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A STUDY OF HEART RATE, BLOOD PRESSURE AND HEART RATE VARIABILITY AT REST, IN NORMOTENSIVE AND HYPERTENSIVE ADULT MALE SUBJECTS

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ABSTRACT

Background: Essential hypertension is associated with cardiovascular autonomic imbalance. Heart Rate Variability (HRV) is a non-invasive tool to monitor the functioning of cardiovascular autonomic nervous system (ANS).

Objectives: To compare Heart Rate, Blood Pressure and Heart Rate Variability in normotensive and hypertensive adult males.

Material and Methods: The study was conducted on 30 normotensive and 30 hypertensive adult males matched for baseline anthropometric characteristics. ECG was recorded and using HRV software, analysis of time domain measures Mean RRI (RR Interval); RMSSD (square root of the mean of the sum of the squares of differences between adjacent NN intervals) and frequency domain measures, LF (Low Frequency); HF (High Frequency); and LF/ HF (Low Frequency/High Frequency) ratio were analysed.

Results: The Heart Rate Variability parameters were significantly reduced in hypertensive subjects as compared to normotensives.

Conclusion: Reduced Heart Rate Variability indicates impaired regulation of the cardiovascular autonomic function in the hypertensives.

Key Words: Hypertension, Autonomic nervous system, Heart rate variability

INTRODUCTION

The heart has rich innervations from the sympathetic and parasympathetic divisions of the autonomic nervous system (ANS). Although the heart is capable of intrinsic regulation of cardiac rhythm, electrical conduction and contractility, these functions are largely under the control of the ANS. The heart rate and its fluctuations reflect changes in cardiac autonomic control. This neural link creates the basis of assessment of cardiac autonomic regulation through measurement of heart rate variability (HRV) [1].

Heart rate variability conventionally describes the beat-to beat fluctuations in the heart rate [2]. HRV is primarily due to the changing modulation of parasympathetic and sympathetic control of the heart and may therefore be considered as an estimate of autonomic heart rate control [3]. Measurements of HRV might assess progressive alterations in the sympatho-vagal balance observed in essential hypertension [4].

Hypertension is the most common human cardiovascular disease, characterized by systolic blood pressure (SBP) of > 140 mmHg and/ or diastolic blood pressure (DBP) of > 90 mmHg [5]. Worldwide it is estimated to cause 7.1 million premature deaths each year [6]. Hypertension doubles the risk of cardiovascular diseases, including coronary heart disease, congestive heart failure, ischemic and hemorrhagic stroke, renal failure, and peripheral arterial disease [7].The pathogenesis of essential hypertension is not clearly understood but is believed to be due to renal, neurogenic, vascular and genetic factors; in reality it has a multifactorial aetiology [8].

The present work represents a study of the autonomic modulation of the heart, using the analysis of the variability in heart rate of normotensive and hypertensive subjects.

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MATERIALS AND METHODS

In this study 30 normotensive and 30 hypertensive male subjects, in the age group of 30-60 years, were included. The study protocol was approved by the Institutional Ethical Committee.

Inclusion Criteria: In the normotensive group, subjects with normal blood pressure, normal electrocardiogram(ECG) and in good health as evaluated by general physical examination without any known respiratory, cardiovascular illness, or any disorder which can interfere the autonomic responses were included. In the hypertensive group known hypertensive on treatment with normal ECG were included.

Exclusion Criteria: Subjects with diabetes mellitus, symptomatic coronary disease, congestive cardiac failure, arrhythmias, any systemic illness and those with h/o tobacco and alcohol consumption were excluded.

Study Design: The study protocol was explained to the subjects and consent was obtained. During the first visit the anthropometric data was obtained. Each subject is given specific dates to visit autonomic laboratory. A day before the test subjects were advised to have their dinner before 9:00 pm and to refrain from any kind of stress. Also instructed not to have coffee, tea and cola 12 hours before the tests and to have light breakfast two hours before the tests. In the laboratory the subject is asked to relax in supine position for 30 minutes and then the tests were performed using ECG V: 52 [HRV analysis software], manufactured by NIVIQURE Meditech pvt Ltd. Bengaluru. ECG V: 52 is a Computerized Data Acquisition System used in conjunction with PC/Laptop.

Resting Heart Rate: The subject was made to lie down in supine position. ECG leads were connected using electrodes from the subject to the ECG V: 52. The resting heart rate was recorded on a computerized ECG from lead II, at a speed of 30 mm/sec.

Blood Pressure: Blood pressure was measured with digital electronic blood pressure monitor in supine position after a period of rest for 5 minutes. Lowest of 3 reading at intervals of 2 minutes was considered.

Heart Rate Variability Analysis: Recording was standardized and instructions followed as per the guidelines of Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology [9]. A chest lead ECG was recorded using ECG V: 52 for 5 minutes in supine rest with eyes closed, which is simultaneously analyzed by the software. Beat-to-beat variations in instantaneous heart rate were derived offline using a rate-detector algorithm. Briefly, a 5-min ECG was acquired at a sampling rate of 1000 Hz during supine rest with the subjects breathing normally at 12–18 per minute.RR intervals were plotted using the ECG V: 52 software. An RR series was extracted using a rate-detector algorithm after exclusion of artefacts and ectopic. A stationary 256 second RR series was chosen for analysis. In the time domain, the standard deviation of normal-to-normal RR intervals (SDNN) was taken as an index of overall HRV. The RR series was resampled at 4 Hz, the mean and trend removed, a Hann window applied and the 1024 data point series transformed by fast Fourier transformation. Low frequency (LF) and high frequency (HF) spectral powers were determined by integrating the power spectrum between 0.04 and 0.15 Hz and 0.15 and 0.4 Hz respectively. Spectral powers are expressed in absolute units of milliseconds squared.

Statistical Analysis: All data is expressed as Mean ± SD. Student't' test used to compare the data of normotensive and hypertensive subjects. Mann-Whitney test used to analyze HRV. p value < 0.05 considered statistically significant and p value < 0.01 as highly significant.

Results: Subjects of both the groups were matched for age and BMI (Table-1). The resting heart rate ($p<0.03$), systolic blood pressure ($p < 0.0001$) and diastolic blood pressure ($p<0.0003$) were significantly higher in hypertensive than those of normotensive group (Table-2). The HRV parameters were significantly reduced in hypertensive subjects as compared to normotensive (Table-3).

DISCUSSION

Heart Rate: In this study, the resting heart rate was significantly higher in the hypertensive group in comparison to those of normotensive group ($p < 0.03$). Higher resting heart rate in the hypertensive group was also observed in various other studies[10,11,12,13].Heart rate is regulated by a complex set of interactions between parasympathetic and sympathetic control. The effects of the two autonomic divisions on the heart can vary reciprocally, independently or coactively [14]. Because the two autonomic divisions exert opposing control over the heart, a given increase in heart rate may arise from distinct autonomic origins, such as vagal withdrawal, sympathetic activation, or both. In general, autonomic cardiovascular control becomes impaired in hypertension and there is a shift in autonomic balance towards sympathetic dominance causing an increase in resting heart rate in hypertension[15.]

Blood Pressure: The baseline values of systolic blood pressure and diastolic blood pressure were higher in the hypertensive group in comparison with the normotensive group . Similar results were obtained in other studies [10,11,12,13]. High blood pressure, a major established predictor of cardiovascular disease, is the leading risk factor for morbidity and mortality worldwide. Both systolic blood pressure and diastolic blood pressure have continuous, independent relations with the risk of cardiovascular disease. Hypertension is associated with reduction in arterial compliance as a result of both structural and functional changes primarily affecting the intima and media of large compliance arteries [16].

Heart Rate Variability (HRV):

The measures of heart rate variability namely the time domain measures, the Mean RRI (RR Interval) and RMSSD(square root of the mean of the sum of the squares of differences between adjacent NN intervals) and also the frequency domain measures, the LF (Low Frequency); HF (High Frequency); and the LF: HF ratio were all reduced in the hypertensive subjects when compared with the normotensive subjects and were found to be statistically significant in the present study.

Time Domain Measures: The ***Mean RRI*** which measures the sum of the levels of parasympathetic and sympathetic influences was lower in hypertensives as compared to normotensives($p < 0.004$).***RMSSD*** (square root of the mean of the sum of the squares of differences between adjacent NN intervals) is an estimate of high-frequency variations in heart rate in short-term NN recordings, which reflects an estimate of parasympathetic regulation of the heart [17]. RMSSD in this study is lower in the hypertensive group than in the normotensive group ($p < 0.01$). Similar statistically significant results of reduced mean RRI and RMSSD in the hypertensives were obtained in various other studies [10, 11, 12]. The time domain methods are used to investigate recordings of short durations. Time domain methods record the HR at any point in time or the intervals between successive QRS complex in a continuous ECG record. In the present study, decreased values of mean RRI and RMSSD indicating decreased HRV are suggestive of decreased vagal modulation and higher sympathetic activity in essential hypertension [18].

Frequency Domain Measures: ***Low Frequency (LF)*** component is believed to be a marker of the sympathetic modulation. In the present study LF component was found to be reduced significantly in the hypertensive group ($p < 0.0001$). ***High Frequency (HF)*** component which is a major contributor of the efferent vagal activity was lower in hypertensives as compared to normotensives ($p< 0.0001$). Harald M. Stauss et al report that HF component is exclusively mediated by the cardiac parasympathetic nervous system, while LF component can be mediated by both divisions of the autonomic nervous system. Consequently the findings regarding reduced LF in the present study may be consequent to the reduction observed in the parasympathetic activity in hypertensive individuals [19]. Reduction in LF and HF components are in accordance with numerous other studies [11, 13]. **Low Frequency /High Frequency (LF/HF):** This measure indicates overall balance between sympathetic and parasympathetic systems [17]. The LF/HF ratio which is the ratio of the extent of fluctuations of the sympathetic tone to that of the parasympathetic tone was reduced in hypertensives as compared to normotensives in the present study (p value of < 0.0001), similar to other studies [10,11].The low and high frequency components and their ratio would provide a model to evaluate the dynamic changes of the sympatho vagal balance. Essential hypertension is commonly neurogenic and attributed to sympathetic overdrive and may be associated with parasympathetic inhibition. It has also been suggested that increased rate of sympathetic nerve firing and also increase in density of sympathetic innervations might cause sympathetic over activity in hypertensive patients [20].

CONCLUSION

The present study concludes that sympatho vagal balance may be altered towards sympathetic predominance in essential hypertension which is supported by markedly decreased parasympathetic activity. Our findings support those of other studies in the medical literature by demonstrating that HRV, both in time and frequency domains, is diffusely decreased in patients with moderate arterial hypertension as compared with that in normotensive individuals. A reduction in HRV is associated with an increased risk of cardiac mortality and has been shown to predict risk for cardiac events and overall mortality, additional research is needed in this aspect.

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Table 1: Baseline Characteristics of Subjects:

Characteristics	Normotensive Group (n=50)	Hypertensive Group(n=50)
Age (years)	49.3 ± 7.71	50.2 ± 7.6
Height (cms)	169.4 ± 4.84	168.06 ± 3.99
Weight (Kg)	60.94 ± 5.79	62.1 ± 6.54
BMI (Kg/m²)	21.22 ± 1.8	22.04 ± 2.77

Table 2: Resting Cardiovascular Parameters.

Parameter	Normotensive (n=50)	Hypertensive (n=50)	p value
Heart Rate (beats per min)	73.34 ± 13.42	79.39 ± 13.56	< 0.03*
Systolic Blood Pressure (mmHg)	127.0 ± 8.23	139.1 ± 12.45	< 0.0001*
Diastolic Blood Pressure (mmHg)	79.8 ± 6.2	83.7 ± 3.96	< 0.0003*

* Statistically significant.

Table 3: Heart Rate Variability Parameters

Parameter	Normotensive	Hypertensive	p value
Mean RRI	848.76 ± 158.52	765.72 ± 64.36	<0.004*
RMSSD	42.74 ± 37.72	24.48 ± 4.73	<0.01*
LF	991 ± 123.17	465.86 ± 41.68	<0.0001*
HF	471.64 ± 51.223	241.91 ± 15.26	<0.0001*
LF/HF	2.12 ± 0.31	1.93 ± 0.20	<0.0001*

* Statistically significant
- Mean RRI: Mean RR Interval.
- RMSSD: square root of the mean of the sum of the squares of differences between adjacent NN intervals.
- LF: Low Frequency.
- HF: High Frequency.
- LF/ HF: Low Frequency/High Frequency ratio.