Ultrasound Based Computational Fluid Dynamics Assessment of the Brachial Artery

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ABSTRACT

Background: Pre-eclampsia (PE) is a pregnancy specific systemic condition that is characterized by high blood pressures and proteinuria, which is currently the leading cause of maternal and perinatal mortality. However, diagnosis of this condition is hindered by the lack of proper understanding of the multifactorial pathogenesis of the condition. Furthermore, many underlying conditions such as pre-existing hypertension may interfere with the diagnosis of the condition. Therefore, it is important to improve current diagnostic methods for PE. Previous studies have established protocols utilizing wall shear stress (WSS) as an indicator for PE using computational fluid dynamics. We aim to validate this methodology using a large patient cohort to better investigate the relationship between WSS, hypertension and PE.

Methods: 2-D ultrasound (US) and doppler scans of the brachial arteries of three different subject cohorts - normotensive, hypertensive and PE, were obtained. These images were then processed using a custom MATLAB script to generate 3-D models that accounted for non-circular cross-section and non-linear structures of the brachial artery (BA) before and after occlusion using a sphygmomanometer. Flow curves were quantified for each model using the doppler scans. The models and the flow rates obtained were imported into SimVascular to simulate blood flow in the modelled artery. From the simulations, time averaged wall shear stress (TAWSS), peak systolic WSS, oscillatory shear index (OSI) and OSI/TAWSS were acquired.

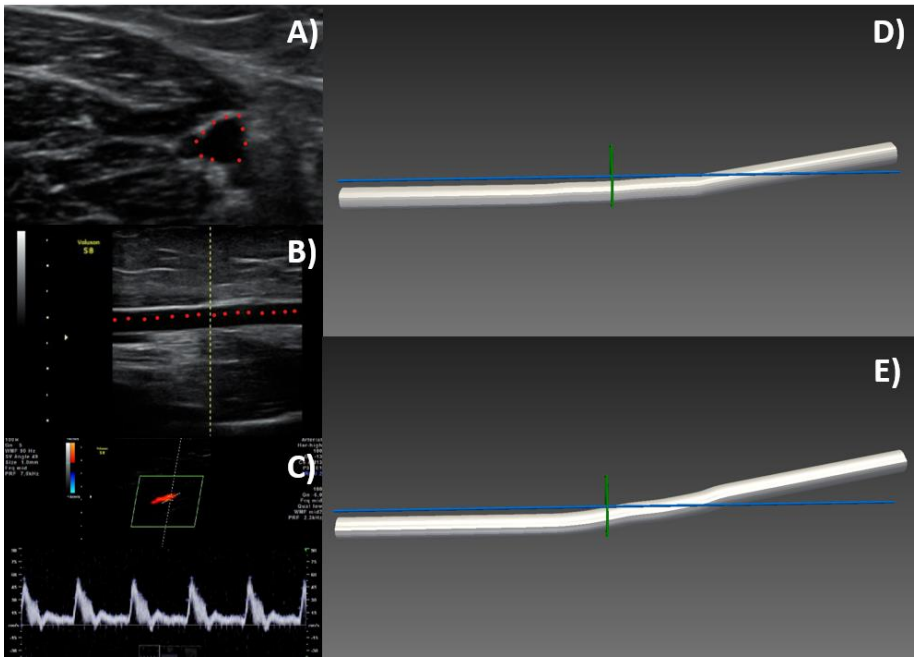

Figure 1: *BA WSS evaluation pipeline. A) BA contour, B) BA length, C) velocity profile from doppler, D) pre and E) post-occlusion BA models.*

Results: Using this methodology around 115 models of pre and post brachial occlusion have been created. Further simulations are underway to calculate WSS derived metrics and generate a more robust analysis. This will allow us to investigate the effect of underlying hypertension, including differences between hypertensive, normotensive and PE patients.

Conclusions: This new method could prove to be more accessible as it eliminates the need for invasive and expensive diagnostic tools (MiRNA). It allows faster processing of images with patient specific models and more accurate diagnosis of PE as opposed to the currently available methods. Future work involves optimizing and automating this process.