A numerical assessment of methods to estimate aortic stiffness from arterial pulse waves

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INTRODUCTION

Aortic stiffness is a predictive of cardiovascular events and all-cause mortality. Consequently, several methods have been proposed to estimate aortic stiffness from the arterial pulse wave. Translation of these methods into clinical practice is hindered by a lack of evidence on the relative performance of the methods, and an incomplete understanding of the physiological factors which cause the methods to be inaccurate. Therefore, the aims of this numerical study were: (i) to compare the accuracy and precision of pulse wave-derived indices of aortic stiffness, and (ii) to identify the physiological determinants of each index.

METHODS

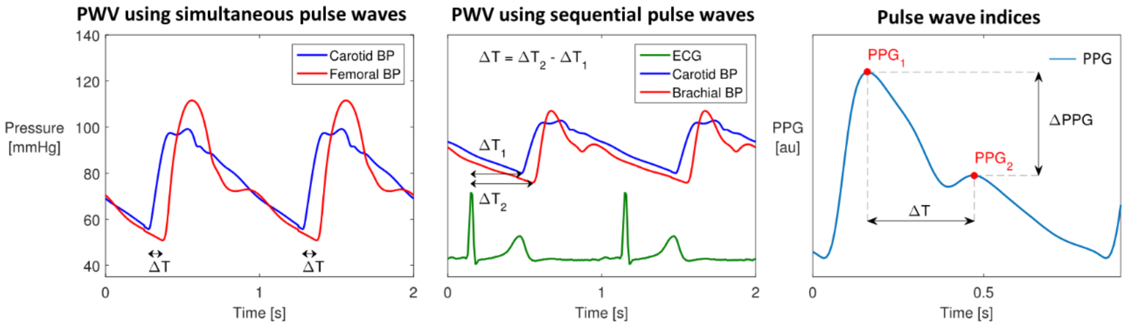
The study was performed using a database of simulated arterial pulse waves and reference values of aortic stiffness. The database was constructed by varying the cardiovascular input parameters of a 1-D model of arterial haemodynamics to simulate a population of adult subjects. The input parameters were varied to model the cardiovascular changes observed during ageing from young to old age, and to model the normal physiological variation observed across a population. Estimates of aortic stiffness were derived from the pulse waves of each virtual subject using a wide range of previously proposed methods (see Figure), including: (i) pulse wave velocities (PWVs) calculated from pulse waves measured simultaneously at central and peripheral locations; (ii) PWVs calculated from ECG-gated pulse waves obtained sequentially; and (iii) pulse wave indices calculated from blood pressure or photoplethysmogram pulse waves at superficial sites including the carotid, radial and digital arteries. Reference aortic stiffness values were obtained by calculating theoretical aortic PWVs from model input parameters.

RESULTS

Relative performance was assessed by comparing the correlations between reference values of aortic stiffness and estimated values produced by each method. In addition, the performance of PWV-based methods was quantified using the limits of agreement technique. Sensitivity analyses were performed to quantify the influence of each input parameter on each method. Most methods were indicative of aortic stiffness to some extent, but were also influenced by the stiffness of other arteries, and by other unrelated cardiovascular parameters. The potential clinical utility of the best performing methods was evaluated by considering their accuracy and precision, potential confounders, and ease of measurement. This informed recommendations of when more laborious, PWV-based methods should be used, and when less time-consuming pulse wave indices should be used.

CONCLUSION

We assessed the performance of a wide range of methods for estimating aortic stiffness using a database of arterial pulse waves simulated numerically. This resulted in recommendations of the most suitable methods for use in different clinical scenarios.



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