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Presentation Abstract

Session:	15-9-Arterial stiffness and disease - measurement, modelling and pathophysiology
Presentation:	Interaction of Wave Reflection with the PU and QA Loop Methods for the Assessment of Local Pulse Wave Velocity
Location:	312
Presentation Time:	Thursday, Jul 10, 2014, 8:36 AM - 8:54 AM

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Abstract:

Background

Single-point methods such as the PU- and QA-loop methods can be used to estimate local pulse wave velocity (PWVPU and PWVQA) in arteries from a combination of pressure (P), flow (Q), velocity (U) or cross-sectional area (A) waveforms. Available data, however, indicate that the PU-loop method generally tends to overestimate PWV, while the QA-loop method tends to underestimate. Wave reflection has been suggested as a factor playing a role in the agreement between different methods, but its exact role has not been fully resolved to date.

Material and Methods

In this study, we first provide a theoretical basis to demonstrate the interference of wave reflection with the PU-loop method using solitary sinusoidal waves. The impact of wave reflection on the PU-loop method can be quantified by a frequency-dependent factor Bk =(1 + Gk)/(1 - Gk) with k the harmonic number and Gk the reflection coefficient. For the QA-loop method, the impact of reflection is ~1/Bk. Knowledge of PWVPU and PWVQA yields Bk, which can then be used to provide a corrected estimate. The theory can be generalized to physiological waveforms composed of multiple harmonics and provides the basis for an operator-independent harmonics-based method to correct for the presence of reflections (with the average of the first five harmonics yielding PWV1-5). The theoretical work is verified by fluid-structure interaction simulations in a carotid artery model, with fully known mechanical properties. Finally, PWVPU, PWVQA and PWV1-5 are determined in a small sample (N=37) of non-invasively acquired data, measured at the carotid artery.

Results

The carotid artery model simulations confirm that PWVPU severely overestimates PWV, while PWVQA underestimates PWV (8.95 vs. 4.10 m/s while the reference range is 5.35 to 6.35 m/s). Correction effectively eliminates the impact of reflections (PWV1-5 = 5.90±0.07 m/s). This is consistent with the in vivo findings, with PWVPU = 7.53±2.85 m/s and PWVQA = 3.39±1.14 m/s. The harmonic-based correction yields PWV1-5 = 4.99±0.87 m/s. PWV1-5 leads to significantly better correlations of carotid PWV with age and systolic blood pressure, but especially with PWV derived from carotid distensibility (with r^2 improving from about 0.25 to 0.91).

Conclusions

Neither the PU-loop nor the QA-loop method provides reliable estimates of local PWV in settings where wave reflections are present. This is particularly the case for application on the carotid artery. A correction method, eliminating the impact of reflections, has been proposed and successfully tested.