ARTERY STIFFNESS ASSESSED BY PULSE COUNTER ANALYSIS

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ABSTRACT

Because pulse contour analysis might be used to assess artery stiffness, an index of stiffness (SI) derived by pulse counter analysis was examined. SI was obtained from subject height and from the time delay between direct and reflected waves in the pulse. Moreover, a pulse contour characteristic value K extracted from calculation of the pulse wave contour is introduced. K is also related to artery stiffness and can be used for artery stiffness assessment. 40 subjects (20 women; mean age 45 years, 20 man, mean age 43) were recruited for pulse wave analysis. By univariate analysis, SI and K are also highly correlated with (r=0.632, P<0.0001). It shows K also can be an accept parameter for artery stiffness assessment. The method for acquiring SI and K is simple, inexpensive, and rapid.

INSTRUCTIONS

Total arterial compliance and increased central pulse-wave velocity are associated with arterial wall stiffening. They are recognized as the dominant risk factors for cardiovascular disease. The contour of the peripheral pressure and volume pulse affected by the vascular aging on in the upper limb is also well recognized. Increased artery stiffness with an increase in pulse wave velocity (PWV) may be the main reasons for the change of pulse contour. [1-4]

Because the pulse pressure and pulse wave velocity (PWV) have been strongly linked to cardiovascular morbidity, some non-invasive methods to assess arterial stiffness based on pulse analysis had been introduced. These methods need to measure the difference of centre artery pulse and reflected pulse wave. Therefore, those methods become complicated for routine checking. The digital volume pulse (DVP) may be obtained rapidly and simply by measuring waist pulse making this a potentially attractive waveform to analyze. [4]

Millasseau et al have demonstrated that arterial stiffness, as measured by peripheral pulse wave analysis, was correlated with the measurement of central aortic stiffness and PWV between carotid and femoral artery, currently the reliable method in adults assessment. They introduced stiffness index (SI) derived from the pulse analysis for artery stiffness assessment. SI was correlated with PWV (*r*=0.65, *P*<0.0001). It is a simple and non invasive method for assessing artery stiffness. [4]

Luo introduced a formula for cardiac output calculation. Then a pulse contour characteristic value K extracted from calculation of the pulse wave contour is introduced. He addressed, with the change of vascular elasticity and blood viscosity, pulse character K may also has a corresponding change. The pulse character is related to artery stiffness and can be used for artery stiffness assessment. [5]

The purpose of this study was to find the relation between the stiffness index (SI) and the pulse character K.

METHODS

<u>Calculation of Stiffness index (SI)</u>

The pulse wave sensor is a pressure-sensitive sensor with PVDF piezoelectric membrane) The advantages of PVDF sensor are high sensitivity, overload, consistency, and stable performance. To record the pulse wave, the patients were comfortably rested with the right hand supported. A pulse wave sensor was applied to the right wrist of the patient. Only the appropriate and stable contour of the pulse wave was recorded.

The first part of the waveform (systolic component) is considered as a result of pressure transmissions along a direct path from the aortic root to the wrist. The second part (diastolic component) is considered as the pressure transmitted from the ventricle along the aorta to the lower body. The timing of the diastolic component relative to the systolic component depends upon the PWV of the pressure waves within the aorta and large arteries relative to large artery stiffness. The SI is an estimate of the PWV about artery stiffness and is obtained from subject height (h) divided by the time between the systolic and diastolic peaks of the pulse wave contour. The height of the diastolic component of the pulse wave relates to the amount of pressure wave reflection. [4]

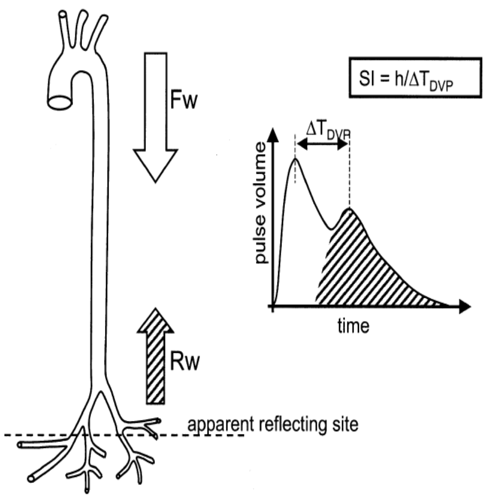


Figure 1. Stiffness index is related to the time delay between the systolic and diastolic components of the waveform and the subject's height $SI = h / \Delta T$ (From [4])

Pulse Character K

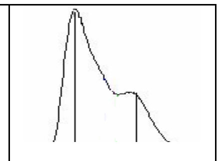
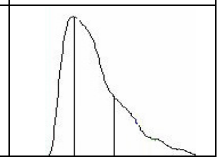
The pulse character is defined as follows:

$$k = \frac{p_m - p_d}{p_s - p_d} \times 10$$

Where $p_m = \frac{1}{T}\int_0^T p(t)dt$ is the average pressure,

p_s is the systolic pressure, p_d is the diastolic pressure. With age change, the value of pulse character is gradually increasing. [5]

Table 1: Comparison of pulse character K and SI based on different age

Age: 39 Male	K=0.35 SI= 6.0m/s	
Age: 57 Male	K=0.38 SI=9.0m/s	

Subjects

40 subjects (20 women; mean age 38 years, 20 man, mean age 41) were recruited for pulse wave analysis. No subject had a previous history of cardiovascular disease or was receiving drugs. Following at least 15 minutes of semi-supine rest, three consecutive measurements of pulse wave were made

Statistics

Associations between SI and K were examined by univariate regression analysis. All the statistical analyses were performed with SYSTAT, version 10 (SPSS Inc., Chicago, IL, USA). Significance was assigned at $P<0.05$.

Results and Discussion

By univariate analysis, SI was correlated with age, systolic blood pressure diastolic blood pressure. K was correlated significantly with age, systolic blood pressure, SI and K are also highly correlated with ($r=0.632$, $P<0.0001$).

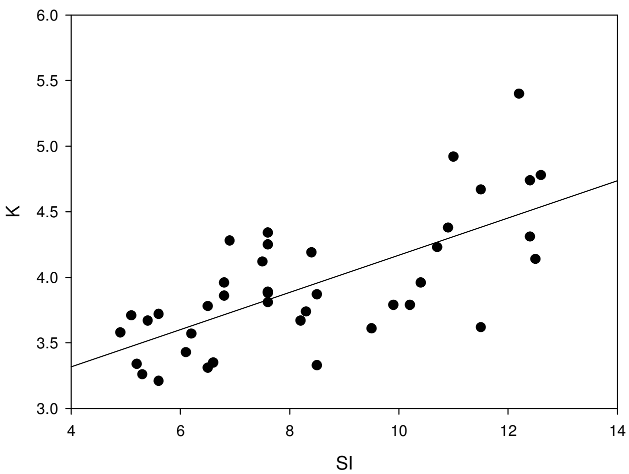


Figure 2. Correlation between SI and K based on 40 subjects

Based on Bramwell Hill equation, the measurement of PWV for assessing artery stiffness is inversely correlated to arterial distensibility [1]. The measurement at the carotid femoral region is the most direct indicator of large artery stiffness. It is a main standard to evaluate central arterial rigidity and the resulting cardiovascular risk. Different pulse wave analysis based on pulse contour have been used to provide indirect estimates of large artery stiffness and measurements of cardiac output [6, 7]

The indirect measurement of central arterial stiffness by analysis of the pulse counter, as an established method, is technically simple, inexpensive and rapid. However, because SI is likely to be influenced by factors other than PWV, such as the characteristics of ventricular ejection and the exact distribution of sites of pressure wave reflection, SI may not provide the identical information as PWV. However, even with these reservations, SI and PWV still have a significant correlation as 0.65 [4]. For pulse character K, because it is calculated based on pulse counter, it can bring more information pulse counter pattern. Moreover, it also reflects change of blood viscosity.

In conclusion, the significant positive correlation between SI and K ($r=0.632$, $P<0.0001$) shows K also can be an accept parameter for artery stiffness assessment. The method for acquiring SI and K is simple, inexpensive, and rapid. SI and K can be combined to assess the artery stiffness.

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