ISSN 0975-6299 Vol 3/Issue 2/April – June 2012

International Journal of Pharma and Bio Sciences

RESEARCH ARTICLE PHYSIOLOGY

NOVEL METHOD FOR MEASUREMENT OF AORTIC PULSE WAVE VELOCITY BY PHOTOELECTRIC PULSE TRANSDUCER COUPLED WITH ECG: A PILOT STUDY

SATISH.G.PATIL*, G.B.DHANAKSHIRUR, MANJUNATHA R AITHALA AND SANTOSH PALEKAR

Department of Physiology, Shri B.M.Patil Medical College and Research Centre, BLDE University, Bijapur, Karnataka, India

SATISH.G.PATIL
Department of Physiology, Shri.B.M.Patil Medical College and Research Centre, BLDE University, Bijapur, Karnataka, India

***Corresponding author**

ABSTRACT

Arterial stiffness is considered an increasingly important biomarker in the evaluation of cardiovascular risk. The gold standard for assessment of arterial stiffness is measurement of aortic pulse wave velocity (PWV). The aim of the present study is to establish a new method for measurement of aortic PWV by using Photoelectric technique coupled with ECG. We studied 36 healthy male subjects between the age of 18 to 60 years. To measure aortic PWV, pulse wave were recorded at the site of right Carotid and Femoral artery by Photoelectric pulse transducer for 10 sec to obtain 6-12 beats with simultaneous recording of ECG. The average time in seconds elapsed between the peak of the R-wave of ECG and the foot of the pulse waves were calculated. Distance in meters from sternal notch to carotid pulse site and distance from sternal notch to groin were measured. Difference in distance (ΔD) divided by time difference (Δt) were given the velocity. The aortic PWV ranges between 4.7 to 10.7 m/s. The values obtained are in accordance with the established methods. Reproducibility of our method was good with very low variability in both interobserver and intraobserver analysis. We conclude that measurement of aortic PWV by photoelectric technique gated with ECG can prove as a simple, reliable and cost effective method.

KEYWORDS

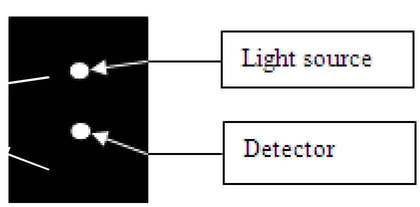
Arterial stiffness, Aortic Pulse wave velocity, Photoelectric pulse transducer

INTRODUCTION

Increase in arterial stiffness with age increases left ventricular afterload by increasing the systolic blood pressure and decreases coronary perfusion by decreasing the diastolic blood pressure. This in turn leads to cardiovascular complications and events such as left ventricular hypertrophy and failure, aneurysm formation and rupture, atherosclerosis, stroke, myocardial infarction and renal failure. Therefore, arterial stiffness has become an increasingly important biomarker in the evaluation of cardiovascular risk[1]. There are various methods to assess arterial stiffness. The gold standard is measurement of aortic Pulse wave velocity (PWV)[2]. PWV is a measure of larger artery elasticity and stiffness. PWV can be calculated in any segment of the circulation, provided the pulse waveform at two arterial sites is possible to record and time elapsed between the travels of waves and distance between them can be measured[3]. Aortic PWV is the most preferred measure of arterial stiffness because of two factors: first, arterial stiffness increases with age due to decrease in elasticity and aorta is the major component of arterial elasticity, and the second is aortic stiffness is an independent predictor of all cause and cardiovascular mortality[4]. It has been shown that, the aortic PWV is more predictive of cardiovascular mortality compared with PWV measured in the brachial or femoral circuits in end stage renal disease (ESRD)[5].

There are various established methods for measuring aortic PWV, among which the most common are Pressure sensitive transducers[2], applanation tonometry[6], Doppler ultrasound[7] and piezoelectric transducers[8]. These require specific devices and are high in cost. We endeavored to record the arterial pulse waveform by photoelectric pulse transducer (PEPT). It contains a light source and a detector (Fig 1). It is commonly used for recording digital volume pulse. An arterial pulse may be picked up by positioning the PEPT over the point of maximum pulsation of an artery. The light passes through the vessel, strikes the bone behind and reflects back which is received by the detector. It is simple to use and low in cost. In the present study, we propose a novel method for the measurement of aortic PWV by using PEPT coupled with ECG.

Figure 1
Photoelectric transducer contains a light source and a detector.



ISSN 0975-6299 Vol 3/Issue 2/April – June 2012

MATERIALS AND METHODS

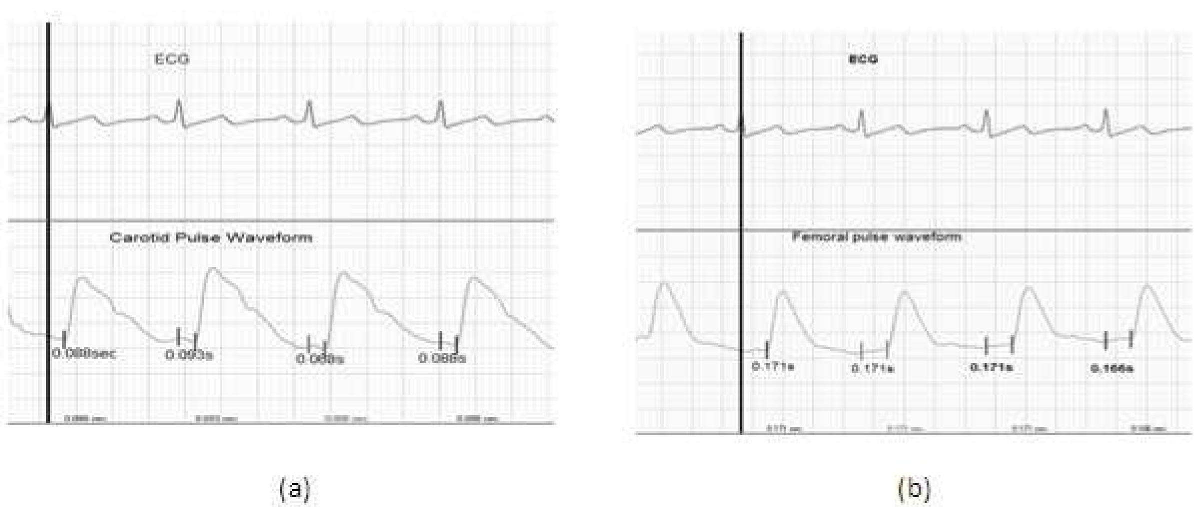
The present study has been conducted on 36 male healthy subjects between the ages of 17 to 60 years with BMI 21.37±3.2. Subjects were divided into three groups between ages of 18 – 20 years, 21 – 40 years and 41- 60 years to obtain normal range in different age groups. Healthy subjects with normal BMI were included in the study. Subjects with any disease, subjects on medications and subjects having habit of chewing tobacco, smoking and alcoholic were excluded from the study. Informed consent was taken for study participation. The study was approved by the institutional ethical committee of Sri B.M.Patil Medical College, hospital and Research centre, Bijapur, Karnataka, India.

Aortic PWV measurement

Pulse waves were recorded at the site of right Carotid and Femoral artery by placing PEPT over the point of maximum pulsation for 10 sec to obtain 6-12 beats using a four channel digital polygraph (Medicaid systems, Chandigarh, India). Simultaneously electrocardiogram (ECG) was also recorded. The average transit time (TT) in seconds elapsed between the peak of the R-wave of ECG and the foot or onset of the pulse waves were calculated by using the digital calipers (Fig 2). Distance in meters from sternal notch to carotid pulse site and distance from sternal notch to umbilicus and then to groin were measured. Difference in distance (ΔD) divided by time difference (Δt) given the aortic PWV expressed in meters per second.

Figure 2

Recording of ECG with Carotid Pulse waveform (a) and Femoral pulse waveform (b)



STATISTCAL ANALYSIS

The values obtained were expressed in range, mean and standard deviation. To check reproducibility and repeatability, two observers separately repeated the procedure twice for 10 subjects. The intraobserver and interobserver variability were analyzed. The standard error of mean differences was calculated.

RESULTS

A total of 36 subjects participated in the present study. The demographic characteristic of all subjects is shown in the Table 1.

Table 1
Demographic Characteristics (n=36)

Variable	Mean ± SD
Age (Yrs)	32.64 ± 13.67
BMI (kg/m^2)	21.37 ± 3.2
Heart Rate (bpm)	72.12 ± 6.22
Systolic BP (mmHg)	117.12 ± 4.83
Diastolic BP (mmHg)	76.96 ± 4.84
Pulse Pressure (mmHg)	39.84 ± 2.79
MAP (mmHg)	88.71 ± 4.92

MAP - Mean arterial Pressure

The range and mean aortic PWV obtained in different age groups are shown in Table 2.

Table 2
Aortic Pulse wave velocity

Age	Subjects (n)	Range (m/s)	Mean ± SD
18 - 20 years	12	4.7-7.06	6.03±0.83
21 - 40 years	12	5.54 - 8.51	7.32 ± 1.3
41 - 60 years	12	7.2 - 10.7	8.59 ± 1.91

The mean difference between the two observers and between the two measurements in 10 subjects is shown in Table 3.

Table 3
Intraobserver and Interobserver variability

	Mean differences	Standard error of mean differences
Intraobserver	0.18	0.032
Interobserver	0.13	0.024

DISCUSSION

Aortic PWV is the most common method used to assess central arterial stiffness. The same has been recommended in the 2007 Guidelines for the management of arterial hypertension[9]. It is a robust measurement of arterial stiffness and independent predictor of cardiovascular mortality in hypertensive[4], non hypertensive[10] and ESRD[11].

Aortic PWV □12m/s is a strong predictor of cardiovascular risk[9]. PWV also predicts the occurrence of cardiovascular events independently of classic risk factor in hypertensives without a history of overt cardiovascular disease[12]. A study conducted by Benetos et al. show that, aortic PWV increases at a faster rate in treated hypertensives than in a normotensive controls, although blood pressure was well controlled, PWV progression was attenuated[11].

There are good number of non-invasive methods and automatic devices for assessment of arterial stiffness. But very few of them measure central arterial stiffness. Aortic PWV can also be measured non-invasively by using MRI[13]. The accurate measurement of path length is an advantage of using MRI, however its usage is limited due to high cost and lack of availability. Doppler ultrasound method is also least used due lack of availability of ECG gating in most of the instrument. Apart from these, most of the methods are having technical difficulties in recording and require training.

There is a need for a simple, low cost, reliable and easily available non-invasive method for assessment of arterial stiffness. Our method does not require any specialized technique and training, which can be performed easily. It can also be performed by a two channel polygraph which can record pulse and ECG simultaneously, which is easily available in most of the institutes or research centers. The examiner only has to place the PEPT on the maximum pulsation site and connect the ECG limb leads. Data analysis should be done as explained in the method. The values obtained by the present method are in accordance with the established methods[14]. Reproducibility of our method was good with very low variability in both interobserver and intraobserver analysis.

The limitation of the present study is that only healthy individuals were included. The further studies are directed for validation of the method. We conclude that measurement of aortic PWV by photoelectric technique gated with ECG can prove as a simple, reliable and cost effective method.

ACKNOWLEDGMENT

We acknowledge deep gratitude to Department of Science and Technology and BLDE University for financial support.

REFERENCES

1. Mark.A.Supiano. Hypertension. In: Jeffrey.B.Halter and Joseph.G.O (eds.), Hazard's Geriatric Medicine and Gerontology, Mc Graw Hill Medical, New Delhi, India. 2009:pp 975-982.
2. Dan.A.Darabantin. Vascular Compliance: Methods of assessment and Clinical significance. *Timisoara Med J*, 55(4):339-334 (2005).
3. Stephanie.S.Deloach, Raymond R Townsend. Vascular stiffness: Its measurement and significance for epidemiologic and outcome studies. *Clin J Am Soc Nephrol,* 3:184-192 (2008).
4. Stephane Laurent, Pierre Bontouyrie, Roland asmar, Isabelle Gautier, Brigitte Laloux, Louis Guize, et al. Aortic stiffness is an independent predictor of all-cause and cardiovascular mortality in hypertensive

patients. *Hypertension*, 37:1236-1241(2001).
5. Pannier B, Guerin AP, Marchais SJ, Safar ME and London GM. Stiffness of capacitive and conduit arteries: Prognostic significance for end-stage renal diseases patients. *Hypertension*, 45:592-596(2005).
6. Mathew.R.Nelson, Jan Stepanek, Michael Cavette, Michael Covalciuc, Todd Hurst and A.Jamil Tajik. Non Invasive measurement of Central Vascular Pressure with arterial tonometry: clinical revival of the Pulse pressure Waveform. *Mayo clin Proc*, 85(5):460-472(2010).
7. Jordi Calabia, Pere Torgnet, Isabel Garcia, Nadia Martin, Bernat Guash, Diana Faur and Marti Valles. Doppler ultrasound in the measurement of pulse wave velocity: agreement with the Complior method. *Cardiovascular Ultrasound*, Apr15, 9:13(2011).
8. Willum Hansen T, Staessen JA, Torp Pedersen C, Rasmussen S, Thij S L, Ibsen H, Jeppesen J. Prognostic value of aortic pulse wave velocity as index of arterial stiffness in the general population. *Circulation,*113:664-670(2006).
9. The Task force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). 2007 Guidelines for the management of arterial hypertension. *European Heart Journal*, 28:1462-1536(2007).
10. Benetos A, Adamopoulos C, Burean JM, Temmar M, Labat C, Bean K et al. Determinants of accelerated progression of arterial stiffness in normotensive subjects and in treated hypertensive subjects over a 6-year period. *Circulation,*105:1202-1207(2002).
11. Jacques Blacher, Alain PG, Bruno P, Sylvain JM, Michael ES, Gerard ML. Impact of aortic stiffness on survival in end-stage renal disease. *Circulation,* 99:2434-2439(1999).
12. Blacher J, Asmar R, Djane S. Aortic pulse wave velocity as a marker of cardiovascular risk in hypertensive patients. *Hypertension,* 33:1111-1117(1999).
13. Mohiaddin RH, Firmin DN, Longmore DB: Age-related changes of human aortic flow wave velocity measured noninvasively by magnetic resonance imaging. *J of applied physiology,* 74:492-497(1993).
14. Michael F O'Rourke, Jan A.Staessen. Clinical applications of arterial stiffness; Definitions and references values. *Am J Hypertens,* 15:426-444(2002).