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A COMPARATIVE STUDY OF ARTERIAL STIFFNESS INDICES BETWEEN SUBJECTS WITH POSITIVE AND NEGATIVE FAMILY HISTORY OF HYPERTENSION

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ABSTRACT

BACKGROUND: Family history of hypertension is one of the primary predictor of high blood pressure (BP). Family history represents the integration of shared genomic and environmental risk factors. This suggests that early detection of arterial changes for those at risk might be a practical and useful way to target interventions and disease prevention. **AIM:** To find out the trend in increase of blood pressure and early changes in arterial elasticity in young individuals with family history of hypertension. **METHOD:** A total of 100 normotensive healthy individuals (aged 20 to 30 years, both gender) were divided into two groups. Group I (50 subjects) with a family history of hypertension and group II (50 subjects) without a family history of hypertension. After a detailed history, the subject's anthropometric and blood pressures were measured. Both the groups underwent arterial stiffness index measurement with the help of finger photo pulse plethysmography. **RESULT:** There were no significant differences in both the groups in regard to systolic and diastolic blood pressure. However when arterial stiffness index and reflection index were analyzed, p value was significant in group I subjects (p=< 0.000). The results were statistically analyzed by using SPSS Software version 17.0 . **CONCLUSION:** In comparison with group II controls, normotensive offspring of hypertensive parents had slight increase in BP and impaired arterial properties, namely large and small arterial compliance. Alteration in arterial function in young non-hypertensive subjects may be a risk factor for hypertension and may contribute to the progression to hypertension in later life.

Key words: positive family history of hypertension, finger photo pulse plethysmography, arterial stiffness index, reflection index.

INTRODUCTION

Cardiovascular disease remains one of the biggest causes of mortality in the world, accounting for 29.3% of deaths recorded in the WHO's report in 2004.[1] The recent years have therefore seen a focus in developing techniques to facilitate early identification of individuals at increased cardiovascular risk. Familial aggregation has been shown to occur for hypertension, myocardial infarction, diabetes and obesity. In fact hypertension in adults may be preceded by high blood pressure values in childhood.[2] Several studies show that many of the changes in vascular structure and function occur before the onset of increased blood pressure and may be even responsible for its subsequent rise.[3] Early identification and treatment of these changes and treatment directed towards the hemodynamic and non hemodynamic mechanisms of the disease, before the increase of BP, may offer a better chance of reversing the process, more effectively reducing the morbidity and mortality rates.[4]

There has been much interest in arterial stiffness measurement as a method of detecting cardiovascular changes before the onset of established cardiovascular disease. Indeed, arterial stiffness is now recognized as an independent and significant predictor of cardiovascular morbidity and mortality and its application to everyday clinical practice appears inevitable.[5]

Finger photo pulse plethysmography with the Pulse Trace system is a portable, operator independent, reproducible and simple method of measuring arterial stiffness. It provides two indices of arterial stiffness: Stiffness index(SI), which is a measure of large arterial stiffness, and reflection index (RI), a measure of small to medium-sized arterial stiffness. Increased arterial stiffness is a marker of cardiovascular damage, even in the absence of

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clinically apparent disease. It is an established predictor of cardiovascular morbidity and mortality, and is, itself, implicated in the development of cardiovascular disease.[6]

The pulse wave (PW) is a complex physiological phenomenon observed and detected in circulation.[7] In the course of heart systole a certain amount of blood is ejected and it is moved into the arteries because of transformation between kinetic and potential energy of each segment of ejected blood. On each artery or venous section affected by a pulse wave, three coherent phenomena can be observed: blood flow (flow pulse), the increase of blood pressure (pressure pulse) and extension of transverse profile (profile or volume pulse). Several invasive methods are available to detect the PW. Arterial stiffness can be assessed noninvasively with the use of pulse wave velocity (PWV) measurement, i.e., the velocity the pulse wave to travel a given distance between 2 sites of the arterial system.

The PW contour varies in different parts of the circulation. It depends on physiological or pathophysiological conditions of the organism. The pathological events like arteriosclerosis or diabetes have a great primary effect on the arterial elasticity.[8] Hypertension or some heart diseases influence the PW velocity. Increased arterial stiffness is an important marker of arteriosclerosis, which is the main cause of cardiovascular mortality in developed countries. The arterial wall progressively loses elasticity and becomes rigid as age advances. Hypertension and other diseases like diabetes mellitus accelerate this process. The increase in arterial wall stiffness is noticeable from the beginning of the arteriosclerosis, before anatomical changes and clinical manifestations are observed.[9]

The relationship between arterial stiffness and predicted cardiovascular mortality has not been conducted previously with a non-invasive and inexpensive tool like finger photo pulse plethysmography in this geographical region. Hence, we studied a group of healthy individuals and measured their arterial stiffness by finger photo pulse plethysmography. The goal of our study was (1) to evaluate whether young healthy individuals with a positive familial history of hypertension have arterial wall changes at early age (2) whether these changes were reflected in terms of Arterial Stiffness Index & Reflection Index (3) and to compare these changes with the controls, that is, young healthy individuals without a family history of hypertension.

Methods

A cross-sectional randomized controlled trial was conducted on a total of 100 healthy normotensive adults in the age group of 20-30 years of both genders. The study period was of six months from Jan 2013 to May 2013. The participants were recruited from residents in and around the VMKV Medical College, Salem. Informed written consent was obtained from all participants. Ethical clearance was obtained from the Institution Ethics Committee.

Subjects:

The subjects were categorized into two groups:

Group I - Consisting of 50 individuals in age group of 20-30 years both genders with a positive family history of hypertension.

Group II - Consisting of 50 individuals, in age group of 20-30 years both genders with a negative family history of hypertension constituted the control group.

The study group was explained about the purpose of the study and a informed written consent was obtained. Using a preset questionnaire, those with history of obesity, hypertension, diabetes mellitus, cardiovascular diseases and any peripheral vascular diseases were excluded from the study. The subjects were matched across age (20-30 years) and sex. A personal history of smoking or other addictions and dietary habits was also obtained.

Demographic, anthropometric, clinical parameters were analyzed. The demographic, anthropometric parameters included gender, age in years, weight in kilograms (kg), height in meters (m) and body mass index (BMI) was also calculated. The clinical parameters included were blood pressure and arterial stiffness measurement.

Blood Pressure Measurement

Blood pressure was measured over the brachial artery of the right arm in the sitting position using a cuff-appropriate manual syphgmomanometer. Three measurements were taken after 15 minutes' rest. The mean of the three consecutive measurements was calculated and used for analysis.

Measurement of arterial stiffness

Arterial stiffness was measured in a sitting position after 15 minutes' rest, using the finger photo pulse plethysmography Pulse Trace system. A digital photoplethysmography transmitting infra-red light was applied to the left index finger. The amount of light transmitted through the finger varies proportionally to changes in its blood volume. The signal from the photoplethysmography obtained over a 30 second period is averaged by the system, to produce a single digital volume pulse (DVP) waveform (Figure 1).

The DVP wave (Figure 1) consists of an early systolic peak (a), which results from an increase in digital blood volume from a pressure wave transmitted from the left ventricle to the finger along a direct path. The second peak (b), occurs in diastole, and is formed by pressure waves reflected back up to the aorta and thence to the finger, from sites of impedance mismatch in the lower body. The time between the systolic and diastolic peaks (transit time) can be used to infer the time taken for the pressure wave to travel from the aorta to the lower body, and thence as a reflected wave back up to the aorta to the finger. This path length is proportional to the subject's height (*h*). An index of large arterial stiffness (stiffness index, SI) can therefore be derived, similar to the calculation of pulse wave velocity (PWV) by the formula: *h*/*Transit time*. Indeed, stiffness index (SI) has been shown to be strongly correlated to central (aortic and carotid-femoral) PWV. An index of small to medium-sized arterial stiffness can be derived from the magnitude of the reflected waves from the lower limbs to the aorta. The reflection index (RI) is thus measured using: b/a x 100%. The Pulse Trace system analyzes the average DVP waveform, and gives absolute values of SI and RI, based on the entered subject's height.[10]

1) Arterial Stiffness Index = Patients Height (h)/ Transit time (ΔT_{DVP})

[Transit time(ΔT_{DVP}) → Time delay between systolic peak & Diastolic peak]

2) Reflection Index = Magnitude of Diastolic peak / Magnitude of Systolic Peak

Statistical Analysis:

The data thus generated were administered in the MS excel spread sheet. Student unpaired 't' test at 5% level of significance was used. All analysis was done using SPSS17.0.

Results:

Baseline Characteristics

A total of 100 subjects met inclusion criteria. Group I consisted of 50 normotensive subjects with positive family history of hypertension and group II consisted of 50 normotensive subjects with a negative family history of hypertension in the age group of 20 to 30 years of both genders were taken.

Table 1. shows the basic statistical characteristics of the overall studied sample of 100 healthy adults (20-30 years of age) with the mean values and standard deviations of all anthropometric and physiological variables viz age, weight, height, body mass index, systolic blood pressure, diastolic blood pressure respectively

In table 2 on statistical analysis it was observed that higher value of systolic blood pressure and diastolic blood pressure was not significant between group I and group II. The mean difference of increase in BMI was more significant ($p<0.01$) between group I and group II ($p<0.05$).

In table 3 on statistical analysis, it was observed that there is an increase in arterial stiffness index and reflection index in Group I and this increase was found to be statistically highly significant.

Figure-1 : Digital Volume Pulse Wave
(a) Systolic Peak
(b) Diastolic Peak
Transit time [Time delay between (a) & (b)]

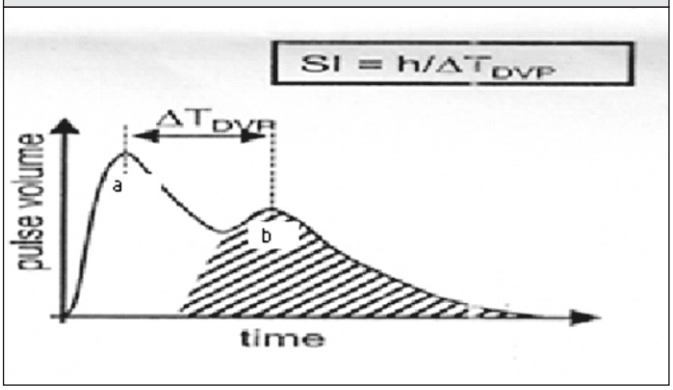

Table 1. Basic Statistical Characteristics of the studied sample of 100 healthy adults (20-30 yrs) of Salem city. (Mean values and standard deviation)

Anthropometric and Physiological variables	Group I (n=50) Mean±SD	Group II (n=50) Mean±SD
Age (Years)	22.06±1.98	22.11±2.44
Weight (Kg)	59.43±12.12	57.38±9.88
Height (cm)	165.96 ±8.12	161.84 ±8.37
Body Mass Index (Kg/m2)	22.61±3.65	20.76±2.68
Systolic Blood Pressure (mm of mercury)	114.82±11.67	111.42±11.04
Diastolic Blood Pressure (mm of mercury)	76.04 ±7.32	73.66±7.21

Table 2. Statistical analysis for comparison between groups according to mean difference of anthropometric and physiological variables.

Anthropometric and Physiological variables	Mean difference	P value
Systolic Blood Pressure (mm of mercury)	3.400	0.133^{NS}
Diastolic Blood Pressure (mm of mercury)	2.380	0.068^{NS}
Body Mass Index (Kg/m2)	1.851	0.001**

NS; p > 0.05; Not Significant; *p < 0.05; Significant at 5% significance level;
**p < 0.01; more Significant at 1% significance level; ***p < 0.001; Highly Significant

Table 3 Statistical analysis for comparison between groups according to mean difference of pulse pressure variables.

Pulse pressure variables	Group I	Group II	p- value
Arterial stiffness index (meter/sec)	53.186 ± 2.5009	49.492 ± 4.1575	<0.000
Reflection index (%)	0.4793 ± 0.00554	0.4725 ± 0.00977	<0.000

p = < 0.001***
NS; p > 0.05; Not Significant; *p < 0.05; Significant at 5% significance level;
**p < 0.01; more Significant at 1% significance level; ***p < 0.001; Highly Significant

DISCUSSION

Currently, hypertension has been recognized as a systemic disease affecting multiple organs and systems, including the arteries and the heart. In these, the abnormalities observed include endothelial dysfunction, reduced arterial elasticity and changes in structure and thickness of the arterial wall and left ventricle.[11]

The ability to identify alterations in structure and function of the vasculature due to adverse anthropometric, hemodynamic, and metabolic factors is crucial to cardio vascular risk assessment at a preclinical stage. The earliest change in the structure and function of the vasculature involves a diminution in the amplitude and duration of the pressure waveform that interrupts the decay of diastolic wave. This change reflects a change in the stiffness or compliance characteristics of the arterial blood vessels. So changes in the pressure pulse waveform have been well described before significant augmentation of BP becomes apparent.[12]

The anthropometric parameters considered in the study were height in cm, weight in kg and body mass index. In accordance with other studies,[13] comparing BMI parameters in group I and group II, the present study too shows that group I has higher values of BMI than group II. This shows increased Body Mass Index is a positive risk factor in developing hypertension in future.

Much attention has been directed to the behavior of arteries, their intrinsic mechanical, neural and hormonal

endothelium-dependent properties, due to their participation in the genesis of hypertension and in the consequences of hypertension on them.[14] Hence the great interest of many researchers in the study of arterial stiffness through various methods, including the analysis of pulse wave velocity (PWV).

Vascular stiffening, however, is a complex phenomenon involving structural and cellular elements of the vessel wall. Although it is independently associated with cardiovascular morbidity and mortality, this effect is not mutually exclusive of intrinsic factors such as an individual's age, gender and race. Shirakawa et al. suggested that a family history of hypertension had an additive impact on the age-associated increase in the risk of hypertension.[15] Tozawa et al. showed that the greater the number of family members with hypertension was, the greater the prevalence of hypertension and BP in the probands, independent of conventional risk factors for hypertension.[16]

In our study, we found that there is a significant change in arterial stiffness index and reflection index in group I subjects in comparison to group II subjects though both the groups had a normal SBP and DBP. Grey et al. reported that reduced small artery elasticity, as a measure of endothelial dysfunction, is significantly associated with CV events independent of age.[17] Another study showed that small arterial compliance may correlate closely with BP.[18] The adverse associations of age and hemodynamic factors with arterial changes are associated with endothelial dysfunction, a characteristic feature of aging, hypertension and atherosclerosis.

Because our study was cross-sectional, the question of cause and consequence cannot be answered from our data. However, it adds to the longitudinal studies because it suggests that increased BP and increased arterial stiffness in parallel in hypertensive families.[19] This might be caused by genetic factors, shared environmental influences, or interaction thereof. Not only does the occurrence of two hypertensive parents increase the genetic component of elevated BP in offspring, but a shared environment (health habits inducive to hypertension) could further increase a child's tendency to become hypertensive.[20]

In this context, several studies have focused on the analysis of these factors in younger age groups. The Bogalusa study evaluated genetic and environmental cardiovascular risk factors in childhood and their contribution to the development of established disease in adulthood.[21] They found a strong association between them. In Brazil, the study of Rio de Janeiro, has shown that the presence of cardiovascular risk factors occurs since the early stages of life and progresses with strong familial aggregation, pointing to a scenario of great preventive potential.[22]

Several studies show that many of the changes in vascular structure and function occur before the onset of increased blood pressure and may be even responsible for its subsequent rise.[23] Early identification and treatment of these changes and treatment directed towards the hemodynamic and non hemodynamic mechanisms of the disease, before the increase of BP, may offer a better chance of reversing the process, more effectively reducing the morbidity and mortality rates.

CONCLUSION

The various basic and derived indices showed changes in apparently healthy adult offspring's of the parents having hypertension. BMI, stiffness index and reflection index gave important inferences by showing increasing values in predicting the onset of this chronic disease in healthy adults in their later life if family history happened to be positive. They should be advised to do regular exercise to control their weight and avoid obesity and also educate them to abstain from taking junk and oily food and motivate them for regular monitoring of their blood pressure. This sincere effort if taken will help them to live a healthy active life and can postpone the chronic disease hypertension.

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