Evaluation of Arterial Diameter by Mathematical Transformation of APG for Ambulatory Stiffness Evaluation

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Background and Objective: Non-invasive, continuous measurement of arterial stiffness indices has established utility in cardiovascular risk stratification. This study aims to develop a subject-specific model of soft tissue sandwich from the common carotid artery wall to the skin surface layer using acceleration plethysmograph (APG) waveforms. It was then used to estimate the lumen arterial diameter waveform using APG for stiffness evaluation.

Methods: The carotid APG waveforms were collected using the developed accelerometer probe and its associated measurement system. Our clinically validated ARTSENS device performing diameter measurement and stiffness evaluation with a single-element ultrasound transducer was used as the reference system. The relationship between carotid diameter and APG from the neck was evaluated via mathematical models using system identification performed in MATLAB. The viscoelastic characteristics were considered for modeling the skin-tissue layer above the carotid artery. The performance of the developed model for non-invasive assessment of carotid lumen diameter waveform and stiffness indices using APG was validated on 15 subjects.

Main results: The developed model was implemented in real time. The developed system continuously evaluated carotid diameter waveform using APG captured from the neck as depicted in figure. An RMSE of less than 0.14 mm was observed between the constructed carotid diameter waveform (using APG) when compared with a true diameter measured using the ultrasound-based system. A beat-to-beat variation of less than 8 % was observed for the estimated end-diastolic and arterial distension. Various carotid stiffness indices (evaluated using the estimated diameter parameters and measured blood pressure) demonstrated acceptable accuracy when compared with the reference system.

Conclusion: The study results demonstrated the feasibility of using a subject-specific skin-tissue model with APG waveforms for arterial diameter measurement and estimation of the vessel stiffness indices.