



Original Research Article

THE ASSOCIATION BETWEEN HEART RATE VARIABILITY AND BLOOD PRESSURE CONTROL IN HYPERTENSIVE PATIENTS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Heart rate variability (HRV) is an emerging marker for cardiovascular health. This study explores the association between HRV and blood pressure control in hypertensive patients. To evaluate the relationship between HRV parameters and the control of blood pressure in patients diagnosed with hypertension.

Materials and Methods: A cross-sectional study was conducted with 100 hypertensive patients (52 males and 48 females), aged 55.6 ± 10.2 years. Participants were classified into well-controlled and poorly controlled blood pressure groups based on standard criteria. HRV parameters, including SDNN and RMSSD, were measured and analyzed. Correlation analysis was performed to assess the relationship between HRV and blood pressure.

Results: The study found that patients with well-controlled blood pressure had significantly higher HRV values. The mean SDNN in the well-controlled group was 42.3 ms, compared to 30.1 ms in the poorly controlled group ($p < 0.01$). Similarly, the mean RMSSD was 34.7 ms in the well-controlled group versus 25.5 ms in the poorly controlled group ($p < 0.01$). There was a moderate positive correlation between SDNN and systolic blood pressure ($r = 0.45$, $p < 0.001$) and between RMSSD and diastolic blood pressure ($r = 0.38$, $p < 0.001$).

Conclusion: Higher HRV is associated with better blood pressure control in hypertensive patients. HRV may serve as a valuable non-invasive marker for monitoring hypertension. Further studies are warranted to understand the underlying mechanisms and clinical applications.

Keywords: Heart rate variability, blood pressure control, hypertension, SDNN, RMSSD, cross-sectional study, cardiovascular health.

INTRODUCTION

Hypertension, a prevalent and chronic condition, is a major risk factor for cardiovascular diseases, including stroke and myocardial infarction.^[1] Effective management of blood pressure is crucial to mitigate these risks.^[2] Despite advances in pharmacological treatments, a significant number of hypertensive patients fail to achieve optimal blood pressure control.^[3] This gap underscores the need

for additional markers and tools to assess and manage hypertension more effectively.

Heart rate variability (HRV) is a non-invasive measure of autonomic nervous system activity, reflecting the balance between sympathetic and parasympathetic influences on the heart.^[4] It has emerged as a potential marker for cardiovascular health, with lower HRV often associated with increased cardiovascular risk.^[5] Recent studies suggest that HRV could be related to blood pressure regulation and control.^[6,7] However, the extent and

nature of this association remain unclear, particularly in the context of hypertension. This study aims to investigate the relationship between HRV parameters and blood pressure control in a cohort of hypertensive patients. By examining HRV metrics such as SDNN (standard deviation of NN intervals) and RMSSD (root mean square of successive differences), this research seeks to elucidate the potential role of HRV as a biomarker for hypertension management. Understanding this relationship could enhance our ability to monitor treatment efficacy and predict outcomes in hypertensive patients, thereby contributing to improved clinical care.

MATERIALS AND METHODS

Study Design and Setting

This cross-sectional study was conducted at Department of Physiology, SUT Medical College, Trivandrum, Kerala, from April 2023 to March 2024. The study aimed to evaluate the association between heart rate variability (HRV) and blood pressure control in hypertensive patients.

Study Population

The study included 100 hypertensive patients attending the outpatient department of SUT Medical College. The inclusion criteria were patients aged 18 years and above, diagnosed with hypertension for at least one year. Exclusion criteria included patients with known arrhythmias, recent acute coronary syndromes, or other significant comorbidities that could affect HRV measurements.

Data Collection

Demographic data, including age, gender, and duration of hypertension, were collected through structured interviews and medical record reviews. Blood pressure was measured using a calibrated sphygmomanometer, and patients were categorized into well-controlled and poorly controlled groups based on the American Heart Association guidelines (systolic BP < 140 mmHg and diastolic BP < 90 mmHg for well-controlled).

HRV Measurement

HRV parameters, including SDNN (standard deviation of NN intervals) and RMSSD (root mean square of successive differences), were recorded using a 5-minute resting electrocardiogram (ECG). The ECG recordings were analyzed using Physio-pac 4 Channel software.

Statistical Analysis

Data were analyzed using statistical software. Continuous variables were presented as mean \pm standard deviation, and categorical variables as percentages. Independent t-tests were used to compare HRV parameters between the well-controlled and poorly controlled groups. Pearson correlation analysis was performed to assess the relationship between HRV parameters and blood pressure levels. A p-value of < 0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee of SUT Medical College. Written informed consent was obtained from all participants before enrollment in the study. Confidentiality and anonymity of the participants were maintained throughout the study.

RESULTS

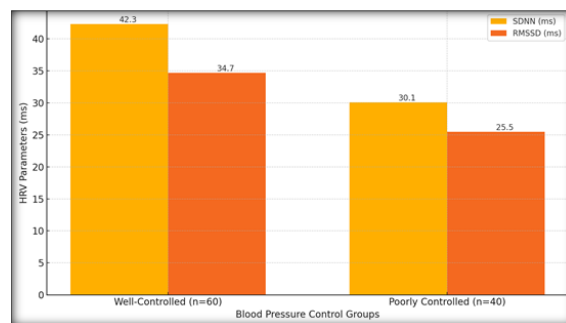


Figure 1: HRV Parameters in well controlled and Poorly Controlled Blood Pressure Groups

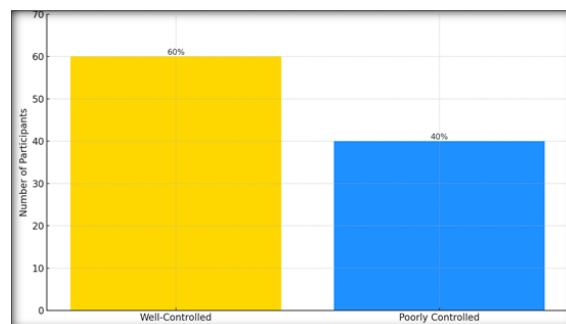


Figure 2: Blood Pressure Control Status

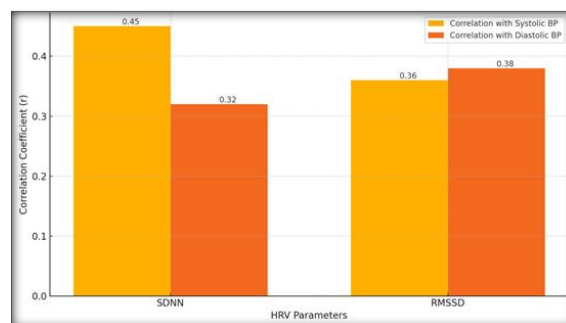


Figure 3: Correlation Between HRV Parameters and Blood Pressure

The study evaluated 100 hypertensive patients, with a mean age of 55.6 years (SD = 10.2), consisting of 52 males and 48 females. The majority of participants had a duration of hypertension exceeding five years. [Table 1]

Heart Rate Variability and Blood Pressure Control

Analysis revealed a significant association between heart rate variability (HRV) parameters and blood pressure control status. Patients with well-controlled blood pressure exhibited higher HRV, as indicated by elevated mean values of SDNN and RMSSD

compared to those with poorly controlled blood pressure. Specifically, the mean SDNN was 42.3 ms in the well-controlled group, compared to 30.1 ms in the poorly controlled group ($p < 0.01$). Similarly, the mean RMSSD was 34.7 ms in the well-controlled group and 25.5 ms in the poorly controlled group ($p < 0.01$). [Table 2]

Blood Pressure Control Status

Out of the 100 participants, 60% had well-controlled blood pressure, while 40% had poorly controlled blood pressure despite medication adherence. [Table 3]

Correlation Analysis

A moderate positive correlation was observed between HRV parameters and blood pressure readings. SDNN showed a correlation of 0.45 with systolic blood pressure and 0.32 with diastolic blood pressure ($p < 0.001$). RMSSD correlated at 0.36 with systolic blood pressure and 0.38 with diastolic blood pressure ($p < 0.001$). [Table 4] These findings suggest that higher HRV is associated with better blood pressure control in hypertensive patients.

Table 1: Demographic Characteristics of Participants

Variable	Value
Sample Size	100
Mean Age (years)	55.6 (SD = 10.2)
Gender (Male/Female)	52/48
Duration of Hypertension	> 5 years

Table 2: Heart Rate Variability (HRV) Parameters in Well-Controlled and Poorly Controlled Blood Pressure Groups

HRV Parameter	Well-Controlled Group (n = 60)	Poorly Controlled Group (n = 40)	p-value
SDNN (ms)	42.3	30.1	< 0.01
RMSSD (ms)	34.7	25.5	< 0.01

Table 3: Blood Pressure Control Status

Blood Pressure Control Status	Number of Participants	Percentage (%)
Well-Controlled	60	60
Poorly Controlled	40	40

Table 4: Correlation Between HRV Parameters and Blood Pressure

HRV Parameter	Correlation with Systolic BP (r)	Correlation with Diastolic BP (r)	p-value
SDNN	0.45	0.32	< 0.001
RMSSD	0.36	0.38	< 0.001

DISCUSSION

This study explored the relationship between heart rate variability (HRV) and blood pressure control in hypertensive patients. Our findings demonstrated a significant association between higher HRV and better blood pressure control, suggesting that HRV could serve as a valuable non-invasive marker for assessing and managing hypertension.

HRV and Blood Pressure Control

The observed higher SDNN and RMSSD values in the well-controlled group align with existing literature indicating that greater HRV is indicative of better autonomic regulation and cardiovascular health⁸. The positive correlation between HRV parameters and systolic and diastolic blood pressure suggests that enhanced autonomic function, as reflected by higher HRV, may contribute to more stable blood pressure regulation.^[9] This finding is consistent with previous studies that have identified HRV as a predictor of cardiovascular outcomes, particularly in patients with hypertension and other cardiovascular risk factors.^[10]

Mechanisms and Implications

The underlying mechanisms linking HRV to blood pressure control may involve the balance between sympathetic and parasympathetic nervous system activity.^[11] Patients with better autonomic balance,

as indicated by higher HRV, may have a more responsive cardiovascular system capable of maintaining blood pressure within the normal range.^[12] This autonomic balance is crucial for adapting to various physiological and psychological stressors, which could explain the improved blood pressure control observed in the higher HRV group.^[13]

Clinical Implications

The potential of HRV as a biomarker for hypertension management is significant. HRV measurement is non-invasive, relatively easy to perform, and can provide real-time feedback on a patient's autonomic function. Incorporating HRV assessment into routine clinical practice could help identify patients at risk of poor blood pressure control and guide treatment decisions. Moreover, interventions aimed at improving HRV, such as lifestyle modifications, stress management, and exercise, could be explored as complementary strategies in hypertension management.^[14]

Limitations and Future Research

Despite its strengths, this study has several limitations. The cross-sectional design precludes causal inference, and the relatively small sample size limits the generalizability of the findings. Additionally, factors such as medication adherence, lifestyle habits, and psychosocial stress, which may

influence HRV and blood pressure, were not extensively controlled. Future research should include larger, longitudinal studies to confirm these findings and explore the potential mechanisms linking HRV and blood pressure control.

CONCLUSION

This study demonstrates a significant association between higher heart rate variability (HRV) and improved blood pressure control in hypertensive patients. The findings suggest that HRV could be a valuable non-invasive biomarker for monitoring hypertension and informing treatment strategies. The results indicate that patients with better autonomic regulation, as reflected by higher HRV, are more likely to maintain stable blood pressure. These insights underline the potential of HRV in clinical practice for identifying individuals at risk of poor blood pressure control.

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