Comparative Study of Heart Rate Variability in Normotensive And Hypertensive Individuals

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ABSTRACT

**Background** - Hypertension is the most prevalent cardiovascular disorder that affects many organs of our body. Heart rate variability (HRV) is a simple, sensitive and non-invasive tool to monitor the cardiovascular function. The present study is for assessment of sympathovagal balance by analysing HRV in hypertensive individuals.

**Objectives** - To analyse Heart Rate Variability (HRV) in normotensive and hypertensive individuals.

**Material and methods** - 30 hypertensive and 30 normotensive subjects between the age group of 30-60 years were selected. Lead-II ECG was recorded using instrument PHYSIOPAC-PP4, MEDICAID system, Chandigarh and HRV analysis was done using KUBIOS HRV analyser. Spectral indices of HRV based on frequency domain such as normalized low frequency power (LFnu), normalized high frequency power (HFnu), ratio of low frequency power to high frequency power (LF-HF ratio) and time domain such as standard deviation of normal-to-normal RR intervals (SDNN), root mean square successive difference (rMSSD) and the proportion of NN50 to the total number of NN intervals (pNN50) were assessed.

**Results** - Our results showed LFnu (78.17±5.73) and LF-HF ratio (2.14±0.24) was significantly increased in hypertensives and significant decrease was seen in HFnu (37.13±3.70), SDNN (149.1±4.82), rMSSD (36.4±4.75) and pNN50 (9.97±1.90) in hypertensives by student’s paired t-test.

**Conclusion** - Above result suggests increased sympathetic and decreased parasympathetic activity. The pathophysiology of hypertension is primarily due to an increase systemic vascular resistance. This is attributed to enhanced sympathetic activity leading to sympathovagal imbalance.

**Keywords** - Hypertension (HTN), Heart Rate Variability (HRV), Time Domain Measures, Frequency Domain Measures.

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INTRODUCTION

Hypertension is the most prevalent non communicable disorder that affects many organs of the body including cardiovascular system [1]. Hypertension represents a multifactorial disease of Blood Pressure (BP) regulation with persistently elevated systolic and/or diastolic BP over 140/90 mmHg. Hypertension is a risk factor for development of cardiovascular and cerebro-vascular diseases (3). It has been estimated that hypertension accounts for 6% of death worldwide (2).

Blood Pressure (BP) is maintained physiologically by multiple regulatory mechanisms such as neural control, hormonal control and local control mechanism. Among them, neural control by autonomic nervous system (ANS) is the most important regulatory mechanism of blood pressure. Though hypertension is a multifactorial disease, ANS dysfunction is an important factor in the development and progression of hypertension (4).

ANS plays a fundamental role in the control of arterial blood pressure and heart rate and therefore, may be considered an important pathophysiological factor in the development of arterial hypertension (5). Measurements of HRV might assess progressive alterations in the sympato-vagal balance observed in essential hypertension (6).

Heart rate variability (HRV) is defined as the oscillation of heart rate around the mean value. It is caused by variations in the input to the sinus node from the autonomic nervous system (7). It is simple, sensitive and non-invasive tool to monitor the cardiovascular ANS function. It is a measure of balance between sympathetic mediators of heart rate and parasympathetic mediators of heart rate that is the influence of acetylcholine released by the parasympathetic nerve fibres acting on the sino-atrial and atrio-ventricular nodes leading to a decrease in the heart rate (8). HRV analysis thus can identify any change in sympathovagal balance.

This study is designed to assess the sympathovagal balance by analysing the HRV changes in hypertensive and normotensive subject.

AIMS AND OBJECTIVES

To analyse Heart Rate Variability (HRV) by Time domain measures and Frequency domain measures in normotensive and hypertensive individuals.

METHODS AND MATERIALS
This study was conducted in Department of Physiology, Grant Government Medical College and Sir JJ Group of hospitals, after obtaining clearance from the Institutional ethical committee. Study comprises of 60 individuals out of which, 30 were patients with primary hypertension between the ages of 30-60 years of both sexes, along with 30 ages and sex matched normotensive subjects as controls.

**INCLUSION CRITERIA**

- Criteria for considering hypertensive will be volunteers with blood pressure ≥140/90mm Hg based on average of three consecutive readings at an interval of 3 weeks will be recruited as hypertensive (group 2), according to JNC-7 classification (9).
- Normotensive - will be volunteers with BP values of 100-119/60-79 mm Hg will be recruited as normotensive (group 1), according to JNC-7 classification (9).

**EXCLUSION CRITERIA**

- Age less than 30 years and more than 60 years.
- Subjects with Diabetes Mellitus, Ischemic heart disease, peripheral arterial disease, strokes, renal failure, AIDS, TB, symptomatic coronary artery disease.
- Smokers and alcoholics.

Informed consent was obtained from all the subjects prior to the study. 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 (10). Subjects were advised to have their meal by 9:00 pm, to have a good sleep at night before and to remain free from any physical or mental stress, not to take sedatives or any drugs affecting central nervous system. They were also instructed to avoid tea or coffee at breakfast. All subjects were clinically examined and detailed history was taken with reference to duration of hypertension, family history, personal history like smoking, alcoholism etc and previous drug history. During this period subject was advised not to talk, eat or drink and also not to perform physical or any mental activity. Blood Pressure was recorded using mercury sphygmomanometer 10 minutes after taking rest. A standard adult size cuff measuring 23 cm by 12 cm was used for all subjects (11). A 5 min of ECG was done in supine position, in the morning time, using instrument PHYSIOPAC–PP4, MEDICAID SYSTEM, CHANDIGARH. The data analysis was done using the kubios HRV analyser. Following spectral indices of HRV will be assessed (12).

A. Time domain measures:

- Standard deviation of normal –to- normal RR intervals (SDNN).
- Root mean square successive difference (rMSSD).
- The proportion of NN50 to the total number of NN intervals (pNN50).

SDNN, rMSSD and pNN50 are measures of parasympathetic activity (12).
B. Frequency domain measures:

- Normalized low frequency power (LFnu).
- Normalized high frequency power (HFnu).
- Ratio of low frequency power to high frequency power (LF-HF ratio).

HFnu is a measure of parasympathetic activity and LFnu and LF/HF ratio are measures of sympathetic activity (12).

STATISTICAL ANALYSIS

The data analysis will be done using the kubois HRV analyser. HRV measures were expressed as mean ± SD. Student paired “t-test” and chi-square test was used for comparison the values between hypertensive and normotensive group. p value < 0.05 was considered statistically significant.

Table 1 - Comparison of Time Domain Measures

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hypertensive (n=30)</th>
<th>Normotensive (n=30)</th>
<th>t value</th>
<th>p value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± s.d</td>
<td>Mean ± s.d</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SDNN (ms)</td>
<td>149.1 ± 4.82</td>
<td>157.73 ± 4.92</td>
<td>6.863</td>
<td>P&lt;0.0001</td>
<td>significant</td>
</tr>
<tr>
<td>rMSSD (ms)</td>
<td>38.4 ± 4.78</td>
<td>45.77 ± 3.08</td>
<td>9.066</td>
<td>P&lt;0.0001</td>
<td>significant</td>
</tr>
<tr>
<td>pNN50</td>
<td>9.97 ± 1.90</td>
<td>16.27 ± 3.66</td>
<td>8.368</td>
<td>P&lt;0.0001</td>
<td>Significant</td>
</tr>
</tbody>
</table>

Graph 1 – Comparison of Mean Time Domain Measures
Table -2 Comparison of Frequency Domain Measures

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hypertensive Mean±s.d. (n=30)</th>
<th>Normotensive Mean±s.d. (n=30)</th>
<th>t value</th>
<th>p value</th>
<th>conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF nu</td>
<td>78.17±6.73</td>
<td>75.3±4.46</td>
<td>2.165</td>
<td>0.0345</td>
<td>significant</td>
</tr>
<tr>
<td>HF nu</td>
<td>37.13±3.70</td>
<td>59.1±4.58</td>
<td>20.438</td>
<td>p&lt;0.0001</td>
<td>Significant</td>
</tr>
<tr>
<td>LF/HF ratio</td>
<td>2.14±0.34</td>
<td>1.396±0.15</td>
<td>16.334</td>
<td>P&lt;0.0001</td>
<td>significant</td>
</tr>
</tbody>
</table>

Graph -2 Comparisons of Mean Frequency Domain Measures.
**DISCUSSION**

In the present study LFnu and LF/HF ratio was significantly increased in hypertension but HFnu is decreased. Similarly, time domain measures – SDNN, rMSSD and pNN50 were significantly reduced in hypertensive. This shows that there is increased sympathetic activity and decreased parasympathetic activity in hypertensive.

A study shows that hypertensive subjects had markedly depressed HRV which reflects sympathovagal imbalance (3). Virtanen R et al. found that HRV is significantly lower in mild or moderate untreated hypertension (13). Another study revealed that adolescents with primary hypertension had lower HF and higher LF and LF/HF ratio suggesting sympathetic predominance and reduced vagal activity(7). Urooj et al showed that the time domain parameters such as SDNN, rMSSD and pNN50 were significantly reduced in hypertension compared to normal healthy subjects(14).Nirmala et al showed that there is increased sympathetic activity and decreased vagal tone associated with hypertension(2).
The results of our study were similar to the previous studies. Thus, our findings suggest that there is sympathovagal imbalance occurring in hypertensive.

Many pathophysiological factors have been implicated in the genesis of essential hypertension: increased sympathetic nervous system activity, perhaps related to heightened exposure or response to psychosocial stress; overproduction of sodium-retaining hormones and vasoconstrictors; long-term high sodium intake; inadequate dietary intake of potassium and calcium; increased or inappropriate renin secretion with resultant increased production of angiotensin II and aldosterone; deficiencies of vasodilators, such as prostacyclin, nitric oxide (NO), and the natriuretic peptides; alterations in expression of the kallikrein–kinin system that affect vascular tone. Increased activity of vascular growth factors; alterations in adrenergic receptors that influence heart rate, inotropic properties of the heart, and vascular tone; and altered cellular ion transport. (15)

The pathophysiology of essential hypertension is primarily due to an increase in systemic vascular resistance. This is mainly attributed to the enhanced activity of sympathetic nervous system (2).

The sympathetic hyperactivity might be due to baroreceptor resetting that causes suppression of sympathetic inhibition. There is also evidence of norepinephrine spill over into the circulation in essential hypertension that leads onto sympathetic hyperactivity.

Experimental studies have shown increased Angiotensin II level in blood which can stimulate the secretion of catecholamines. (15) Angiotensin II also causes oxidative stress that leads onto interaction of reactive oxygen species (O-) with nitric oxide (NO) causing reduced levels of NO which results in vasoconstriction. (15) Local factors like endothelin might also be the contributing factor for adrenergic activation characterizing hypertension. (16) This sympathetic hyperactivity eventually may lead onto sympathovagal imbalance in hypertensives.

CONCLUSION

From this study we concluded that there is an increased sympathetic activity and decreased parasympathetic activity in hypertensive individuals. Our study showed that HRV is significantly reduced in hypertensive patients compared to controls, indicating a decrease in the baroreceptor reflex. There is impairment in cardiac autonomic function characterized by sympathetic over activity and also showed sympatho-vagal balance in hypertensive patients is towards higher sympathetic and lower vagal modulation. Since reduced HRV is associated with cardiac arrhythmias, this suggests hypertensive patients may have risk for occurrence of cardiac arrhythmias in future. These simple noninvasive measures can be used for early detection and treatment of cardiac arrhythmias and other variations in cardiac autonomic function. Thus, it can be used as a routine screening test to predict future risk of hypertension and also for better prognosis during treatment.

FUTURE DIRECTIONS
Since reduced HRV is associated with cardiac arrhythmias, this suggests hypertensive patients may have risk for occurrence of cardiac arrhythmias in future.

These simple non-invasive measures can be used for early detection and treatment of cardiac arrhythmias and other variations in cardiac autonomic function.

Thus, it can be used as a routine screening test to predict future risk of hypertension and also for better prognosis during treatment.

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