Potential values of the oscillation wave generated in a suprasystolic oscillometric cuff in assessing arterial stiffness: a computational model study

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Abstract

Assessment of arterial stiffness is increasingly being recognized to be significant for the treatment of cardiovascular disease. Although a variety of techniques for noninvasively assessing arterial stiffness have already been developed, few of them are suitable for wide application in general clinical settings. In recent years, some researchers attempted to assess arterial stiffness through analyzing oscillation waves recorded in oscillometric cuffs. The cuff-based techniques are promising for clinical use as they employ simpler technology, are easier to be automated and require less operator training in comparison with the traditional ones. However, the ways in which cardiovascular factors involve in the formation of cuff oscillation wave yet remain poorly understood. The deficient understanding may potentially cause misleading interpretations for measurements and hamper the further development of such kind of techniques.

The aim of this study is to clarify the relations between characteristics of cuff wave and cardiovascular properties. To this aim, an integrated computational model was constructed by combining a cardiovascular model with a model of an oscillometric cuff. A specific advantage of the model is that it integrates arterial wave propagation, global hemodynamics and cuff mechanics into a unique computational system and hence allows us to quantitatively investigate the respective effects of various cardiovascular factors.

The model was applied to study a suprasystolic oscillometric cuff applied to the left upper arm. Computed results indicated that 1) the cuff wave resembles the blood pressure wave in the brachial artery, and 2) two systolic peaks are always present on the cuff wave, with the time lag between them and their relative amplitudes varying with physiological conditions. The characteristics were then utilized to estimate the pulse wave velocity (PWV) in the aortic-subclavian-brachial (ASB) path and derive the brachial augmentation index (BAIx) for assessing systemic arterial stiffness. Computations performed under various conditions revealed that the accuracy of the PWV estimation may be compromised by the influence of reflected waves traveling from the aorta to the brachial artery, particularly at older ages; and the BAIx is not solely determined by arterial stiffness but potentially affected by many other physiological/physical factors such as heart rate, cuff location, etc. These model-based findings may help in interpreting measurements or serve as a reference from

which to develop novel measurement techniques.

Keywords: Suprasystolic oscillometric cuff; Oscillation wave; Cardiovascular model; Pulse wave velocity; Arterial stiffness