National Journal of Basic Medical Sciences ORIGINAL ARTICLE Volume - IV, Issue-3

A COMPARATIVE STUDY OF ARTERIAL STIFFNESS INDICES BETWEEN NORMOTENSIVE AND HYPERTENSIVE SUBJECTS

G. Sivagami[1], Milind V Bhutkar[2]

ABSTRACT

Background: Cardiovascular disease remains the leading cause of death worldwide. Uncontrolled hypertension places patients at significant risk of complications including coronary artery disease, cerebrovascular disease and cardiovascular death. Arterial stiffness is recognized as an important determinant of outcome in hypertensive population. Arterial stiffness can be measured from stiffness indices by digital volume pulse (DVP) wave recording. **Aim and Objective:** To compare the arterial stiffness indices (stiffness index [SI] and reflection index [RI]) of DVP between normal and hypertensive patients. **Materials and Methods:** A study was conducted in 50 normal subjects (control group)and 50 hypertensive patients (study group)within the age group of 40-60 years. After a detailed history, baseline parameters were measured. DVP was recorded and Arterial stiffness Indices were measured from DVP in both the groups. **Results:** There was significant ($P < 0.001$)increase in both SI and RI in hypertensive patients when compared to normotensive subjects. The results were statistically analyzed by using SPSS Software version 17.0. **Conclusion:** By using noninvasive and cost effective method of arterial stiffness indices by finger photo pulse plethysmography, we can predict the vascular complications of hypertensive patients.

Key words: Digital volume pulse, Finger photo pulse plethysmography, Reflection index, Stiffness index

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of mortality and disability worldwide, accounting for 29.3% of deaths recorded in the World Health Organisation's report in 2004.[1] Increased arterial stiffness is one of the independent, significant and an established risk factor for CVD and provides prognostic information above and beyond traditional risk factors for CVD.[2-4] Even though diabetes mellitus, hypertension, smoking are the direct predictors of CVD, they are independent and indirect factors of increased arterial stiffness also. Stiffness of large arteries also influences the contour of the peripheral pulse. So recording of peripheral pulse wave or digital volume pulse (DVP)gives the idea about large artery stiffness.

In previous studies, large artery stiffness was determined by pulse wave velocity. Even though Pulse wave velocity is standard method, it is difficult method. But the recording of peripheral pulse wave or DVP is an easy and convenient method. It gives the two indices; one is stiffness index (SI) which is a measure of large arterial stiffness, another one is reflection index (RI), a measure of small to medium-sized arterial stiffness.[5]

In present study arterial stiffness indices were calculated from DVP recording in normotensive and hypertensive subjects and it was compared between the normotensive group and hypertensive group.

MATERIALS AND METHODS

The study was carried out in normal subjects (control group)and hypertensive patients (study group). The control group comprised of 50 normal healthy subjects with in the age group of 40-60 years. The study group comprised of 50 hypertensive patients with blood pressure >140/90 mmHg who were under irregular treatment and their hypertension duration was 4-6 years.

Institutional ethical committee clearance was obtained. The subjects were selected by a detailed history and thorough physical examination. Written informed consent was taken from all the subjects involved in the study.

Subjects with H/O diabetes mellitus, smoking, cardio vascular disease peripheral vascular disease, alcoholism, on any drug treatment were excluded from the study.

Subject's height (in centimeters)and weight (in kilograms) was measured. Body mass index was matched between normotensives and hypertensives. Systolic and diastolic blood pressure was measured over the brachial artery of the right arm in sitting position after 5 min of rest by using mercury sphygmomanometer. Three measurements were taken. The mean of the three consecutive measurements was calculated and used for analysis.

[1]Postgraduate Student, [2]Professor and Head, Department of Physiology, Vinayaka Mission K V Medical College, Salem.

Recording of digital volume pulse

Digital volume pulse was recorded by instrument known as finger photoplethysmography, using infra-red light with wave length of 940 nm; placed on the right index finger of the subjects. The signal from the instrument was digitalized by digital converter with a frequency of 100 Hz; which was connected to the computer. DVP recording was done with the help of software virtual oscilloscope which was provided by national instrument which can be freely distributed for academic purpose.

Digital volume pulse contains 2 peaks [Figure 1]:
1. Systolic peak
2. Diastolic peak

Early systolic peak is formed by pulse wave transmitted from the left ventricle to the finger directly. Second peak or diastolic peak arises from pulse wave transmitted along the aorta to the small arteries in the lower body, from where they are again reflected along the aorta as a reflected wave. This path length is proportional to the subject's height (h).

The time delay between systolic peak and diastolic peak is called pulse transit time (PTT or ΔT). It was measured by software image tool (which was provided by Stanford University). Magnitude of systolic and diastolic peak were also measured by same software. SI is based on the subject's height.[6] SI and RI were calculated by the following formulas.

$$\text{Stiffness index } (SI_{DVP}) = \frac{\text{Subject's height (h)}}{\text{Pluse transit time } (\Delta T)}$$

$$\text{Reflection index}(RI) = \frac{\text{Magnitude of diastolic peak}(b) \times 100}{\text{Magnitude of systolic peak}(a)}$$

Statistical analysis

Statistical analysis was performed by Student's unpaired *t*-test. *P* <0.05 were considered as significant. Results were expressed as mean ± SD. All analysis was done using SPSS17.0.

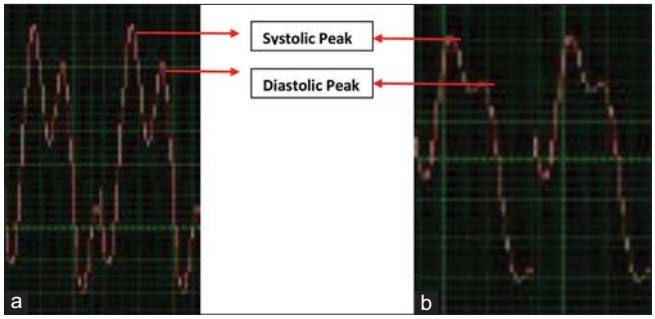

Figure 1: (a) Digital volume pulse (DVP) recording of normal subjects. (b) DVP recording of hypertensive patients

RESULTS

Table 1 shows the statistical analysis of baseline parameters of age, weight, height, body mass index in both groups (control and study group)with the mean values and standard deviations.

Table 2 shows the arterial stiffness indices of both groups (control and study group)with the mean values and standard deviations

Increased SI in hypertensive patients (11.77 ± 0.85)when compared to normotensive subjects (5.68 ± 0.27)which is statistically significant (*P* < 0.001).

Statistically significant (*P* < 0.001)increase of RI in hypertensive patients (81 ± 0.06)than in normotensive subjects (48 ± 0.09).

DISCUSSION

A number of noninvasive and invasive methods are available for measuring the large artery stiffness. Measurement of stiffness indices is one of the noninvasive method, previously it was studied in different age groups. Millasseau *et al*. have shown that measurement of stiffness indices in different age groups

Table 1: Statistical analysis of baseline parameters of control and study group

Baseline parameters	Control group (normotensives) (*n*=50)	Study group (hypertensives) (*n*=50)
Age (Years)	51.34±5.27	52.92±4.48
Height (cm)	154.08±6.24	157.44±7.30
Weight (Kg)	55.4±4.94	57.12±5.01
BMI (Kg/m^2)	23.14±1.50	23.34±1.40
Systolic blood pressure (mmHg)	128.82±8.52	146.42±8.04
Diastolic blood pressure (mmHg)	82.42±7.03	94.66±7.21

BMI: Body mass index

Table 2: Arterial stiffness indices of control and study group

Parameters	Control group (normotensives) (*n*=50)	Study group (hypertensives) (*n*=50)	*P* value
Stiffness index (m/s)	5.68±0.27	11.77±0.85	<0.001
Reflection index (%)	48±0.09	81±0.06	<0.001

by using finger photo plethysmography having equal value of Pulse wave velocity measurement.[5] Millasseau *et al*. have concluded in their study that, in healthy men SI may be a better index of vascular aging and RI may be a more reliable index of the effects of vasoactive drugs.[7]

Our study was carried out in hypertensive patients. Because hypertension is one of the risk factor for increased arterial stiffness. There was a significant increase in SI and RI in hypertensive patients when compared to normotensive subjects. These findings are in agreement with the previous studies.

Hypertension causes decrease in arterial elasticity[8] due to sclerotic changes and endothelial dysfunction. Grey *et al*. reported that reduced small artery elasticity, as a measure of endothelial dysfunction.[9] Sclerotic changes cause thickening of arterial walls. So the arteries become rigid and the waves will move faster through the rigid arteries. This causes decrease in PTT. When PTT decreases, that will cause increase in SI. Because SI is inversely proportional to transit time.

In DVP of hypertensive patients, increase in magnitude of diastolic peak causes increase in RI.

Nichols have reported in their study that small arterial compliance may correlate closely with BP.[10] Brillante *et al*. have shown the same result in healthy volunteers and they reported age and Blood pressure are the independent risk factor for the arterial stiffness.[11] Chen *et al*. have reported that stiffness index derived from digital volume pulse simply derived from the DVP can be used as a marker for risk stratification in untreated hypertensive patients and it can be used as a marker for target organ damage.[12] Gunarathne *et al*. have done the study in cardiovascular risk patients (diabetes mellitus, hypertension, hypercholesteremia patients)and they have shown the result, SI was strongly associated with CVD risk score (the European Society of Cardiology.[13]

CONCLUSION

Reflection index and stiffness index arterial stiffness indices can be used to assess the arterial stiffness by using finger photo pulse plethysmography. It is a noninvasive, cost effective, portable and rapid method. Arterial stiffness indices can be used to predict the vascular complications of hypertensive patients.

REFERENCES

1. World Health Organisation (WHO). The World Health Report 2004. Geneva: WHO; 2004. p. 120.
2. Kum F, Karalliedde J. Critical appraisal of the differential effects of antihypertensive agents on arterial stiffness. Integr Blood Press Control 2010;3:63-71.
3. Schiffrin EL. Vascular stiffening and arterial compliance. Implications for systolic blood pressure. Am J Hypertens 2004;17:39S-48S.
4. Zhang L, Zhang ZK, Jiang BY, Chen XQ, Mi J. Digital pulse wave analyzing method in evaluating arterial compliance based on population study in Chinese 415 adults. Zhonghua Yu Fang Yi Xue Za Zhi 2006;40:113-5.
5. Millasseau SC, Kelly RP, Ritter JM, Chowienczyk PJ. Determination of age-related increases in large artery stiffness by digital pulse contour analysis. Clin Sci (Lond)2002;103:371-7.
6. Chen CH, Nevo E, Fetics B, Pak PH, Yin FC, Maughan WL, *et al*. Estimation of central aortic pressure waveform by mathematical transformation of radial tonometry pressure. Validation of generalized transfer function. Circulation 1997;95:1827-36.
7. Millasseau SC, Kelly RP, Ritter JM, Chowienczyk PJ. The vascular impact of aging and vasoactive drugs: Comparison of two digital volume pulse measurements. Am J Hypertens 2003;16:467-72.
8. Cugini P, Baldoni F, De Rosa R, Pandolfi C, Colotto M, Buccarella PA, *et al*. Higher blood pressure load (baric impact)in normotensives with endothelial dysfunction: A paraphysiological status of "pre-hypertension". Clin Ter 2002;153:309-15.
9. Grey E, Bratteli C, Glasser SP, Alinder C, Finkelstein SM, Lindgren BR, *et al*. Reduced small artery but not large artery elasticity is an independent risk marker for cardiovascular events. Am J Hypertens 2003;16:265-9.
10. Nichols WW. Clinical measurement of arterial stiffness obtained from noninvasive pressure waveforms. Am J Hypertens 2005;18:3S-10S.
11. Brillante DG, O'Sullivan AJ, Howes LG. Arterial stiffness indices in healthy volunteers using non-invasive digital photoplethysmography. Blood Press 2008;17:116-23.
12. Chen JY, Tsai WC, Lin CC, Huang YY, Hsu CH, Liu PY, *et al*. Stiffness index derived from digital volume pulse as a marker of target organ damage in untreated hypertension. Blood Press 2005;14:233-7.
13. Gunarathne A, Patel JV, Hughes EA, Lip GY. Measurement of stiffness index by digital volume pulse analysis technique: Clinical utility in cardiovascular disease risk stratification. Am J Hypertens 2008;21:866-72.

Corresponding Author: Dr. G. Sivagami, Postgraduate Student, Department of Physiology, Vinayaka Mission K V Medical College, Salem.
E-mail: sgshivudr64@gmail.com