Original Research Article

International Physiology
Volume 7 Number 1 January - April 2019
DOI: https://dx.doi.org/10.21088/ip.2347.1506.7119.2

HRV in Wards of Hypertensive Parents During Deep Breathing

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Abstract

Background: Hypertension is one of the most rampant diseases in the world. Many genes are responsible for expression of normal blood pressure. This hints a probable role of family history in the development of hypertension, which we are trying to assess in this study. As BP is regulated by autonomic nervous system (ANS), altered activity of ANS suggestsa greater risk of development of hypertension. ANS is assessed by HRV which is a simple and noninvasive test. HRV represents the total amount of fluctuations in heart rate and R-R interval measured by time domain and frequency domain methods. Deep breathing causes stimulation of parasympathetic system by activating the stretch receptors. Hence HRV during deep breathing gives an idea about the activity of parasympathetic nervous system. *Materials & Methods:* We studied 67 subjects with or without family history of hypertension. BP and HRV of the two groups were compared,during normal breathing and deep breathing. *Results:* Two groups did not show significant discrepancy in BP and HRV at rest. However, HRV by time domain analysis (RMSSD and pNN50) showed a lower value in study group compared to control group in which RMSSD values were significantly less during deep breathing. This indicates that although the recorded BP of offsprings of hypertensive parents show a normal value at rest, they are havinga distorted ANS activity which is not manifested at rest. The low parasympathetic activity present in them became evident by the autonomic excitatory maneuver i.e. deep breathing. *Conclusion:* From this study it is apparentthat the wards of hypertensive parents are more prone to develop hypertension.

Keywords: Blood Pressure; Deep Breathing; Heart Rate Variability.

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Received on: 03.11.2018

Accepted on: 03.12.2018

How to cite this article:

Amrutha Mary Zachariah, Rekha D. Kini, Vinod Jose Kakkanatt et al. HRV in Wards of Hypertensive Parents During Deep Breathing. International Physiology. 2019;7(1):9-14.

Introduction

Hypertension contributes for worldwide burden of disease and disability considerably. Complications associated with hypertension continue to be the one of the leading cause of death in developed as well as developing countries. Many of these complications can be prevented, if not, their onset can be delayed with timely detection, appropriate treatment and life style modification [1,2]. As it remain asymptomatic, early recognition is often a challenge unless we have high index of suspicion.

Therefore the risk factors associated with the development of hypertension is always an area of interest. The role of genetic factors in the development of hypertension is already elucidated [3]. The contribution by many genes have been detected each having small effects in development of hypertension.

Heart rate variability (HRV) is the amount of heart rate fluctuations around the mean heart rate. The term HRV conventionally describes the beat-to-beat fluctuations in the heart rate or the variations in consecutive RR intervals. The HRV is mainly caused by efferent modulations of the sinus node which is considered as the pacemaker of heart. HRV is a valuable tool to investigate sympathetic and parasympathetic function of the Autonomic Nervous System. Also, it should be emphasized that it is a variable that can be measured in a noninvasive manner with minimal error using simple and low-cost equipment. HRV analysis can assess the overall cardiac health and the balance between sympathetic and parasympathetic regulation on cardiac activity. Low HRV reflects reduced parasympathetic activity or elevated sympathetic tone and is considered an important cardiovascular risk factor [4,5].

Most of the various mechanisms involved in regulation of BP acts via the two divisions of autonomic nervous system; the sympathetic and parasympathetic nervous systems. Imbalance in the activity of these systems is considered to be the core cause of hypertension. Parasympathetic system is more involved than the sympathetic system in subjects with newly diagnosed essential hypertension. The decreased parasympathetic tone in hypertension is associated with increased sympathetic tone.

Controlled slow, deep inhalation produces stimulation of parasympathetic system. Chang et al. [6] assessed the Influence of respiratory rate on autonomic nervous system using time domain and frequency domain methods and found an increase in vagal activityduring slow breathing. An augmented vagal activity was reported in slow breathing by Zhang et al. [7]. who compared effect of slow, medium and fast breathingon ANS using time domain analysis. The key role in the stimulation of vagus nerve during deep breathing is played by the central respiratory centres where inputs from stretch receptors and reflex mechanisms converge. Although the central respiratory centres has control over both sympathetic and parasympathetic branches of ANS, effect on parasympathetic system is more prominent. There is increased output from stretch receptors during deep inhalation resulting in stimulation of parasympathetic system by the central respiratory centres.

As genes contribute towards development of hypertension, parental history can have an influence on hypertension. HRV during deep breathing may be able to detect the possible altered autonomic system activity and thus their inclination to develop hypertension in those persons.

Materials and Methods

The present study was a cross sectional study conducted in young adults of age group 17-20 years. Institutional ethics committee approval was obtained and subjects were recruited based on inclusion and exclusion criteria.

Inclusion criteria:

1. Young adults in the age group of 17-20 years
2. Non–smokers
3. Normal BMI (18.5-24.9 kg/m2)
4. Non-alcoholics

Exclusion criteria:

1. Any recent illness during the past two week
2. Diabetes Mellitus
3. Known hypertensive
4. History of chest pain, breathlessness, orthopnea
5. Cardiac patients
6. Females with irregular menstrual cycle

The procedure was explained to the subjects in detail. They were divided into two groups; study group (children of hypertensive parents) and control group(children of normotensive parents). A written informed consent was obtained on the day of the experiment.

A detailed relevant clinical history including menstrual history from female subjects was obtained. This was followed by a brief general physical examination, examination of vital signs and a complete systemic examination.

The height (in meters), weight (in kg) were noted and Body Mass Index (BMI) was calculated. After the basic examination the subjects were asked to lie down calmly and relax in supine position. Pulse rate and BP were measured after five minutes of rest in supine position. The recording of BP was done using mercury sphygmomanometer with appropriately sized cuffs by indirect method (Riva Rocci method). ECG was recorded for five minutes, in the base line condition when the subjects were breathing normally. This was followed byrecording during deep breathing for one minute. The tests were carried out in the follicular phase (day 4 to day 14 of menstrual cycle) in females to avoid influence of menstrual cycle in HRV.

Deep Breathing Test

1 to 5 Counts were given in each 5 seconds and the subjects were instructed to inspire deeply in the first five seconds followed by expiration in the next five seconds. This is repeated for one minute. Thus the test was given during six respiratory cycles in each subject

Assesment of HRV

ECG was recorded from limb lead II using BPL ECG machine and analogue output from the machine was digitalized by A/D converter from National Instruments, Bangalore

HRV analysis of the subjects were done as per the task force guidelines. The HRV was analyzed using Digital Data acquisition system HRV soft 1.1 Version, AIIMS, New Delhi. Both time domain and frequency domain analysis were done. In time domain analysis pNN50 (percentage of NN50) and RMSSD (root of mean of squared successive R-R interval difference) were done. In frequency domain low frequency in normalized units (LF), high frequency in normalized units (HF) and LF/HF were assessed.

Statistical Analysis of Data

The collected data were entered into MS Excel & analysis was be done by using SPSS (Statistical Package for Social Sciences) version 11.5.

The outcome variables included the mean scores of BP and heart rate variability at baseline condition and following deep breathing in subjects with and without family history of hypertension. Statistical tests included student's unpaired t test and Mann Whitney U test is used for nonparametric data. P-value was taken as statistically significant at 5 percent confidence level ($p<0.05$).

Results

Study group included 30 subjects and control group 37 subjects.There were 15 males and 22 females in the control group and 12 males and 18 femalesin the study group. Results are expressed as mean ± standard deviation. NS (non-significant) when study group was compared with control group. $p < 0.05$ is taken as statistically significant.

Demographic characteristics of control and study group are presented in Table 1. The two groups did not differ significantly in age, weight or body mass index when tested using student's unpaired t test.

Table 1: Demographic characteristics of control and study group.

Parameter	Control Group	Study Group
Age	18.38 ± 0.89	18.23 ± 1.13
Weight (Kg)	54.91 ± 7.31	53.63 ± 6.51
Body mass index	21.91 ± 1.83	20.57 ± 1.97

NS-Not significant

Blood pressure response in control and study group.

The systolic blood pressure (SBP) and diastolic blood pressure (DBP) during normal breathing and deep breathing did not vary significantly between the control and study groups (Table 2). Statistical test used is student's unpaired t test.

Table 2: Blood pressure response during normal breathing and deep breathing in control and study groups

	Group	Systolic BP	Diastolic BP
Normal Breathing	Control	112.70 ± 5.29	69.89 ± 5.44
	Study	113.07 ± 5.53^{NS}	72.27 ± 5.72^{NS}
Deep Breathing	Control	111.78 ± 5.70	70.33 ±5.32
	Study	109 ± 4.56^{NS}	71.05 ± 6.30^{NS}

NS-Not significant

HRV of control and study groups

A. Time domain analysis

Table 3: Time domain analysis of control and study group during normal breathing and deep breathing

Parameter	Group	pNN 50	RMSSD
Normal Breathing	Control	34.16 ± 16.41	74.80 ± 38.09
	Study	30.60 ± 14.24^{NS}	70.13 ± 33.20^{NS}
Deep Breathing	Control	31.91 ± 22.98	63.89 ± 49.17
	Study	26.12 ± 25.97^{NS}	49.12 ± 40.35*

pNN50 - Percentage of NN50, RMSSD-square root of the mean squared differences of successive NN intervals, NS-Not significant,*-significant (p=0.05)

Table 3 summarizes time domain analysis of control and study group during normal breathing and deep breathing. During deep breathing RMSSD (square root of the mean squared differences of successive NN intervals) of control and study group were 63.89 ± 49.17 and 49.12 ± 40.35 respectively. This showed a significant difference between study group and control group ($p<0.05$). Percentage of NN50 (pNN50) were 31.91 ± 22.98 in control and 26.12 ± 25.97 in study group which did not show any significant difference. Statistical test used is Mann Whitney U test for both variables.

B. Frequency domain analysis.

Table 4: Frequency domain analysis of control and study group during normal breathing and deep breathing

Parameter	Group	LF (normalized power)	HF (normalized power)	LF/HF
Normal Breathing	Control	55.50 ± 20.15	44.50 ± 20.15	2.85 ± 5.10
	Study	62.27 ± 22.06[NS]	37.72 ± 22.05[NS]	3.12 ± 4.33[NS]
Deep Breathing	Control	83.56 ± 12.22	16.44 ± 12.22	7.89 ± 5.55
	Study	86.77 ± 11.33[NS]	13.23 ± 11.33[NS]	10.79 ±7.93[NS]

LF –low frequency, HF –high frequency, NS-Not significant

Table 4 comprises frequency domain analysis of study group and control group during normal breathing and deep breathing. We did not get any significant difference between study and control groups in both the above parameters when tested using Mann Whitney U test.

Discussion

Measurement of heart rate variability (HRV) has become a hot issue in the field of medicine for the past few years. Originally this technique was promoted by well-known clinicians and physiologists who reported that HRV gave insights into sympatho-vagal balance in autonomic outflow. [8,9] This led to it being applied as a non-invasive indicator of cardiac autonomic tone. Impaired HRV has been shown to be an important predictor of serious arrhythmic events and of sudden death after myocardial infarction [10,11]. The current study extends the observations on heart rate variability to predict whether the children of hypertensive parents are more inclined to develop hypertension and associated complications in the future. In this study hypertension was defined based on hypertension in only one of two parents.

In our study the demographic characteristics of the study and control groups were well harmonized .We made it certain that these subjects did not differ significantly in age, weight and BMI since all these factors are known to affect HRV.

These subject’s BP and HRV were analyzed during normal breathing condition (basal state), deep breathing condition (to assess the vagal activity).

BP response and HRV in normal breathing

In our study there was no statistically significant difference observed in SBP and DBP between study and control group in normal breathing.

A study conducted by Sonia Garg et al in 200 subjects showed a similar result [12]. Comparable results were reported by Verma et al. [13]. This is in accordance with the study conducted byPreeti Rathi et al which showed resting HR, systolic and diastolic blood pressures did not vary between two groups [14].

However, there are few studies which have shown that subjects with family history of hypertension had displayed a difference in BP from those without the parental difference at rest [15]. This may be probably due to the use of much smaller sample size in their studies.

In our study subjects with family history of hypertension had not shown a difference from those without the parental history in parasympathetic tone during normal breathing. Studies have shown reduced HRV in new onset hypertension [16,17]. But the autonomic imbalance is not found in prehypertensive states when assessed at basal conditions [18]. Perhaps the decrease in vagal tone seen in essential hypertensive subjectsdevelops as a consequence of high blood pressure rather than as a precursor to the disease.

Blood pressure and HRV in deep breathing

The deep metronomic breathing test is one of the most used autonomic tests that attempts to standardize respiratory changes and their relation to heart rate, hence to vagal activity. The deep breathing test elicits the typical modulation of blood pressure by respiration and particularly marked changes in R–R intervals. Deep breathing causes activation of parasympathetic system.

Deep breathing exercises are found to be effective in reducing BP in established hypertension [19,20].

In the present study time domain analysis of HRV during deep breathing showed a statistically significant difference in RMSSD value ($p<0.05$) when study group was compared with control group. pNN50 which is another variable in time domain method was also less in the study group although it did not reach a statistically significant level. Previous studies have shown that pNN50 and RMSSD primarily reflect parasympathetic activity [21] and RMSSD has better statistical properties compared to pNN50 [22]. Hence, the result of current study represent the reduced parasympathetic activity in those with a parental history of hypertension, evoked by vagal excitatory maneuver i.e deep breathing.

In the frequency domain method,efferent vagal activity is a major contributor of the High frequency component as seen in clinical and experimental observations of autonomic nervous system [21,22]. The LF component is considered by some as a marker of sympathetic modulation (especially when expressed it as normalized units) [21] and by others as a parameter that includes both sympathetic and parasympathetic influences [22]. Studies have shown that normotensives with a family history of hypertension exhibit altered sympathovagal balance with decreased parasympathetic activity and hence decreased heart rate variability at the cardiac level [18,23].

In accordance with these studies, we also got a high LF which represented sympathetic activity, low HF which represented parasympathetic activity and high LF/HF ratio which is considered by some to mirror sympatho vagal balance in the study group with respect to control group although these values did not exhibit statistically significant difference. Long term recording of Frequency domain variables often show strong correlations [24]. Therefore statistically insignificant result of present study might have resulted from short term recording. Further studies with long term recording may be able to bring out the difference between two groups. Also deep breathing practiced for longer period has a greater influence on ANS. Hence researches in such a group may yield more clear-cut results.

Conclusion

We found that non hypertensive subjects with positive family history of hypertension were characterized by altered balance between the sympathetic and parasympathetic nervous system which was not present at rest. Such an altered response could be an early marker for subsequent development of primary hypertension in the future.

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