. The t-test outcome is found to be below the critical value as shown in table-3.

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