A NEW METHOD FOR THE ESTIMATION OF TOTAL ARTERIAL COMPLIANCE

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Introduction

Total arterial compliance (C_T) is an important biomechanical property of human circulation with major pathophysiological impact. C_T is a main determinant of cardiac afterload, left ventricular function and arterio-ventricular coupling. In terms of physiology, C_T is more relevant than regional aortic stiffness which is most commonly used in clinical research. However, direct in vivo, non-invasive, measurement of C_T is not feasible. Several methods exist for indirect C_T estimation [Stergiopulos, 2009], mostly based on simultaneous recording of both pressure and flow waves in the aorta. This complex approach limits the widespread assessment and use of C_T in clinical practice. On the contrary, measurement of aortic pulse wave velocity (aPWV) is simple and it is now considered as the "gold standard" method to assess arterial stiffness. Nonetheless, the association of aPWV with C_T remains unknown. Aim of this study was to establish the relation between aPWV and C_T and to provide a new simple method for C_T estimation based only on aPWV measurement.

Methods

We used an accurate, validated, distributed, nonlinear, one-dimensional model of the systemic arterial tree [Reymond, 2010]. A total of 1000 different hemodynamic cases were simulated by modifying heart rate, arterial compliance, resistance as well as arterial geometry. A theoretical approach based on Bramwell-Hill theory [Bramwell 1922] was utilized in order to derive a mathematical equation relating directly C_T with aPWV.

Results

Based on various physical and hemodynamic principles we found that the following formula estimates accurately C_T from aPWV.

$$C_T = k \cdot \frac{1}{\mathrm{a}PWV^2} \qquad (1)$$

The constant *k* was determined by fitting C_T vs aPWV data as shown in figure 1.

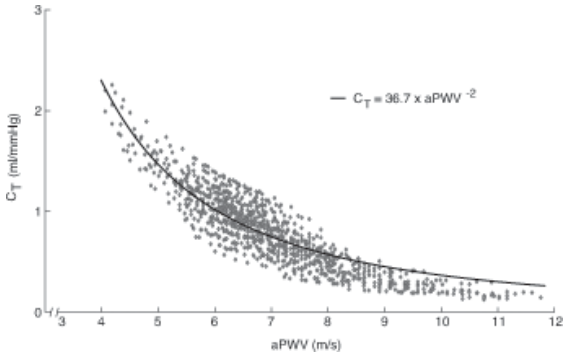

Figure 1: Power relationship between total arterial compliance and aortic pulse wave velocity.

The value of *k* was 36.7 (95% CI: 36.2-37.2). Goodness of fit parameters were also calculated; the SSE was 29.94, the R^2 was 0.8 and the RMSE was 0.17.

Discussion

It was found that aPWV reflects C_T following a non-linear power equation. The proposed equation yields an estimation of C_T only from aPWV. Since aPWV is a broadly and easily measured surrogate of arterial stiffness in clinical practice, C_T could be easily assessed, providing an additional research and clinical tool for better cardiovascular risk assessment and management. The proposed method may have greater impact when applied in elderly populations or subjects with increased arterial stiffness, where aPWV seems to have limited prognostic value. Further clinical studies should verify this hypothesis and also validate the new relationship between C_T and aPWV with in vivo data.

References

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Bramwell *et al*, Proc R Soc Lond B, 93:298-306,1922.