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Original Research Article

Study of Relationship between Arterial Stiffness and Hypertension in Jodhpur City

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Abstract: Cardiovascular diseases are emerging as one of the leading causes of morbidity and mortality in the Indian population. The major risk factors contributing to cardiovascular diseases include hypertension, diabetes mellitus, smoking, hypercholesterolemia and family history of coronary artery disease. Among which hypertension contributes the most. Arterial stiffness, a major contributor of atherosclerosis, has been shown to have positive relationship with systolic hypertension, coronary artery disease, stroke and heart failure. Hence measurement of arterial stiffness seems to be an important tool to assess cardiovascular risk in hypertensive patients. So the present study was undertaken to find out the relationship between arterial stiffness and hypertension in Jodhpur city. 103 subjects with systolic blood pressure >120 mm Hg, were taken, ranging between 25-90 years of age. Anthropometric measures were done manually while all other measures including the parameters of arterial stiffness were recorded by the PERISCOPE. All the parameters of arterial stiffness were found positively and significantly increasing with systolic blood pressure as well as with pulse pressure of the subjects. So a population based screening and early detection of hypertension and arterial stiffness can be an important strategy to reduce cardiovascular disease incidence which is the no. 1 cause of death globally.
Keywords: Arterial stiffness, Pulse wave velocity, Augmentation Index, Compliance, Elastance.

INTRODUCTION

Cardiovascular diseases are the leading cause of deaths worldwide and now India is also synchronizing with the global data. By 2020, 2.6 million deaths are predicted to be due to coronary heart disease among Indians [5]. The major risk factor contributing to cardiovascular diseases is hypertension which contributes to nearly 7.1 million premature deaths, two-thirds of all strokes and half of myocardial infarction every year [1]. The worldwide prevalence of hypertension in 2000 was 26.4% including approximately a quarter of the adult population and it is estimated to rise to 29.2% by 2025 [6]. Arterial stiffness, a major contributor of atherosclerosis, has been shown to have positive relationship with systolic hypertension, coronary artery disease, stroke and heart failure. Further, aortic stiffness has been shown to be an independent predictor of all-cause and cardiovascular mortality in hypertensive patients. In the present scenario, arterial stiffness and the ensuing hemodynamic changes are recognized as imperative predictors of adverse cardiovascular events. Hence measurement of arterial stiffness seems to be a promising tool to assess cardiovascular risk in hypertensive patients [2,3].

Several studies indicated that the cardiovascular (CV) risks associated with high blood pressure (BP) begin from the level of 115/ 75 mmHg and each increment of 20 mmHg systolic and 10 mmHg diastolic BP is associated with twofold increase in mortality from both ischemic heart disease and stroke [7]. The arterial stiffness is an independent marker of CV risk [8] that increases with age and elevation of BP [9]. Systolic BP and Pulse Pressure (PP) are related to the physical properties of elastic arteries. Pulse Wave Velocity (PWV), Augmentation Index (AIx) and Arterial Stiffness Index (ASI) are markers of arterial stiffness which are widely accepted and recommended for measure of arterial stiffness [3,10]. Measurement of PWV and wave reflection have now recognized as an important prognostic indicator than BP to assess the CV risk. Carotid-femoral PWV (c-f PWV) is a gold standard measure of aortic stiffness [3]. Brachial-ankle PWV (ba PWV) is also an index of arterial stiffness and is strongly correlated with c-f PWV [11]. It reflects the

function of central elastic artery and peripheral muscular arteries. It is a simple measure of arterial stiffness and an independent predictor of carotid atherosclerosis in the elderly [12]. Hypertension is known to elevate the arterial stiffness [9]. Impaired aortic elastic properties in young and middle-aged subjects with pre-HT have been reported [13, 14]. Recent technical advancements have made noninvasive measurement of arterial stiffness feasible in clinical practice. Several clinical trials have demonstrated utility of these parameters in CV risk stratification as well as in guiding antihypertensive therapy [3,15,16]. Acknowledging the available evidence base, European Society of Cardiology has recommended assessment of arterial stiffness as an integral component of evaluation of any individual with hypertension [17].

Due to rapidly increasing burden of CV risk factors and CV diseases in India, arterial stiffness measurement can be of great clinical value. Unfortunately, the vast differences in CV disease epidemiology between Indians and the Western populations preclude direct extrapolation of results obtained in Western populations to Indians. Very limited data of arterial stiffness studies in Indians hypertensive patients are available. Since the greatest value of arterial stiffness assessment appears to be in hypertensive individuals, we thought it appropriate to perform the study on the vascular parameters of stiffness in hypertensive subjects with different stages of hypertension.

MATERIAL & METHODS

The present study was conducted in M.D.M. Hospital associated with Dr. S. N. Medical College, Jodhpur. 103 subjects aging between 25 to 90 years attending OPD of Medicine Deptt. of MDM Hospital, Jodhpur were examined. All these subjects were having their systolic blood pressure >120 mm Hg. They were subdivided into different groups according to the stages of hypertension and the increasing range of pulse pressure.

Inclusion criteria:

1. Subjects above 25 years.
2. Subjects who have their systolic blood pressure >120 mm Hg and not on antihypertensive medication.

Exclusion criteria:

3. Subjects below 25 years.
4. Subjects who were previously diagnosed as hypertensive and were taking medications.
5. Subjects who were having diabetes mellitus (on the basis of fasting blood glucose levels).
6. Subjects with cardiovascular symptoms.
7. Subjects with any acute or chronic disease (medical or surgical).

An informed consent was obtained from all the subjects after explaining the procedure in detail to them. Detailed history about name, age, occupation, personal and past history, habits of the subjects were taken. Family history of hypertension, diabetes or any other disease was enquired. Physical examination of all the subjects including height in meters (m), weight in kilograms (kg) was done. BMI was derived by Quetelet's index i.e. (weight in kg) / (height in m)^2 .Vital parameters like heart rate, blood pressure and pulse pressure were automatically recorded in the device (PERISCOPE) To assess the arterial stiffness PERISCOPE [RMS India] was used. This device is based on oscillometric method and records arterial pressure wave forms noninvasively. PERISCOPE is a PC based Cardiovascular Analysis System that uses simultaneous Noninvasive Blood Pressure measurements from four limbs and ECG waveforms to calculate important parameters like Pulse Wave Velocity [PWV], Arterial stiffness Index [ASI], Ankle-Brachial Index, Central Aortic Pressure Values and Ejection Slopes etc.

The subjects were instructed to lie in the supine position and recording was started after 5-10 minutes of rest. They were told to relax & breathe normally. Assessment was performed in the morning between 9 to 10 a.m. and after 10 hours overnight sleep. Subjects were asked to refrain from smoking and drinking caffeine-containing beverages 12 h before the test. Subjects were also informed not to speak or sleep during the procedure. Four BP cuffs, which are connected to the Periscope device, were tied around both arms and ankles. These BP cuffs have oscillometric sensors to record the pressure waveforms from underlying arteries. ECG electrodes were applied to on the wrists and ankles to record ECG simultaneously. The machine then automatically inflates and deflates all the cuffs simultaneously while recording pressure waveforms from all the four sites. From these pressure waveforms Pulse Wave Velocity, Arterial Stiffness Index, Augmentation Index, Central Aortic SBP DBP were calculated by the system.

Results obtained in the subjects were then compared in

(a) Four groups made up according to the stages of hypertension and

(b) Five groups made up according to the increasing range of pulse pressure.

Results obtained were analyzed statistically by "Open Epi" computerized software. Results were presented as Mean ± SD and Anova test was used for comparing means of various groups. p – Value of 0.05 or less was considered for statistical significance.

RESULTS AND DISCUSSION

The states of hypertension were classified according to the following criteria:-
Normal BP – SBP upto 120 mmHg, Pre HT [Pre hypertensive]- SBP 121-140 mm Hg, Hypertensive stage 1[mild hypertensive]- SBP 141-160 mmHg, Hypertensive stage 2[moderate hypertensive]-SBP 161-180mm Hg, Hypertensive stage 3[severe hypertensive]- SBP >180 mm Hg.

Table 1- relation of prehypertension, mild, moderate & severe hypertension with various arterial stiffness parameters

Stage of HTN►	PRE HT[n=46]	HT 1[n=43]	HT 2[n=11]	HT 3[n=3]
Stiffness parameters ▼				
R Br Ank PWV	1423.27±330.87	1563.22±447.42	2241.81 ±1187.78	3041.05± 1638.49
L Br Ank PWV	1021.69 ±298.98	1105.45 ±215.05	1474.75 ±289.75	1475.5± 403.85
C-F PWV	794.27± 236.37	878.53± 233.93	1315.19 ±582.46	1648.63 ±745.89
R Br ASI	23.48 ±8.95	32.66± 6.78	39.04 ±11.14	55.27 ±10.3
L Br ASI	25.74 ±7.18	31.04 ±3.82	38.44 ±7	51 ±16.09
R Ank ASI	32.97 ±10.11	42.98 ±11.5	60.95 ±13.66	66.27 ±4.8
L Ank ASI	31.9 ±11.26	43.07 ±11.19	54.93 ±16.34	59.2 ±6.24

Table 1 shows the relation between various states of hypertension and arterial stiffness. Arterial stiffness is expressed as various parameters. As the systolic BP increases all the parameters of arterial stiffness are also increase. The relations between the mean values of all the parameters of arterial stiffness and the states of hypertension were found statistically significant as the p value is very less than 0.05.

According to The Global status report on Non Communicable Diseases-2014 by WHO the cardiovascular diseases (CVDs) are the number 1 cause of death globally in which coronary artery disease and stroke are the main contributors. . [4] Current projections suggest that India will have the largest cardiovascular disease burden in the world. Sadly, many of these Indians will be dying young because heart disease in India occurs 10 to 15 years earlier than in the west. There appears to be a steady increase in hypertension prevalence over the last 50 years, more in urban than in rural areas. To overcome this situation WHO released its Global Action Plan for the prevention of Non Communicable Diseases – 2013-2020. The sixth target in the Global NCD action plan calls for 25% reduction in the global prevalence of raised blood pressure. Raised blood pressure is one of the leading risk factors of cardiovascular disease. To achieve it a total-risk approach needs to be adopted for early detection and cost-effective management of hypertension in order to prevent heart attacks, strokes and other complications [18].

Early detection has a great importance in reducing the advancement of disease and its complications and hence in reducing the morbidity and mortality load of any disease. As arterial stiffness is a major contributor of atherosclerosis and it has been shown to have positive relationship with systolic hypertension, coronary artery disease, stroke and heart failure, measurement of arterial stiffness seems to be a promising tool to assess cardiovascular risk in hypertensive patients [2, 3]. Also the arterial stiffness is a growing epidemic associated with increased risk of cardiovascular events, dementia, and death because decreased compliance of the central vasculature alters arterial pressure and flow dynamics and impacts cardiac performance and coronary perfusion. The primary sites of end-target organ damage following an increase in arterial stiffness are the heart, brain (stroke, white matter hyperintensities (WMHs)), and kidneys (age-related loss of renal function).So early detection of the severity of arterial stiffness can help in reducing the toll of cardiovascular diseases.

Since very less data are available for the study of arterial stiffness and hypertension and their relationship in the Indian population the present study was done in the subjects of Jodhpur city. The study showed that (a) the arterial stiffness increases as the systolic BP rises. (b) The arterial stiffness increases as the pulse pressure rises. Similar study was performed by RR Kasliwal and associates [2012] who studied 144 CV free subjects and estimated ba-PWV, cf-PWV and AIx as a measure of arterial stiffness by using PERISCOPE. The mean age of their subjects were 45.7 yrs, 75.7% were males. Out of 144 subjects 101 [70.1%] were hypertensives. All arterial stiffness parameters (cf-PWV, right and left ba-PWV, and AIx) were significantly elevated in patients with hypertension. They conclude that in North-Indian subjects without known CV disease, arterial stiffness is significantly increased among hypertensives and is positively correlated with both systolic and diastolic BP [19].

Shourya Kola *et al.;* [2014] performed their study on 120 subjects divided into three groups of 40 persons each. One group was of chronic hypertensives on medication, another of recently detected hypertensives and third of healthy persons. They used PERISCOPE device to measure PWV, ASI and pulse pressure. They found that values of all the parameters of arterial stiffness were significantly higher in hypertensives on medication and recently diagnosed hypertensives in comparison to controls [20]. PS Gurunathrao *et al.;* [2015] conducted cross sectional study in 25 elderly [60-80] prehypertensive subjects and compared data of arterial stiffness with 20 age-matched normotensive subjects. They found a significant increase in c-f PWV ($p<0.001$), ba-PWV ($p<0.001$) and AIx@75 ($p<0.001$) in prehypertensives than normotensive elderly individuals. These findings show an augmentation of age-related arterial stiffness in elderly with pre-hypertension. [21] Y Sridhar *et al.*; [2007] investigated 3969 subjects [CAD -845, DM 073, ESRD 942, RA 221 and normal controls 988]. They found that in CAD, DM, ESRD & RA blood pressure and PP were significantly more than healthy controls. Peripheral and central arteries PWVs were higher in all patients. There was a good correlation between ba-PWV and PP in all patients and healthy controls. Thus they concluded that increase in PWV is a good independent predictor of cardiovascular morbidity. [22] A number of studies in Western populations have also shown that arterial stiffness is significantly related to BP and is an independent predictor of CV events in hypertensives [2, 3, 23, 24, 25].

The main limitations with the present study were the small sample size of the study which limits the inferences to be used for the mass population. Secondly, the exclusion criteria excluded the diabetics, hypertensives with cardiovascular symptoms and patients of any other acute or chronic disease, one or more of which are very common with the presence of hypertension. So the results obtained cannot be correlated with all the hypertensives.

Owing to its significant prognostic value, assessment of arterial stiffness has been recommended as a routine tool, wherever available, in the evaluation of hypertensive individuals [17]. In addition, assessment of arterial stiffness may also be helpful in guiding anti-hypertensive therapy [3, 26]. Various pharmacological and non-pharmacological interventions aimed at control of BP have been shown to improve arterial stiffness also, though not to the same extent [27, 28, 29-35]. There is evidence to suggest that such improvement in arterial stiffness may be an important determinant of benefits achieved with antihypertensive therapy. In a study on patients with end-stage renal disease, Guerin et al. found that lack of attenuation of arterial stiffness in spite of reduction in BP was an independent predictor of all-cause mortality. In addition, use of angiotensin converting enzyme inhibitors was associated with better survival, an effect which was independent of BP reduction [36].

Since Arterial stiffness also repositions the site of pulse wave reflections, stiffened arteries equate to an earlier reduction in the diameter of the artery, thus establishing the point of wave reflection at an earlier point along the arterial tree so the future research should focus on a better localization of reflection sites. Modern imaging technologies, such as MRI of the entire vascular tree in living subjects, will play an important role in this future research. In addition, molecular imaging methodologies may give important new information on the in vivo contribution of the various components of the vessel wall to the propagation of the BP wave and on the discontinuities of the arterial wall as a function of the distance from the heart.

CONCLUSION

Increased blood pressure is a major cause for developing arterial stiffness which itself is a common cause of cardiovascular diseases. Cardiovascular diseases are the leading causes of morbidity and mortality in Indian population. If it is diagnosed early and managed appropriately, its progression can be arrested. It can be concluded that , persons with increased blood pressure and advancing age need to be monitored for increased arterial stiffness. Similarly, in persons with increased arterial stiffness, periodic screening for other cardiovascular parameters may be indicated. Hence a population based screening for increased arterial stiffness and blood pressure and their control could reduce the number of people at greatest risk of cardiovascular diseases which is the number one cause of death globally and one of the leading causes of death in India.

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