PULSE WAVE VELOCITY AS A NEW ASSESSMENT TOOL FOR ATHEROSCLEROSIS

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Introduction

The World Health Organization reported in 2005 that cardiovascular disease was the most common cause of death worldwide, accounting for approximately 30% of all deaths [1]. Age-specific statistics show that the main cause of death between the ages of 15-59 was HIV/AIDS, followed by ischemic heart disease and tuberculosis [2]. Among elderly individuals, main causes of death were ischemic heart disease followed by cerebrovascular disease [2]. The data stress the importance of preventing and treating atherosclerotic disease.

One of the most important factors contributing to the increase in atherosclerotic disease is aging. Over the past several decades, life expectancy at birth has increased globally by approximately 20 years, from 46.5 years in 1950-1955 to 65.2 years in 2002, and this trend is observed in both developed and developing countries [2]. Another factor that contributes to atherosclerosis is diabetes, which is increasing globally at an alarming rate. The International Diabetes Federation (IDF) predicts the prevalence of diabetes to increase from 5.1% (194 million people worldwide) in 2003 to 6.3% (333 million) in 2025 [3]. In response, the United Nations passed a resolution in December 2006 recognizing diabetes as a chronic, debilitating, and costly social burden [4].

Conventional and noninvasive tools for evaluating atherosclerosis have been recently developed and are currently in use [5,6]. Among these is pulse wave velocity (PWV), which depicts the velocity of a pulse wave between two arterial points and constitutes a clinical index of aortic stiffness. The use of PWV has received increasing attention as a non-invasive method to measure vascular injury [6]. PWV levels change with age, differ between sexes, and increase in the presence of atherosclerotic disease and associated risk factors [7]. In this commentary, we discuss the mechanisms of PWV and summarize recent studies that address a connection between PWV and atherosclerotic diseases [6-12].

Development of PWV

PWV measures the speed of a blood pressure wave between two given sites of an artery, and is determined by arterial wall elasticity and thickness [7]. The first use of PWV was reported in 1922 in a study examining an association between age and arterial stiffness [13]. At the time, procedures for measuring PWV were complicated and not suitable for diagnostic purposes. During the 1960s, as new techniques were developed to assess pulse wave and pressure, reports on PWV increased. Initially, the carotid-femoral PWV (cfPWV) was identified for its usefulness as a marker of vascular damage, and its relationship to disease prognosis was confirmed in several studies [8-10]. However, this method proved impractical in the clinical setting, as patients were required to disrobe, which made screening many subjects in a short time frame difficult.

To accommodate the demand for measuring arterial stiffness in the clinic, an automatic system to measure brachial-ankle PWV (baPWV) was developed and commercialized in Japan in
1999. Since then, about 10,000 devices have been sold in Japan, South Korea, China, and Taiwan. The reliability and validity of baPWV versus cfPWV has been confirmed. Importantly, baPWV does not require examiners to acquire specialized techniques, and measurements are made by wrap cuffs on the brachia and ankles [14]. Results of cfPWV and baPWV measurements are not equivalent because baPWV reflects sclerosis of both central elastic arteries and peripheral muscular arteries, while cfPWV reflects only the sclerosis of central arteries. However, a high correlation between the two has been reported (r = 0.87) [14].

**PWV as an Atherosclerotic Disease Marker**

Following its commercialization in 1999, many reports on PWV have been published. These studies revealed that PWV increases with age, is higher among men as compared to women until age 60, and then becomes similar in both sexes in older age groups [7]. PWV has wide potential applications for predicting the prognosis of early vascular damage. Table 1 summarizes recent studies on PWV and associated risk factors following three stage categories: “health behaviors,” “clinical indicators,” and “final outcomes.”

Smoking is considered as a “health behavior” reported to increase PWV level [15], and the duration of smoking cessation is known to have a significant linear relationship with improvement in cfPWV in ex-smokers [16]. Similarly, excessive alcohol consumption is associated with elevated PWV [17-18]. Furthermore, some reports suggest that physical activity has favorable effects on aortic stiffness assessed by PWV [19-20].

PWV also increases in the presence of atherosclerosis-related conditions such as diabetes mellitus [7,21], dyslipidemia [22], and hypertension [23]. In our previous reports, we showed that among health check-up attendants, blood pressure and glucose-related measurements, in addition to age and sex, were associated with PWV level [24]. Along with recent worldwide attention, evidence regarding metabolic syndrome and PWV are starting to accumulate. These studies suggest PWV as a predictor of metabolic syndrome and its synergetic increase in the presence of multiple components [25-27]. In relation to increasing attention on chronic kidney disease as an important risk factor of cardiovascular diseases as well as end stage renal disease, PWV is reported to correlate with proteinuria and renal function [28-30].

Finally, there have been a number of longitudinal studies reporting the effects of PWV on cardiovascular and cerebrovascular [31-32]. In the case of cardiovascular disease, a longitudinal study among middle-aged hypertensive patients in France demonstrated that relative risk increased by 1.4 times for each standard deviation (SD) increase in PWV (3.5 m/sec) [8]. Additionally, the same research group reported that PWV was an independent predictor of cerebrovascular diseases [10] and all-cause mortality [9] among hypertensive patients. The relative risk of stroke mortality was 1.7 for 4 m/sec PWV and that of all-cause mortality was 2.1 for 5 m/sec PWV. We also conducted a case-control study in a Japanese population to examine the association between PWV and cerebral infarction [11]. Subjects consisted of 92 pairs of cerebral infarction patients (cases) and healthy individuals (controls) admitted for a health check-up at a general hospital, matched for age and sex. In our analysis, family history of hypertension (OR = 8.6), cerebrovascular diseases (OR = 13.7), a high-density lipoprotein cholesterol of 40 mg/dl or higher (OR = 0.1), and PWV over 1600 cm/sec (OR = 2.9) remained significant in a multivariate conditional logistic regression model.

**Unique Applications of PWV**

Recently, unique assessments of the usefulness of PWV have been carried out. One study determined a relationship between PWV and obstructive sleep apnea syndrome (OSAS), which is
known to be a risk factor of cardiovascular morbidity and mortality through hypertension, abnormal metabolic parameters, and obesity [33-34]. A cross-sectional study among Japanese patients coming to a hospital for sleep apnea treatment revealed that PWV was significantly higher among those diagnosed with OSAS [33]. In addition, Kitahara et al. [34] treated patients with OSAS by using continuous positive airway pressure, and reported that the treatment effectively reduced PWV levels along with heart rate and blood pressure. Moreover, there are trials that have used PWV to evaluate the effectiveness of consuming green coffee bean extract [35], beta-carotene [36], beta-cryptoxanthin [36], and eicosapentaenoic acid [37] in preventing atherosclerotic vascular damage.

Conclusion

Atherosclerotic diseases are receiving public health attention due to a rapid increase in prevalence, their impact on individual mortality and morbidity, and their influence over national health policy. Here, we have indicated the potential value of using PWV, which is a convenient, inexpensive, and noninvasive test to identify vascular injury and predict vascular disease. The European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) have added PWV measurement as an early index of large artery stiffening in the “2007 Guideline for the Management of Arterial Hypertension” [38]. We recommend increased utilization and further evaluation of PWV as a screening tool for atherosclerotic diseases.

References


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