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Decoding the Intricate Nexus Between Hypertension and Short-Term Heart Rate Variability: A Narrative Review

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Abstract: Hypertension is among the most significant global health issues to date with a global age-standardised prevalence of hypertension in adults aged 30–79 years varies between 32% to 34%. The absolute number of people with hypertension has almost doubled from 1990 to 2019. High blood pressure is closely related to the autonomic nervous system, as evidenced by short-term heart rate variability (HRV). Short-term HRV is a noninvasive marker of the autonomic regulation of cardiac activity, related to the balance between sympathetic and parasympathetic activity. This is a narrative review on the complex interaction between hypertension and short-term HRV, considering pathophysiological mechanisms, clinical implications, and potential applications in diagnosis and management. Evidence has shown that hypertension is associated with reduced HRV, which means autonomic dysfunction and increased cardiovascular risk. The mechanistic pathways include alterations in increased sympathetic activity, and reduced vagal tone. Decreased HRV has also emerged as a predictor of the development and progression of hypertension, suggesting that it may be a useful biomarker. However, standardization of HRV measurement and interpretation are some of the challenges that have been identified. This review integrates the current knowledge, highlights gaps in understanding, and proposes directions for future research that may help leverage HRV in the management and risk stratification of hypertension.

Keywords- **hypertension, heart rate variability, cardiovascular risk, autonomic function**

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1. INTRODUCTION

Hypertension, a prevalent clinical condition with significant morbidity and mortality rates, characterized by consistently high elevated blood pressure against the walls of blood vessels, with systolic blood pressure at or above 140 mmHg or diastolic blood pressure at or above 90 mmHg [1]. As the global elderly population is growing in numbers so is the rise in cases of hypertension. In 2019, the global age-standardised prevalence of hypertension in adults aged 30–79 years was 32% in females and 34% in males (2). The absolute number of people with hypertension doubled from 331 million females and 317 million males in 1990 to 626 million females and 652 million males in 2019 due to population growth and ageing [2].

In response, scientists are looking for methods to enhance the health of this demographic stratum of society. One commonly used tool for evaluating cardiac autonomic function is heart rate variability (HRV). It measures the fluctuations in the inter-beat intervals among consecutive beats, providing insights into cardiovascular health.

Past and recent research has highlighted the relationship between HRV and hypertension. Understanding this relationship can have substantial implications for clinical practice.

The objectives of the review were to synthesize existing evidence by providing a comprehensive overview of current research findings on the association between HRV and hypertension and to assess the clinical applications of HRV in hypertension management and to understand how the relationship between HRV and hypertension can be utilized in clinical settings for better management and treatment of hypertensive patients.

2. EXPLORING THE NEXUS BETWEEN HRV AND HYPERTENSION

Cardiovascular disease and sudden mortality are more common among anxious people than in the general population. Numerous research has highlighted causes of the same as aberrant pulse rate, inappropriate cardiac response conditioning, high prevalence of arrhythmia, and abnormal blood pressure. Higher HRV is generally associated with better cardiovascular health and increased resilience to stress, while lower HRV indicates a higher level of sympathetic dominance and reduced parasympathetic activity, which may be linked to adverse cardiovascular outcomes.

Researches in the past have shown a relationship between reduced HRV and the presence and severity of hypertension. Reduced HRV has been associated with increased blood pressure and a higher risk of developing hypertension. This suggests that HRV may serve as a useful biomarker for early detection and management of hypertension.

Liao D et al.(1996) in a stratified random sample of 2061 examinees from the biracial Atherosclerosis Risk In Communities (ARIC), a cohort study aimed to relate the cardiac autonomic function measured by HRV with prevalent and incident hypertension was performed. Baseline, supine, resting beat to beat heart rate data were collected. The findings were positive as the reduced vagal function and the imbalance of sympatho-vagal function are associated with the risk of developing hypertension [3].

In a study by Singh et al. (1998) measures of HRV were compared between hypertensive and normotensive subjects and to examine the role of HRV as a predictor of new onset hypertension in 2042 individuals, it was found that HRV is reduced in men and women with systemic hypertension and in normotensives, lower HRV was associated with greater risk for developing hypertension [4].

QT intervals and HRV in hypertensive patients was studied by Kaftan & Kaftan in the year 2000 by measuring cardiac autonomic modulation in 76 essential hypertension cases and 70 healthy cases and found that low HRV and increased QT dispersion are risk factors for cardiac mortality in various patient populations [5].

Schroeder EB et al. (2003) investigated the temporal sequence linking hypertension, blood pressure, and heart rate variability in a population-based cohort of 11061 individuals aged 45 to 54 years at baseline. Individuals with hypertension had decreased heart rate variability at baseline, and this association was present across the full blood pressure range. Among 7099 individuals without hypertension at baseline, low heart rate variability predicted greater risk of incident hypertension over 9 years of follow-up. Findings suggest that there is a decline in HRV relatively early in the development of hypertension, even though the study didn't detect any substantial differences in the rate of change in HRV between hypertensives and normotensives over 9 years. The result also indicates that decreases in autonomic nervous function precede the development of clinical hypertension [6].

Erem C et al. (2009) undertook a study to estimate the prevalence, awareness and control of prehypertension (preHT) and hypertension (HT) as defined by JNC-7 criteria in the Trabzon Region and its associations with demographic factors like age, sex, obesity, marital status, reproductive history in women, education, socioeconomic factors, family history of selected medical conditions like diabetes, hypertension, obesity and cardiovascular disease, lifestyle factors in the adult population were considered in a cross-sectional survey, in the central province of Trabzon and its nine towns. A total of 4809 adult subjects (2601 women and 2208 men) were included in the study. The prevalences of HT and preHT were found to be 44.0% (46.1% in women and 41.6% in men) and 14.5% (12.6% in women and 16.8% in men), respectively. It also revealed that HT were significantly associated with age, male gender, BMI, low education level, nonsmoking, positive family history of selected medical conditions, occupation, and parity. Patients who are unaware of their status and treated uncontrolled hypertensives are at high risk of having early cardiovascular morbidity and mortality [7].

Gudina EK, Michael Y and Assegid S (2013) conducted a hospital-based cross-sectional study to find prevalence of hypertension and its risk factors in southwest Ethiopia on 734 participants aged 15 years or older. They used a pretested structured questionnaire consisting of characteristics related to socio-demographic profiles and risk factors for hypertension for data collection and three separate measurements of blood pressure and relevant anthropometric evaluation were taken according to recommended standards. The mean age of the participants were 42.3 ± 13.2 years and 71.7% of them were 35 years and older; 58% of them were females. The findings showed an overall prevalence of hypertension to be 13.2%. Only 35.1% of them were aware of their hypertension and only 23.7% were on treatment. The overall control rate was 15.5%. Family history of hypertension, having diabetes mellitus, being overweight, and oral contraceptive use were found to be associated with high blood pressure [8].

Gui-Ling X et al. (2013) from China performed a study in First Hospital of Jilin University. A total of 101 children were recruited in this study. They were divided into a high systolic blood pressure (SBP) group (HS group) and normal SBP group (NS group) according to the SBP levels. In the second set of experiments, the children were divided into a high diastolic blood pressure (DBP) group (HD group) and normal DBP group (ND group) according to the DBP levels. They provided evidence that HRV is reduced and the circadian rhythm of HRV is weakened in hypertensive children, and hypothesize that a reduced HRV is a potential pathophysiological mechanism linking childhood hypertension and adulthood cardiovascular diseases [9].

Mori H et al. (2014) through a community based cross sectional study among Japanese men and women aged between 40-74 yrs attempted to find association of HRV and blood pressure levels. 3600 participants (1485 men and 2115 women) were recruited. They found significant associations between decreased HRV levels and increased blood pressure by using the 5-min R-R interval measurement method. An inverse association of HRV with diastolic blood pressure, were concluded even though effect on systolic blood pressure was insignificant [10].

Kishore J, Gupta N, Kohli C, Kumar N (2016) performed a community based cross-sectional study in two rural areas in Delhi to study the prevalence of hypertension and determination of its risk factors among 1005 subjects selected using a systematic random sampling method. WHO STEPS approach was used to collect data and Blood pressure, body mass index, and blood sugar and it was found that the prevalence of hypertension was 14.1% among study subjects. Hypertension was significantly higher in individuals more than 35 years than those less than 35 years and it was significantly higher in those who take alcohol and in subjects with raised total cholesterol level but in analysis only age, education, and cholesterol levels were independently associated with hypertension. It was concluded that there is significant burden of hypertension in rural areas in Delhi and age, education, and cholesterol levels were independent risk factors of hypertension [11].

Singh S, Shankar R, Singh GP (2017) studied the prevalence of hypertension and its associated factors, awareness, treatment, and adequacy of control of hypertension among urban population of Varanasi. It was a community based cross sectional study with multistage sampling consisting a total of 640 study subjects. Out of these, 301 (47%) were male subjects and 339 (53%) were female. The median age (±SD) of the study subjects was 39.0 (±11.9) years. Regarding religion and caste of the study subjects, around 96% subjects were Hindu and majority of the subjects were in general category, respectively. Majority of the study subjects were married and one-third of the subjects belonged to the upper socioeconomic class. Mean (±SD) BMI of the study subjects was 24.11 ± 3.94 kg/m^2; for men it was 23.78 ± 3.95 kg/m^2 and for women it was 24.41 ± 3.92 kg/m^2. According to Body Mass Index (BMI), more than one-third of the study subjects were either overweight or obese. It was found that with regard to abdominal obesity as measured by waist circumference, 40% subjects were at risk of having hypertension [12].

Patnaik L et al. (2017) carried out a study to assess lifestyle pattern and hypertension related knowledge, attitude and practices among diagnosed patients of hypertension attending a tertiary care hospital. Out of 102 participants, 55.9% were males and the mean age was 42.98 + 11.85. The mean systolic *blood pressure* and diastolic *blood pressure* was 146.01+10.59 and 103.7+10.76 respectively. 50% of the patients led a sedentary *life* & only 13.7% were practicing fitness activities daily. The result was in favor of their study [13].

Kim HG et al. (2018) analyzed 24-h electrocardiographic recordings from 33 healthy participants to examine the association between the RR interval, HRV responses, and periodic diary entries measuring physical position, negative affect, and time of day. Their results showed that increases in stress were associated with decreases in the RR interval and psychological stress was significantly associated with an increase in the LF/HF ratio, suggesting increased SNS activity during stressful periods of the day. Using a questionnaire survey and short-term HRV recordings of 223 healthy male white-collar workers, they also investigated the relationship between the number of job stressors, self-reported sleep quality, and daytime autonomic activities. They found that there is no correlation between the HRV parameters and five job stressor scores [14].

There is growing evidence that a range of diseases are accompanied by a decrease in HRV, including, amongst others, diabetes, hypertension and coronary disease. Although indices of HRV do not distinguish between types of disorder, there is a consistent pattern of a reduced variability in HR being associated with disease: a higher HRV is associated with psychological flexibility and allostatic resilience. Indeed, longitudinal studies support the view that reduced HRV predicts psychological and physiological morbidity years later [15-18].

In a study by de Andrade PE (2017) on elderly population, to find a reduction of heart rate variability in hypertensive elderly, a total sample size of 80 elderly people-40 healthy elderly and 40 elderly having high blood pressure was selected and it was concluded that hypertensive elderly patients had decreased heart rate variability and decreased parasympathetic modulation when compared to normotensive elderly [19].

Saito et al. (2018) piloted a study to find relation between Heart Rate Variability and Home Blood Pressure popularly called as The Toon Health Study. They enrolled a total of 1888 participants both men and women in the age group 30-79 yrs. The study was conducted for 3 yrs from 2009 to 2012 by asking the participants to monitor BP at home twice in the morning and evening for 1 week. Initially a casual BP was recorded in the morning during health checkup. It was explored that Low HF and RMSSD, that reflect impaired parasympathetic nervous system activity, were associated with increased home mean arterial pressure in the morning than in the evening [20].

Recently a study was performed by Maciorowska M et al. (2020) to assess the effects of antihypertensive treatment on heart rate variability (HRV) in patients with hypertension (HTN), depending on co-occurrence of Metabolic Syndrome. 118 patients with uncontrolled HTN were enrolled to study. HRV was compared among patients with and without Metabolic Syndrome at baseline and following 12 months antihypertensive treatment. They concluded that HTN control has a beneficial effect on HRV, with the effect being more pronounced in patients with Metabolic Syndrome [21].

3. Conclusion

It is now well understood that HRV is associated with cardiovascular risk and research has indicated that individuals with hypertension tend to have reduced HRV compared to those with normal blood pressure since high BP is associated with increased sympathetic activity and decreased parasympathetic activity. It can be thus be proposed that evaluating HRV would not only facilitate clinicians to quantify hypertension which is at times challenging and also aid in predicting prognosis. Furthermore, such quantification holds potential benefits for the cardiovascular health of patients. To conclude, the observations of the studies narrated in the review suggest that HRV could be a valuable marker for both assessing current hypertension status and predicting its future risk.

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5. Conflicts of Interest

The authors declare that there are no conflicts of interest.

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