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Assessment of Biological Vascular Age by Measuring the Pulse Wave Velocity among the Diabetic and Hypertensive Subjects

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ABSTRACT

Background:
Biological vascular age is an important predictor of cardiovascular diseases, even in the absence of clinically apparent disease. It is likely to become an important clinical tool in cardiovascular risk assessment. Vascular aging is a process linked to arterial stiffness, vessel remodeling, as well as increased pulse wave velocity (PWV).

Aim and Objectives:
To study the biological vascular age by measuring pulse wave velocity among the diabetic and hypertensive subjects using finger photo Pulse Plethysmography (PPG).

Materials and Methods:
The study was done with 120 participants of three different groups diabetic (n=40), hypertension (n=40) and control (n=40) in age group of 45-55 years. Lead – II ECG along with PPG were recorded in dual channel AD converter. The analogue signals of the devices of the AD converter were digitized by using the sound card of the computer for the measurement of Pulse Transit Time [PTT].

Result:
Vascular aging was earlier in diabetic and hypertensive subjects when compared with normal subjects of same age group and further there was a significant increase ($p<0.001$) in pulse wave velocity among the diabetic patient when compared with the hypertensive subjects.

Conclusion:
A finger photo pulse plethysmography can be used as a simple cost-effective tool to assess the biological vascular age which is an early predictor for cardiovascular disease

Keywords:
Finger photo pulse plethysmography, Pulse wave velocity, Stiffness index, Vascular age.

Introduction

Cardiovascular disease is one of the major causes of death in the country. It is utmost important to reduce cardiovascular diseases morbidity and mortality rate by an accurate assessment of the cardiovascular system changes and identification of risk factors.[1] The arterial stiffness is the first vessels modification, responsible for several pathological changes, leading to CVDs. Several non-invasive methods have been developed to measure arterial stiffness. Pulse wave velocity is one of the most widely used ways to evaluate arterial stiffness and involves measuring the distance and time it takes pressure to travel a certain distance. Measuring pulse wave velocity provides an indication of arterial stiffness in the vascular bed. The aortic elastic properties are important determinants of blood pressure and left ventricular function. The association between vascular stiffness and blood pressure is particularly interesting because the functional relationship is likely bidirectional[2] Elevated blood pressure may cause vascular damage and accelerated artery stiffness. Increased stiffness of the aorta is an important determinant of future increases in Blood pressure (BP) and progression of hypertension.[3–7] Conversely, aortic stiffening increases pressure pulsatility and therefore affects systolic blood pressure: not only the aorta, as it also found that higher carotid artery stiffness was associated with incident hypertension.[8,9.]

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The arterial aging is tightly intercorrelated with blood pressure and causes the increase in pulse pressure seen in aged individuals. In fact, several nonhemodynamic components are thought to affect arterial aging, such as hyperglycemia and dyslipidemia. It is also apparent that different arterial segments respond differently to aging, probably related to differences in elastin-collagen smooth-muscle proportions, with most studies showing a much more pronounced relationship of stiffness to age in the more proximal, more elastic, and less muscular arteries[10]. Arterial stiffness could be a marker of aging and frailty in general, including increased risk of many causes of mortality. Measurement of arterial stiffness is mostly performed by use of c-f PWV,[11]with a risk threshold of 10 m/s according to studies in the Journal of Hypertension[12] This can be achieved by both direct and indirect methods, which are reasonably well correlated with each other in most cases, even if the direct measurement (c-f PWV) is preferred. Several cross-sectional studies have shown an association between arterial stiffness and diabetes as well as with markers of impaired glucose metabolism[13,14.]

The findings of various studies and reviews clearly shows that vascular stiffness can be important predictor for cardiovascular diseases. It is a common human finding that most people are interested in their health and would like to avoid disease if possible, especially for their close family members and friends. Easy method of knowing the vascular age is by measurement of pulse wave velocity. Measurement of pulse wave velocity is considered as the gold standard method for assessing arterial stiffness, and a tool to evaluate the arterial system damage, vascular adaptation, and therapeutic efficacy[15]. This study is taken up to show that PPG provides information on arterial wall stiffness and determines the biological age of arteries in less than 3 minutes in simple and cost-effective method.

Materials and Methods:

This study was done with 120 participants after the protocol was reviewed and approved by the Institutional Ethics Committee of Vinayaka mission's KirupandaVariyar medical college & Hospitals, Salem, Tamilnadu. The participants were recruited based on inclusion and exclusion criteria healthy volunteers, patients diagnosed with Hypertension (HTN)<5yrs, Diabetes Miletus (DM)<5yrs, nonsmokers and non-alcoholics were included and Patients with a history of missed or irregular heartbeat, congestive heart failure, and artificial pacemaker were excluded. Detailed information about the nature and purpose of the study was explained to the participants and obtained informed consent before the study enrollment.

Weight and height were recorded using a digital weighing scale and stadiometer. The BMI was calculated using the Quetelet's index (weight/height2). The blood pressure recorded with Diamond mercury free LED BP apparatus in the resting-state the mean of three readings was calculated. All readings were taken with the cuff wrapped around the subject's nondominant arm, with the forearm resting on the table so that the cuff was at the level of the heart.

Vascular age was calculated using a digital photo pulse plethysmograph transmitting infrared light applied to the left index finger. Finger photo pulse plethysmography (PPG) is an added device with the AD converter (PC sound card) to record arterial pulse and ECG in a dual-channel mode of audacity software. The analogue signals of both the devices were digitized by using the sound card of the computer for the measurement of Pulse Transit Time [PTT]. The recording was done using audacity software for a minimum of 10 min. The time between the R wave of Lead II ECG and the beginning of the finger pulse was measured as the Pulse Transit Time[16]. The distance [D] between the left forefinger and the right second intercostal space was measured in

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meters. Then by applying the formula Velocity = Distance/Pulse Transit Time, the pulse wave velocity was calculated as meters/second.

Result:

Statistical analysis was performed using SPSS software (version 20). The values are reported as mean± SD. Demographic details were summarized for all randomized subjects using descriptive statistics ANOVA for repeated measures was performed to detect significant changes in variables over time within the diabetic, hypertensive and control groups separately (Table 1) Statistical significance was at P<001.

Descriptive statistics:

N= 120

Mean ± SD.

Age (years) **45±08 BMI** (kg/m2) **20 ±3**

Systolic blood pressure (mm Hg) **136±4**

Diastolic blood pressure (mm Hg) **82±3**

Table:1

Stiffness index and PWV among the Diabetic, Hypertensive and control group

Parameter	control	study		p-value
		Diabetic	Hypertensive	
Arterial stiffness	5.68± 0.38	12.06 ±0.75	11.39±0.27	<0.001
PWV	5.65± 0.75	7.24 ±1.60	6.83±1.07	<0.001

Discussion:

Early vascular aging (EVA)provides information on arterial wall stiffness and determines the biological age of arteries in less than 3 minutes. The Photo pulse Plethysmography (PPG) performs the analysis of the arterial pulse wave and vascular age. PPG is user-friendly, non-invasive device uses a finger probe to observe the changes in pressure, blood flow, velocity and profile throughout the whole pulse wave. Photoplethysmography is one of the straightforward and convenient methods for the estimation of PTT which is obtained from the time difference between the R wave in an electrocardiogram (ECG) and the beginning of the next pulse wave. There are number of risk markers which constitute the knowledge behind early vascular aging with arterial stiffness (PWV) as the core variable as given the table 1. PWV is estimated as the speed at which a pulse wave passes through blood vessels of arteries and is an extensively recognized indicator of arterial stiffness[17].

Measuring pulse wave velocity provides an indication of arterial stiffness in the vascular bed. In this study the PWV of diabetic and hypertensive subject was compared with the control group showing the vascular aging was faster in diabetic subjects in comparing with hypertensive subjects. In some individuals, the arterial stiffening seen with increasing age is more pronounced and occurs earlier in life, a marker of EVA. Early prediction of vascular aging will help in reducing cardiovascular disease and prevent the rate of mortality and morbidity. PTT depends on the blood pressure variation, a sudden increase in blood pressure causes the vascular tone to rise, and hence the arterial wall becomes stiffer and vice versa.[18]Arterial stiffness is known to be strongly associated with age. It is known that large conduit arteries lose their compliance with advancing age even in the absence of cardiovascular disease[19]. Pulse–wave velocity (PWV) is a

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way to measure arterial stiffness and detect hardening of the arteries well before other symptoms appear. It is always safe to know the vascular age even in absence of any vascular disease to be protected from occurrence of cardiovascular disease in future.

Conclusion

Finger photo pulse plethysmography can be used as a simple cost-effective instrument to measure arterial stiffness and PWV before the other symptoms of vascular aging appear. Further studies are on progress with larger different groups for validation.

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