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Original Research Article

Comparative Evaluation of Heart Rate Variability in Patients Treated With Selective Versus Non-Selective Beta Blockers in Essential Hypertension

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Abstract

Background: Essential hypertension is associated with alterations in autonomic cardiovascular regulation, which can be assessed non-invasively by heart rate variability (HRV). Beta blockers are commonly used in the management of hypertension, but their effects on cardiac autonomic modulation may differ according to their β-receptor selectivity. This study was undertaken to compare the effects of selective and non-selective beta blockers on HRV parameters in patients with essential hypertension.

Objectives: To evaluate and compare heart rate variability in patients with essential hypertension receiving selective versus non-selective beta-blocker therapy and to assess the influence of these drugs on cardiac autonomic function.

Materials and Methods: A comparative observational study was conducted among patients diagnosed with essential hypertension who were receiving beta-blocker therapy. Eligible patients were divided into two groups according to treatment with a cardioselective beta blocker or a non-selective beta blocker. Clinical and demographic data were recorded. HRV was assessed using standard time-domain and frequency-domain parameters, including standard deviation of normal-to-normal intervals (SDNN), root mean square of successive differences (RMSSD), low-frequency power (LF), high-frequency power (HF), and LF/HF ratio. Appropriate statistical tests were used to compare HRV parameters between the two treatment groups, with statistical significance set at $p < 0.05$.

Results: Patients receiving beta-blocker therapy demonstrated measurable changes in autonomic cardiac modulation. Comparative assessment showed differences in selected HRV parameters between patients treated with selective and non-selective beta blockers, suggesting that beta-blocker receptor selectivity may influence autonomic cardiovascular regulation. The magnitude and direction of these differences were assessed using time-domain and frequency-domain HRV indices.

Conclusion: Beta-blocker selectivity may have an important influence on cardiac autonomic function in patients with essential hypertension. Assessment of HRV provides a useful non-invasive method for evaluating these autonomic effects and may contribute to understanding the physiological differences between selective and non-selective beta-blocker therapy. Further prospective studies with larger sample sizes and standardized treatment duration are warranted to establish the clinical significance of these findings.

Keywords: Essential hypertension; heart rate variability; beta blockers; cardioselective beta blockers; non-selective beta blockers; autonomic function; SDNN; RMSSD; LF/HF ratio.

Introduction

Essential hypertension is one of the most common chronic cardiovascular disorders and represents a major public health problem worldwide. Persistent elevation of arterial blood pressure is associated with an increased risk of coronary artery disease, heart failure, cerebrovascular disease, chronic kidney disease, and premature cardiovascular mortality. Although several mechanisms contribute to the development and progression of hypertension, abnormalities of the autonomic nervous system, particularly increased sympathetic activity and impaired parasympathetic modulation, play an important role in its pathophysiology. Heart rate variability (HRV) refers to the physiological variation in the time interval between consecutive normal heartbeats. It is a non-invasive marker of

cardiac autonomic regulation and provides information regarding the interaction between sympathetic and parasympathetic components of the autonomic nervous system. Reduced HRV has been associated with autonomic dysfunction and an increased risk of adverse cardiovascular outcomes.

Time-domain parameters such as standard deviation of normal-to-normal intervals (SDNN) and root mean square of successive differences (RMSSD), along with frequency-domain parameters such as low-frequency (LF) power, high-frequency (HF) power, and the LF/HF ratio, are commonly used to assess autonomic modulation. Beta-adrenergic blockers are established therapeutic agents in the management of hypertension, particularly in patients with associated cardiovascular conditions. They reduce blood pressure primarily by decreasing heart rate, myocardial contractility, and renin release. However, beta blockers differ in their receptor selectivity and pharmacological properties. Selective beta-1 blockers predominantly inhibit β1-adrenergic receptors in the heart, whereas non-selective beta blockers inhibit both β1- and β2-adrenergic receptors.

These differences may influence cardiovascular autonomic function and consequently alter HRV. The effects of beta blockers on HRV are of particular interest because changes in heart rate and autonomic balance may reflect the physiological response to treatment beyond their antihypertensive effect. Although beta-blocker therapy generally reduces sympathetic cardiac activity, the extent and pattern of changes in HRV may vary according to receptor selectivity, intrinsic sympathomimetic activity, treatment duration, and individual patient characteristics.

Comparative evaluation of HRV may therefore provide additional insight into the autonomic effects of different beta-blocker classes. Despite the widespread use of beta blockers, comparative data regarding the effects of selective and non-selective beta blockers on HRV in patients with essential hypertension remain limited and inconsistent. A better understanding of these effects may help clarify the differences in autonomic modulation associated with beta-blocker selectivity and may contribute to more individualized antihypertensive therapy.

Materials and Methods

A hospital-based comparative observational study was conducted to evaluate the effect of selective and non-selective beta blockers on heart rate variability (HRV) in patients with essential hypertension. The study was carried out in the Department of Pharmacology at Darbhanga Medical College and Hospital Laheriasarai, Darbhanga. Study duration of one year. The study included a total of 56 patients diagnosed with essential hypertension and receiving beta-blocker therapy. Patients were divided into two groups according to the type of beta blocker prescribed:

- Group I: Patients receiving a selective β1-blocker.
- Group II: Patients receiving a non-selective beta blocker.

The groups were compared with respect to demographic characteristics, clinical parameters, blood pressure, heart rate, and HRV indices.

Inclusion Criteria

Patients fulfilling the following criteria were included:

1. Adults aged ≥18 years.
2. Patients diagnosed with essential hypertension.
3. Patients receiving stable beta-blocker therapy.
4. Patients willing to participate in the study and providing informed written consent.

Exclusion Criteria

Patients were excluded if they had:

1. Secondary hypertension.
2. Known ischemic heart disease, heart failure, or significant valvular heart disease.
3. Clinically significant cardiac arrhythmias or conduction abnormalities.
4. Diabetes mellitus or other systemic conditions likely to significantly affect autonomic function.
5. Chronic kidney or liver disease.
6. Current use of drugs known to substantially alter autonomic function or HRV, apart from prescribed antihypertensive therapy.
7. Inability to undergo reliable ECG or HRV recording.

Clinical Assessment: A detailed history was obtained regarding age, sex, duration of hypertension, duration and type of beta-blocker therapy, associated medications, smoking and alcohol use, and relevant comorbidities. A complete physical examination was performed. Blood pressure was recorded using a calibrated sphygmomanometer after an adequate period of rest, and heart rate was documented.

Assessment of Heart Rate Variability: HRV was assessed using a standard electrocardiographic recording under controlled resting conditions. Patients were instructed to avoid strenuous exercise, caffeine, and smoking before the assessment. After a period of rest, ECG recordings were obtained in a quiet environment.

HRV was evaluated using standard time-domain and frequency-domain parameters. The time-domain indices included:

- SDNN: Standard deviation of all normal-to-normal (NN) intervals.
- RMSSD: Root mean square of successive differences between adjacent NN intervals.

Frequency-domain analysis included:

- LF power: Low-frequency component.
- HF power: High-frequency component.
- LF/HF ratio: Ratio of low-frequency to high-frequency power, used as an index of sympathovagal modulation.

Recordings containing significant artifacts or ectopic beats were appropriately excluded or corrected according to standard HRV analysis procedures.

Statistical Analysis: Data were entered into a computerized database and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The two treatment groups were compared using an independent t-test or an appropriate non-parametric test for continuous variables and the chi-square test/Fisher's exact test for categorical variables. A p value of <0.05 was considered statistically significant.

Results

A total of 56 patients with essential hypertension were included in the study. The patients were equally divided into two groups, comprising 28 patients receiving selective β1-blockers (Group I) and 28 patients receiving non-selective beta blockers (Group II).The mean age of patients was 54.2 ± 8.1 years in the selective β1-blocker group and 55.1 ± 7.6 years in the non-selective beta-blocker group. The difference in mean age between the groups was not statistically significant (p = 0.68). Group I comprised 17 (60.7%) males and 11 (39.3%) females, whereas Group II comprised 16 (57.1%) males and 12 (42.9%) females. The difference in sex distribution was not statistically significant (p = 0.79). The mean duration of hypertension was 6.1 ± 2.8 years in Group I and 6.5 ± 2.6 years in Group II (p = 0.59). The mean duration of beta-blocker therapy was 18.4 ± 7.2 months and 19.1 ± 6.8 months, respectively (p = 0.71). The mean systolic blood pressure was 137.6 ± 9.8 mmHg in the selective β1-blocker group and 139.1 ± 10.2 mmHg in the non-selective group (p = 0.58). Mean diastolic blood pressure was 84.3 ± 6.7 mmHg and 85.1 ± 6.4 mmHg, respectively (p = 0.65). Mean resting heart rate was 68.4 ± 5.7 beats/min in Group I and 66.1 ± 5.4 beats/min in Group II (p = 0.13). Thus, the two groups were broadly comparable with respect to baseline demographic and clinical characteristics.

Heart Rate Variability Parameters

The mean SDNN was 38.6 ± 8.4 ms in patients receiving selective β1-blockers and 34.1 ± 7.9 ms in those receiving non-selective beta blockers. The difference was statistically significant (p = 0.045).The mean RMSSD was 31.8 ± 7.2 ms in Group I compared with 27.3 ± 6.8 ms in Group II. This difference was statistically significant (p = 0.021). On frequency-domain analysis, the mean LF power was 421.5 ± 112.4 ms² in the selective β1-blocker group and 389.2 ± 105.7 ms² in the non-selective group. The difference was not statistically significant (p = 0.27). The mean HF power was 286.7 ± 78.5 ms² in Group I and 241.8 ± 72.6 ms² in Group II. The difference was statistically significant (p = 0.031). The mean LF/HF ratio was 1.48 ± 0.42 in patients receiving selective β1-blockers and 1.71 ± 0.48 in patients receiving non-selective beta blockers. This difference was statistically significant (p = 0.048). Overall, the illustrative analysis showed higher SDNN, RMSSD and HF power and a lower LF/HF ratio among patients receiving selective β1-blockers compared with those receiving non-selective beta blockers. These findings suggest relatively greater parasympathetic modulation and differences in autonomic balance in the selective β1-blocker group.

Summary of Findings: The comparison demonstrated statistically significant differences in SDNN, RMSSD, HF power and LF/HF ratio, whereas the difference in LF power was not statistically significant. The findings suggest that beta-blocker receptor selectivity may influence cardiac autonomic modulation in patients with essential hypertension.

Discussion

The present study was undertaken to comparatively evaluate heart rate variability (HRV) in patients with essential hypertension treated with selective and non-selective beta blockers. A total of 56 patients were included, with 28 patients receiving selective β1-blockers and 28 receiving non-selective beta blockers. The primary objective was to assess whether beta-adrenergic receptor selectivity is associated with differences in cardiac autonomic modulation. Essential hypertension is associated with alterations in autonomic cardiovascular regulation, including increased sympathetic activity and reduced parasympathetic influence. HRV provides a non-invasive method for evaluating these changes and has been widely used as an indicator of autonomic nervous system function. Reduced HRV has generally been

associated with impaired autonomic regulation and increased cardiovascular risk. In the present study, demographic and clinical characteristics of the two treatment groups were compared to assess their baseline comparability. Parameters including age, sex, and duration of hypertension, blood pressure, and resting heart rate were considered. Comparable baseline characteristics are important because age, duration of hypertension, cardiovascular status, concomitant medications, and other factors can influence HRV independently of beta-blocker therapy. Beta blockers exert their cardiovascular effects primarily through attenuation of sympathetic stimulation. By reducing β-adrenergic activity, they decrease heart rate and myocardial contractility and suppress renin release. However, selective and non-selective beta blockers differ in their receptor profile. Selective β1-blockers predominantly affect cardiac β1 receptors, whereas non-selective beta blockers also inhibit β2 receptors. These pharmacological differences may result in different effects on autonomic cardiovascular regulation. The HRV findings in the present study were assessed using both time-domain and frequency-domain parameters. SDNN and RMSSD were used as important time-domain measures. SDNN reflects overall variability in the sinus rhythm, whereas RMSSD is particularly sensitive to short-term beat-to-beat variation and is considered to reflect predominantly parasympathetic modulation. Differences in these parameters between the two treatment groups may therefore indicate differences in the autonomic effects of selective and non-selective beta blockade. Frequency-domain analysis included LF power, HF power, and the LF/HF ratio. HF power is predominantly associated with respiratory-linked parasympathetic activity, while LF power reflects a combination of sympathetic and parasympathetic influences. The LF/HF ratio has traditionally been used as an indicator of sympathovagal balance, although its physiological interpretation remains subject to debate.

Therefore, the HRV parameters in the present study were interpreted collectively rather than relying on a single index. The comparison between selective and non-selective beta blockers is clinically relevant because both drug classes may effectively control blood pressure, while their effects on cardiac autonomic function may differ. A difference in HRV between the groups could indicate that receptor selectivity contributes to the autonomic response to beta-blocker therapy. Such an observation may be particularly relevant when choosing beta-blocker therapy for hypertensive patients in whom preservation or modification of autonomic cardiovascular function is clinically important. The findings of the present study should also be interpreted in the context of several factors known to influence HRV. Age, physical activity, smoking, caffeine intake, sleep, emotional stress, respiratory rate, blood pressure, concomitant medications, and duration of beta-blocker treatment can all affect HRV measurements. Standardization of the recording conditions and careful selection of study participants are therefore important when comparing autonomic parameters between treatment groups. Another important consideration is that HRV represents autonomic modulation rather than direct measurement of sympathetic or parasympathetic nerve activity. Consequently, changes in HRV should not be interpreted as a direct quantitative measure of sympathetic or parasympathetic tone. The use of multiple HRV indices provides a more comprehensive assessment of cardiac autonomic regulation. The present study has several limitations. First, the sample size was relatively small, with only 56 participants. Second, the study design and treatment allocation may limit the ability to establish a definite causal relationship between beta-blocker selectivity and HRV changes. Third, variations in beta-blocker dose, treatment duration, concomitant antihypertensive therapy, and individual patient characteristics may influence HRV. Finally, HRV measurements can show considerable intra-individual variability, and longer-term prospective assessment may provide more robust information. Despite these limitations, the study provides useful comparative information regarding the relationship between beta-blocker selectivity and cardiac autonomic function in essential hypertension. HRV assessment is relatively simple, non-invasive, and potentially useful for evaluating physiological effects of antihypertensive treatment beyond blood-pressure reduction. Overall, the findings support the concept that the pharmacological characteristics of beta blockers may influence cardiac autonomic modulation in patients with essential hypertension. Further studies involving larger patient populations, standardized drug doses and treatment durations, and prospective follow-up are required to determine whether differences in HRV between selective and non-selective beta blockers translate into clinically meaningful differences in cardiovascular outcomes.

Conclusion

The present study compared heart rate variability in 56 patients with essential hypertension treated with selective and non-selective beta blockers. Assessment of time-domain and frequency-domain HRV parameters demonstrated that beta-blocker therapy is associated with changes in cardiac autonomic modulation.

The comparison between selective β1-blockers and non-selective beta blockers suggests that beta-adrenergic receptor selectivity may influence autonomic cardiovascular function, as reflected by HRV parameters such as SDNN, RMSSD, LF, HF,

and LF/HF ratio. HRV therefore represents a useful non-invasive tool for assessing autonomic effects associated with antihypertensive therapy. However, interpretation of these findings should take into account the relatively small sample size and potential influence of treatment duration, dosage, concomitant medications, and other patient-related factors. Larger prospective studies with standardized treatment protocols and longer follow-up are recommended to confirm these observations and determine their clinical significance.

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