Heart Rate Variability and Sympathovagal imbalance in Prehypertensives- The Physiological Perspective

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Abstract- Hypertension (HT) is defined as a rise of arterial BP with, a systolic BP more than 160 mmHg and diastolic BP more than 90 mmHg. It is a preventable risk factor for cardiovascular diseases (CVDs) like coronary artery disease, stroke, peripheral artery disease, cerebrovascular disease, and chronic kidney disease. Studies have shown that 25% of children with one hypertensive parent and 50% of children with both parents being hypertensive eventually develops the condition. HRV measurement and quantification of its spectral components provide powerful information of cardiovascular morbidity and mortality. Studies have shown a decreased RMSSD and increased SDNN post autonomic tests. It can be concluded that offspring of Hypertensive parents tend to have some degree of autonomic imbalance before the actual onset of essential hypertension.

Keywords- Heart Rate Variability, sympathovagal imbalance, Hypertension.

INTRODUCTION

Blood pressure(BP) is defined as the lateral pressure exerted by flowing blood on the wall of blood vessels. BP is expressed in terms of the systolic BP (SBP, maximum pressure), over diastolic BP (DBP, minimum pressure) (1). The normal resting BP in an adult is in range of 100–140 mmHg systolic and 60–90 mmHg diastolic.(2).

Hypertension (HT) is defined as a rise of arterial BP with, a systolic BP more than 160 mmHg and diastolic BP more than 90 mmHg(3). This elevation in BP can be transitory or persistent. HT is a worldwide problem affecting around 333 millions in developed and 639 millions in developing countries (4). It is a preventable risk factor for cardiovascular diseases (CVDs) like coronary artery disease, stroke, peripheral artery disease, cerebrovascular disease, and chronic kidney disease(5). The prevalence of HT is increasing throughout the lifespan of a person though enough strategies of screening, prevention, and treatment are taken (6,7).

Prehypertension---is defined as a systolic pressure from 120–139 millimeters of mercury (mm Hg) or a diastolic pressure from 80–89 mm Hg.

Need of Review- Essential hypertension is a hereditary condition. Positive parental history plays a major role in the development of this condition coupled with the interplay of genes with environmental factors. Studies have shown that 25% of children with one hypertensive parent and 50% of children with both parents being hypertensive eventually develops the condition(8,9). Hypertensinogenic factors like obesity, insulin resistance, salt sensitivity interact with modifiable risk factors like sendentary life style, stress, alcohol consumption etc. which causes expression of HT(10,11). This disease starts with disturbance in the sympathovagal balance which gradually proceeds to sympathetic overactivity and parasympathetic attenuation. (12, 13, 14).

Beat-to-beat fluctuations in heart rate (HR) are determined by activity of the cardiac sympathetic and parasympathetic systems. HRV measurement and quantification of its spectral components provide powerful information of cardiovascular morbidity and mortality.

This review pursues two main issues. First, the role of sympathovagal imbalance in Prehypertensives and the uses of heart rate variability in addressing this issue.

Heart Rate Variability – A Historical Perspective

The fluctuations in heart rate marks a synchrony with respiration (increases during inspiration and decreases during expiration called as respiratory sinus

arrhythmia(RSA)) and this fluctuation reflects changes in cardiac autonomic regulation. Stephen Hales (1733) was the first to note that pulse varied with respiration. In 1847, Carl Ludwig was the first to record RSA. HRV measurement started after advent of digital signal processing techniques in the 1960s.(15).

Heart Rate Variability (HRV)- It is used to determine cardiac autonomic function. The low-frequency component (LF) (0.04 to 0.15 Hz) is predominantly under sympathetic control . High-frequency (HF) (0.15 to 0.40 Hz) component reflects pasympathetic effect. The LF/HF ratio exhibits the index of sympathovagal balance.(16,17).

Time domains- Time-domain indices quantify the amount of HRV observed during monitoring periods that may range from ~2 min to 24 h.

Table 1 HRV time-domain measures

Parameter	Unit	Description
SDNN	ms	Standard deviation of NN intervals
SDRR	ms	Standard deviation of RR intervals
SDANN	ms	Standard deviation of the average NN intervals for each 5 min segment of a 24 h HRV recording
SDNN index (SDNNI)	ms	Mean of the standard deviations of all the NN intervals for each 5 min segment of a 24 h HRV recording
pNN50	%	Percentage of successive RR intervals that differ by more than 50 ms
HR Max − HR Min	bpm	Average difference between the highest and lowest heart rates during each respiratory cycle
RMSSD	ms	Root mean square of successive RR interval differences
HRV triangular index		Integral of the density of the RR interval histogram divided by its height
TINN	ms	Baseline width of the RR interval histogram

Interbeat interval, time interval between successive heartbeats; NN intervals, interbeat intervals from which artifacts have been removed; RR intervals, interbeat intervals between all successive heartbeats. (18).

Frequency domains- Frequency-domain values calculate the absolute or relative amount of signal energy within component bands.

Table 2 HRV frequency-domain measures

Parameter	Unit	Description
ULF power	ms^2	Absolute power of the ultra-low-frequency band (≤0.003 Hz)
VLF power	ms^2	Absolute power of the very-low-frequency band (0.0033–0.04 Hz)
LF peak	Hz	Peak frequency of the low-frequency band (0.04–0.15 Hz)
LF power	ms^2	Absolute power of the low-frequency band (0.04–0.15 Hz)
LF power	nu	Relative power of the low-frequency band (0.04–0.15 Hz) in normal units
LF power	%	Relative power of the low-frequency band (0.04–0.15 Hz)
HF peak	Hz	Peak frequency of the high-frequency band (0.15–0.4 Hz)
HF power	ms^2	Absolute power of the high-frequency band (0.15–0.4 Hz)
HF power	nu	Relative power of the high-frequency band (0.15–0.4 Hz) in normal units
HF power	%	Relative power of the high-frequency band (0.15–0.4 Hz)
LF/HF	%	Ratio of LF-to-HF power (18)

HRV in Hypertension - Recent advances-

In 1996, the Task Force document on heart rate variability (HRV) was published. Standardization document have been more recently tested in appropriately sized populations. New changes have been incorporated in techniques like Entropy, fractal

analysis , Short-term complexity, Long-range correlation and Nonlinear dynamical systems(19).

DISCUSSION

As remarkable decrease in total power of HRV may not be associated with proportionate alterations in LF and HF power, decreased HRV representing poor vagal modulation of cardiac activities could possibly manifest with decreased LF-HF ratio (20).

G. K. Pal et al 2011 in their study on Sympathovagal Imbalance in Prehypertensive Offspring of Two Parents versus One Parent Hypertensive found that the LF-HF ratio of prehypertensive subjects (Groups III and IV) was significantly higher than that of normotensive subjects (Groups I and II) indicating a considerable sympathovagal imbalance (SVI) in prehypertensives as LF-HF ratio is a marker of sympathovagal balance (20,21). A significant finding was obtained in SDNN & LF/HF variable of study group in a study by Dalia et al (22).

Mario Estévez-Báez et al in their study on Influence of Heart Rate, Age, and Gender on Heart Rate Variability in Adolescents and Young Adults found that heart rate produced more significant effects on HRV indices than age or gender(23).

Amrendra Jha et al 2018 in their research on Time and Frequency Domain Analysis of Heart Rate Variability (HRV) In Response to Cold Stress in Subjects with Family History of Hypertension ,found RMSSD was decreased (p value= 0.042) and SDNN was increased (p value= 0.048: borderline) post-CPT in subjects with family history of hypertension, suggesting that some amount autonomic dysfunction is manifested at early age(16).

Unlike our study Chen et al., 2016 found reduction in the ratio of low-frequency power to high-frequency power (the LF/HF ratio) and increment in the normalized high-frequency power (HFnu) during the stress tests(24).

Camm et al., 2004; Muralikrishnan et al., 2011 found that basal LFnu (normalized unit) and LF/HF ratio were significantly higher while the basal HFnu was significantly lower in the study group compared to control group, LF power was significantly increased in the study group. HF power was decreased in the study group(25,26).

CONCLUSION

Studies have shown a decreased RMSSD and increased SDNN post autonomic tests. It can be concluded that offspring of Hypertensive parents tend to have some degree of autonomic imbalance before the actual onset of essential hypertension.

Future direction- This fact should be taken into consideration and appropriate lifestyle modification measures should be incorporated in daily life for such subjects.

REFERENCE

[1] Hodgkinson, J. A., Tucker, K. L., Martin, U., Beesley, L., and McManus, R. J. (2015). The use of ambulatory blood pressure measurement. *Br. J. Hosp. Med. (Lond).* 76, 631–637.

[2] Mancia, G., Fagard, R., Narkiewicz, K., Redon, J., Zanchetti, A., Böhm, M., et al. (2013). 2013 ESH/ESC guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *Eur. Heart. J.* 34, 2159–2219.

[3] Wright, T. A., and Diamond, J. W. (2006). Getting the pulse of your employees: the use of cardiovascular research in better understanding behavior in organizations. *J. Organ. Behav.* 27, 395–401.

[4] Santulli, G. (2013). Epidemiology of cardiovascular disease in the 21st century: updated numbers and updated facts. *J. Cardiovasc. Dis. Res.* 1, 1–2.

[5] Jennings, G. L., and Touyz, R. M. (2013). Hypertension guidelines: more challenges highlighted by Europe. *Hypertension* 62, 660–665.

[6] Hansen, M. L., Gunn, P. W., and Kaelber, D. C. (2007). Underdiagnosis of hypertension in children and adolescents. *JAMA* 298, 874–879.

[7] Floyd, C. N. (2015). Hypertension - state of the art 2015. *Clin. Med. (Lond).* 16, 52–54. doi: 10.7861/clinmedicine.16-1-52.

[8] K Tamilselvan1, N Nirmala2, R Latha3, S G Vijayasri4). Assessment of Autonomic Functions in the Normotensive Offspring of Hypertensive

Parents. *International Journal of Physiology*, January-March 2018, Vol. 6, No. 1.

[9] Veena HC, Itagi V, Takalikar RH, Patil RS. Effect of deep breathing on heart rate variability in normotensive male offspring's of hypertensive parents. *Indian Journal of Applied Basic Medical Sciences.* 2013;15(21):80-8.

[10] Lu N, Yang Y, Wang Y, Liu Y, Fu G, Chen D, Dai H, Fan X, Hui R, Zheng Y. ACE2 gene polymorphism and essential hypertension: an updated meta-analysis involving 11,051 subjects. *Molecular biology reports*. 2012;39(6):6581-9.

[11] Carretero OA, Oparil S. Essential hypertension. *Circulation*. 2000;101(3):329-35.

[12] Puddu P, Puddu GM, Cravero E, Ferrari E, Muscari A. The genetic basis of essential hypertension. *Acta cardiologica*. 2007 ;62(3): 281-93.

[13] Pal GK, Pal P, Nanda N, Lalitha V, Dutta TK, Adithan C. Sympathovagal imbalance in prehypertensive offspring of two parents versus one parent hypertensive. *International journal of hypertension.* 2011 :8.

[14] Rathi P, Agarwal V, Kumar A. Sympathetic hyperactivity in children of hypertensive parents. *Annals of neurosciences*. 2013;20(1):4-6.

[15] George E. Billman· Heart Rate Variability – A Historical Perspective. *Front Physiol.* 2011; 2: 86.

[16] Amrendra Jha et al. Time and Frequency Domain Analysis of Heart Rate Variability (HRV) In Response to Cold Stress in Subjects with Family History of Hypertension. *International Journal of Health Sciences & Research* . March 2018. Vol.8; Issue: 3; 228

[17] Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Standards of measurement, physiological interpretation, and clinical use. *Circulation* 1996; 93: 1043-65

[18] Fred Shaffer and J. P. Ginsberg.An Overview of Heart Rate Variability Metrics and Norms. *Front Public Health.* 2017; 5: 258.

[19] Roberto Sassi, Sergio Cerutti, Federico Lombardi, Marek Malik, Heikki V Huikuri, Chung-Kang Peng, Georg Schmidt, Yoshiharu Yamamoto. *Europace* . 2015 Sep;17(9):1341-53.

[20] Malik, M. (1996). Task force of the European society of cardiology and the north American society of pacing and electrophysiology. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. *Eur Heart J.*, *17*, 354-381.

[21] Malliani, A. (2005). Heart rate variability: from bench to bedside. *European journal of internal medicine*, *16*(1), 12-20.

[22] Dalia Biswas & Prerna Agarwal; Study of Status of Sympathovagal Balance in Offsprings with Family History of Hypertension and in Those without It. *Sch J App Med Sci*, Feb, 2022; 10(2): 253-257.

[23] Estévez-Báez, M., Carricarte-Naranjo, C., Jas-García, J. D., Rodríguez-Ríos, E., Machado, C., Montes-Brown, J., ... & Pié, E. A. (2018). Influence of heart rate, age, and gender on heart rate variability in adolescents and young adults. In *Advances in Medicine and Medical Research*.2018,pp 19-33. Springer, Cham.

[24] Chen, S., Sun, P., Wang, S., Lin, G., & Wang, T. Effects of heart rate variability biofeedback on cardiovascular responses and autonomic sympathovagal modulation following stressor tasks in prehypertensives. *Journal of human hypertension*,2016,*30*(2), 105-111.

[25] Camm, A. J., Pratt, C. M., Schwartz, P. J., Al-Khalidi, H. R., Spyt, M. J., Holroyde, M. J., ... & Brum, J. M. Mortality in patients after a recent myocardial infarction: a randomized, placebo-controlled trial of azimilide using heart rate variability for risk stratification. *Circulation*, 2004,*109*(8), 990-996.

[26] Muralikrishnan, K., Balasubramanian, K., & Rao, B. V. Heart rate variability in normotensive subjects with family history of hypertension. *Indian J Physiol Pharmacol*,2011, *55*(3), 253-61.