SPECTRAL ANALYSIS OF HEART RATE VARIABILITY IN PATIENTS WITH CORONARY ARTERY DISEASE

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ABSTRACT

Objective: To carryout frequency domain analysis ofheart rate variability in patients with coronary artery disease.

Methods: Forty coronary artery disease patients with coronary artery stenosis greater than 70% of at least one vessel lumen were included. Patients with diabetes mellitus, atrial fibrillation, structural heart diseases and bundle branch block were excluded. DMS 300 4A Holter monitors were used to obtain long-term 12 lead digital ECG recordings. Cardio Scan premium luxury software was used for analysis of heart rate variability.

Results: The mean values of heart rate variability in patients were TP (2171.70 ± 1028.7), VLF (1661.41 ± 807.88), LF (392.71 ± 227.92), HF (112.03 ± 77.90) and LF/HF ratio (4.03 ± 1.75). On comparison with normal reference values there was a significant decrease (p-value < 0.05) in all parameters except VLF (p-value = 0.351). TP was reduced in all the patients (100%), VLF in 26 (65%), LF in 36 (90%), HF in 36 (90%) and LF/HF ratio in 29 (72.5%) patients. The difference between the frequency of patients with decreased heart rate variability was statistically significant (p-value < 0.05) except VLF (p-value = 0.082).

Conclusion: Heart rate variability decreases significantly in patients with coronary artery disease.

Keywords: Heart rate variability, Coronary artery disease, Myocardial ischemia, Holter monitoring.

INTRODUCTION

Heart rate variability (HRV) can be defined astemporal fluctuation of beat to beat interval occurring physiologically during normal sinus rhythm[1]. It is reflected as variations in heart rate around the mean value. Heart rate variability is also known as RR variability or cardiac cycle variability. The discovery of difference betweensuccessive beat intervals in 1733 by Stephen Hales unlocked new exploration horizons particularly in the arena of cardiac electrophysiology[2]. Heart rate variability has been studied broadly in numerous research endeavors[3]. During the preceding few decades, heart rate variability is known as a marker of ongoing autonomic nervous system activity.[4]It has been agreed by most of the researchers that in nearby future, heart rate variability will become an important part of routine examination. It is predicted thatit will be soon incorporated into vitals chart due to its authentic results which provides an overview of autonomic nervous system activity[5].

According to the guidelines provided by the task force of European society of cardiology and North American society of pacing and electrophysiology, heart rate variability can be calculated by time and frequency domain analysis[6]. In frequency domain analysis, heart rate variability is defined as a sinusoidal phenomenon of linear dynamics. Heart rate variability can be computed into its frequency components on the basis of rate of fluctuations measured in Hertz. Power spectral density (PSD) delivers the essential details aboutallocation of variance in the rapports of different frequencies. Power spectral density method depends on the element that oscillations of heart beat intervalscan be allocated into various component frequencies by computing their proportionalinfluence[7]. Various algorithms can be applied to compute respective components of which fast fourier transformation is a non-parametric techniqueas well asrelatively easy to use with a radical processing pace[3]. Itmodifies normal to normal interval (NN) statistics into a group of frequencies based on their relative intensity or power. Heart rate variability can be analyzed in frequency domain using fast fourier transformation by dividing the spectral power into band widths of ultra-low frequency, very low frequency, low frequency and high frequency spectrums. The lowest frequency

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calculated by long term analysis is 0.00001 Hz. Ultra low frequency (ULF) band is effected with circadian rhythm and its changes show diurnal pattern.[8]Very Low Frequency (VLF) denotes power frequency range between 0.003 - 0.04 Hz. Role of VLF is uncertain, however, some studies state that VLF is affected by temperature regulation and humoral systems.[9] Low Frequency (LF) shows frequency range between 0.04 - 0.15 Hz which can be principally correlated to sympathetic tone or to baroreflex mechanism that denotes short term changes of blood pressure through autonomic regulation of heart rate. High frequency (HF) shows frequency range between 0.15 - 0.4 Hz. It shows high oscillatory changes in RR intervals. Amplified HF value validatessuperiorityof parasympathetic activity that is anemblem of well-being[10]. While, at any instant of time LF/HF ratio is considered asa magnitude of sympathovagal stability.

Decline in heart rate variability is an attribute ofpoorprognosis invarious diseases while amplified variability is considered as a healthy characteristic[11]. Understanding of heart rate variability aids in reckoning autonomic nervous system activity through its control our heart rhythm. Unbalancedactivity of autonomic nervous system also known as dysautonomia, is an approved predictor of tachyarrhythmias which may cause sudden cardiac death[12].

Enhanced sympathetic activity is the leading cause of sudden cardiac death in ischemic heart disease patients. Increased sympathetic activity favors genesis of life threatening arrhythmias while an antifibrillatory effect is generated by parasympathetic bustle[13]. Numerous noninvasive procedures have been established with an objective to forecast high risk patients of sudden cardiac death[14]. Some of these include QT dispersion, T wave alternans, heart rate variability and heart rate turbulence etc[15].

Myocardial ischemia is mostly caused by occlusions of coronary vessels due to coronary artery disease[16]. Ischemia causes ionic and metabolic imbalance across the myocardial membrane which causes heterogeneity of impulse spread in ischemic tissue. These changes result in decreased ventricular refractoriness leading to ventricular repolarization heterogeneity[17]. Diminished

Table-1: Frequency domain variables of heart rate variability in coronary artery disease patients (n=40).

Frequency domain analysis	
Variables	Values (mean ± SD)
TP (ms^2)	2171.70 ± 1028.75
VLF (ms^2)	1661.41 ± 807.88
LF (ms^2)	392.71 ± 227.92
HF (ms^2)	112.03 ± 77.90
LF/HF ratio	4.03 ± 1.75

heart rate variability in coronary artery disease patients denotes amplified sympathetic activity. Tachycardia due to increased sympathetic activity with coexistence of myocardial ischemia leads to fatal ventricular arrhythmias[18]. The objective of the current study was to carry out spectral analysis of heart rate variability in coronary artery disease patients.

PATIENTS AND METHODS

This cross sectional study was conducted at the department of Cardiac Electrophysiology, Armed Forces Institute of Cardiology incorporation with Army Medical College, Rawalpindi from January 2014 to August 2014. An official approval was obtained prior to commencement of the study aftermedical ethics committee of Army Medical College. Written and informed consent was taken from all the patients included in the study. Forty coronary artery disease patients of either sex and any age were recruited by non-probability convenience sampling. Coronary artery occlusion was diagnosed by cardiologists on the basis of coronary angiography. Coronary artery disease patients with at least one stenotic lesion of greater than 70% of the vessel lumen were included in the study. Patients with diabetes mellitus, systemic arterial hypertension, structural heart disease and bundle branch block were excluded. DMS 300-4A Holter monitors were used to obtain 12-lead ECG recording. Digital ECG data were transferred to the computer and analyzed by using Cardio Scan premium luxury software. After complete

editing of the 24 hour digital ECG recording. Data devoid of erroneous beats, ectopics and artefacts were used for heart rate variability

± 77.90 and 4.03 ± 1.75, respectively, as shown in table-1. Shapiro Wilk test revealed that data followed 'normal distribution' ($p > 0.05$) hence

Table-2: Comparison of frequency domain indices of heart rate variability in coronary artery disease patients with normal values (n=40).

Frequency domain variables	Values (mean ± SD)		One sample t test
	Patients	Normal	p-value
TP (ms^2)	2171.70 ± 1028.75	21222 ± 11 663	0.000*
VLF (ms^2)	1661.41 ± 807.88	1782 ± 965	0.082*
LF (ms^2)	392.71 ± 227.92	791 ± 563	0.000*
HF (ms^2)	112.03 ± 77.90	229 ± 282	0.000*
LF/HF ratio	4.03 ± 1.75	4.61 ±2.33	0.007*

*p-value significant (< 0.05)

Table-3: Frequency and percentages of patients with normal and decreased frequency domain variables of heart rate variability.

Frequency domain variables	Frequency		p-value
	Decreased	Normal	
TP (ms^2)	40 (100%)	0 (0%)	0.000*
VLF (ms^2)	26 (65%)	14 (35%)	0.082*
LF (ms^2)	36 (90%)	4 (10%)	0.000*
HF (ms^2)	36 (90%)	4 (10%)	0.000
LF/HF ratio	29 (72.5%)	11 (27.5%)	0.007*

*p-value significant (< 0.05)

analysis. Heart rate variability wasanalysed by spectral analysis in fourfrequency bands TP, VLF, LF, HF and LF/HF ratio. Heart rate variability analysis was done in three selected leads. The leads were selected on the basis of least artefacts present in them. Distorted and erroneous recordings with abundance of aberrant beats and artefacts were not selected for heart rate variability.

Statistical analysis was done using computer software IBM SPSS version 22. Qualitative variables were presented as frequency and percentages whereas quantitative variables as mean and standard deviation. Variables studied were TP, VLF, LF, HF and LF/HF ratio. As the data followed a normal distribution it was compared with standard normal values accepted by Task Force Committee,[19,20] using 'one sample t test'.

RESULTS

Forty patients with mean age of 55.2 ± 8 years, ranging from 34 to 68 years. Male female ratio was 39:1. The mean value of Total Power, LF, VLF, HF and LF:HF ratio were 2171.70 ± 1028.75, 1661.41 ± 807.88,392.71 ± 227.92, 112.03

parametric one sample 't' tests was applied for comparisons of heart rate variability indices with normal reference values as shown in table-2. The result showed significantly reduced heart rate variability in all the frequency domain parameters of coronary artery disease patients (p-value < 0.05). The p-values of only one frequency domain parameter (VLF) was above 0.05; however its mean valuealso showed a decline as compared to the normal reference values.TP was reduced in all the patients (100%) of patients, VLF in 26 (65%), LF in 36 (90%), HF in 36 (90%) and LF/HF ratio in 29 (72.5%) patients.The difference between frequency of patients with decreased heart rate variabilityas calculated by binominal t test, was significant in all the parameters (p-value < 0.05) except VLF (p-value = 0.08), as shown in table-3.

DISCUSSION

Heart rate variability of patients with coronary artery disease is attributed to changes caused by ischemia. Autonomic nervous system imbalance in the form of reduced vagal and enhanced sympathetic activity is supposed to be the basis of diminished heart rate variability

in coronary artery disease patients[21]. Research evidence suggests that distorted vagal nerve endings and enhanced release of norepinephrine from sympathetic nerve fibers is the underlying mechanism of altered autonomic nervous system activity[22]. Preceding myocardial ischemia causes alteration in distribution of autonomic nerve fibers[17]. Heterogeneity of autonomic innervation leads to augmented sympathetic influence and reduce vagal intonation in coronary artery disease patients leading to reduced heart rate variability[22].

A case control study carried out by Huikuri et al in 20 patients with coronary artery disease without myocardial infarction and 20 controls showed a significant difference of frequency domain parameters between the groups. They figured that autonomic nervous system control analyzed by frequency domain parameters of heart rate variability is decreased in coronary artery disease patients. Sleep awake rhythm was also decreased significantly in coronary artery disease patients[23]. These results are comparable to our study whereby we also found reduced heart rate variability in coronary disease patients as compared to the reference values taken from healthy individuals.

Feng et al carried out a study to compare heart rate variability in coronary artery patients with normal controls[24]. Study included 236 patients with coronary artery disease and 86 healthy controls. They calculated time domain indices of heart rate variability. Conclusion of the study revealed that overall heart rate variability was decreased in patients with coronary artery disease. Our results of reduced heart rate variability due to coronary occlusion is also supported by study conducted by Karjalainen et al, They conducted a study in coronary artery disease patients with and without diabetes mellitus and found an overall significant decrease in standard deviation of normal to normal beat intervals in coronary artery disease patients[21]. Another study was conducted by Laing et al in 17 patients of coronary artery disease patients. Their results showed that there was a significant decrease in heart rate variability in coronary artery disease

patients which increased on cardiac rehabilitation. Decreased beat to beat variability shows diminished vagal modulation and increased sympathetic stimulation in coronary artery disease patients[25].

A review study conducted by Oliveira et showed various follow-up studies affirming that there is decreased inter beat variability in coronary artery disease patients that makes them more prone to fatal ventricular arrhythmias[26]. However the series concerned have integrated coronary artery disease patients with and without myocardial infarctions.

CONCLUSION

Heart rate variability decreases significantly in patients with coronary artery disease. Reduced heart rate variability is reflective of heightened sympathetic activation which puts these patients on the risk of ventricular arrhythmogenesis. These patients need to be kept under medical surveillance to avoid arrhythmogenic events leading to adverse outcomes including sudden cardiac death.

Acknowledgements

Conflict of Interest

This study has no conflict of interest to declare by any author.

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