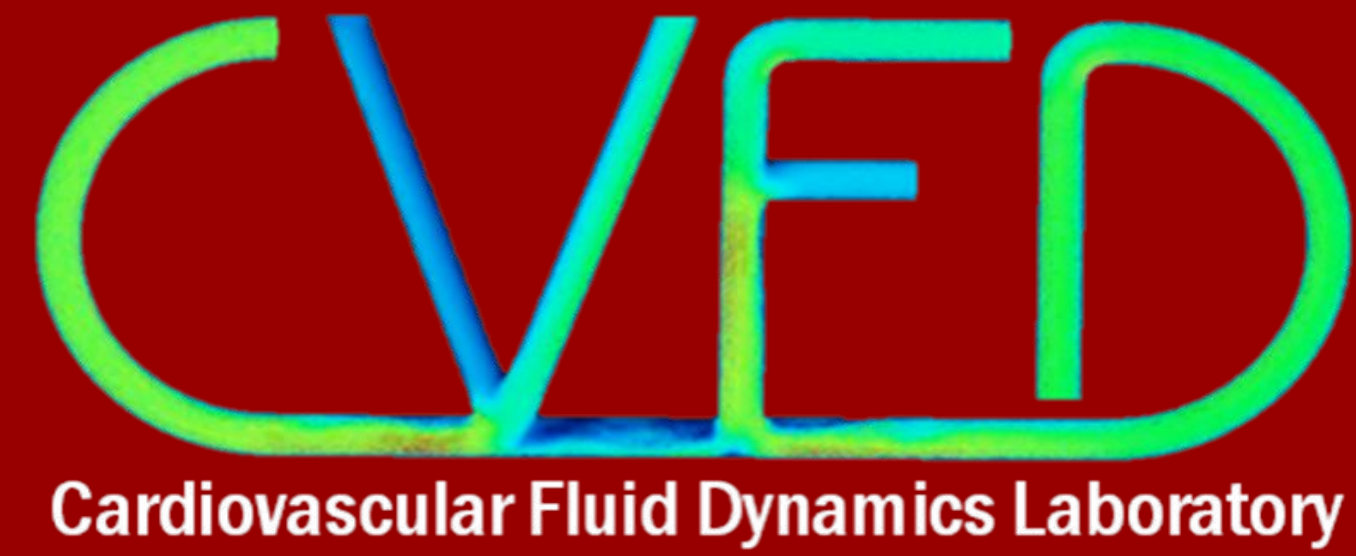


Ultrasound Based Computational Fluid Dynamics Assessment of the Brachial Artery



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Introduction

Background

- Pre-eclampsia [PE] - pregnancy specific syndrome affecting 3-5% of all pregnancies.
 - Associated with significant mortality and morbidity of both the person and the fetus.
 - Leading cause of maternal, prenatal and neonatal mortality.
 - PE is currently characterized by the presentation of high blood pressures along with proteinuria (presence of proteins in urine).
 - If left untreated, PE leads to maternal eclampsia, liver rupture, stroke, pulmonary oedema or kidney failure. Further, it increases the risk of future cardiovascular diseases.
 - Children born to preeclamptic patients tend to be predisposed to bronchopulmonary dysplasia and cerebral palsy.
 - Despite the prevalence, there is a lack of understanding of the pathologies that lead to PE
- Early diagnosis is key for effective management of this condition
- Currently, symptomatically, the diagnosis involves blood pressure tests and urine tests.
- Other proposed tests include invasive and expensive diagnostic tools such as MiRNA testing.
- Underlying conditions such as pre-existing hypertension leads to underdiagnosis of PE and/or misdiagnosis.

Previous studies have established protocols using Wall Shear Stress (WSS) derived parameters as an indicator for PE using computational fluid dynamics.

Aim

Validate this methodology using a larger patient cohort and better investigate the relationship between WSS, hypertension and PE.

Materials and Methods

Patient Information

- Normotensive (NT), hypertensive (HT) and PE patients in their second and third trimesters of a singleton pregnancy were recruited. Exclusion criteria included eclampsia, preterm labor, rupture of membranes, evidence of systemic infections, multifetal gestations and an active autoimmune condition.
- All patients were matched for age, gestational period and parity. All PE patients were prescribed blood pressure medication (labetalol, hydralazine or nifedipine) and magnesium for seizure prophylaxis. Co-morbidities in the PE patients included fetal growth restriction (n=1) and gestational diabetes (n=1). One of the NT pregnant patients had prior morbid obesity and type 2 diabetes mellitus, treated with gastric bypass surgery.
- The study is HIPAA compliant and approved by the The Health Sciences Institutional Review Boards of the University of Wisconsin and UnityPoint-Health Meriter Hospital

Computational Fluid Dynamics

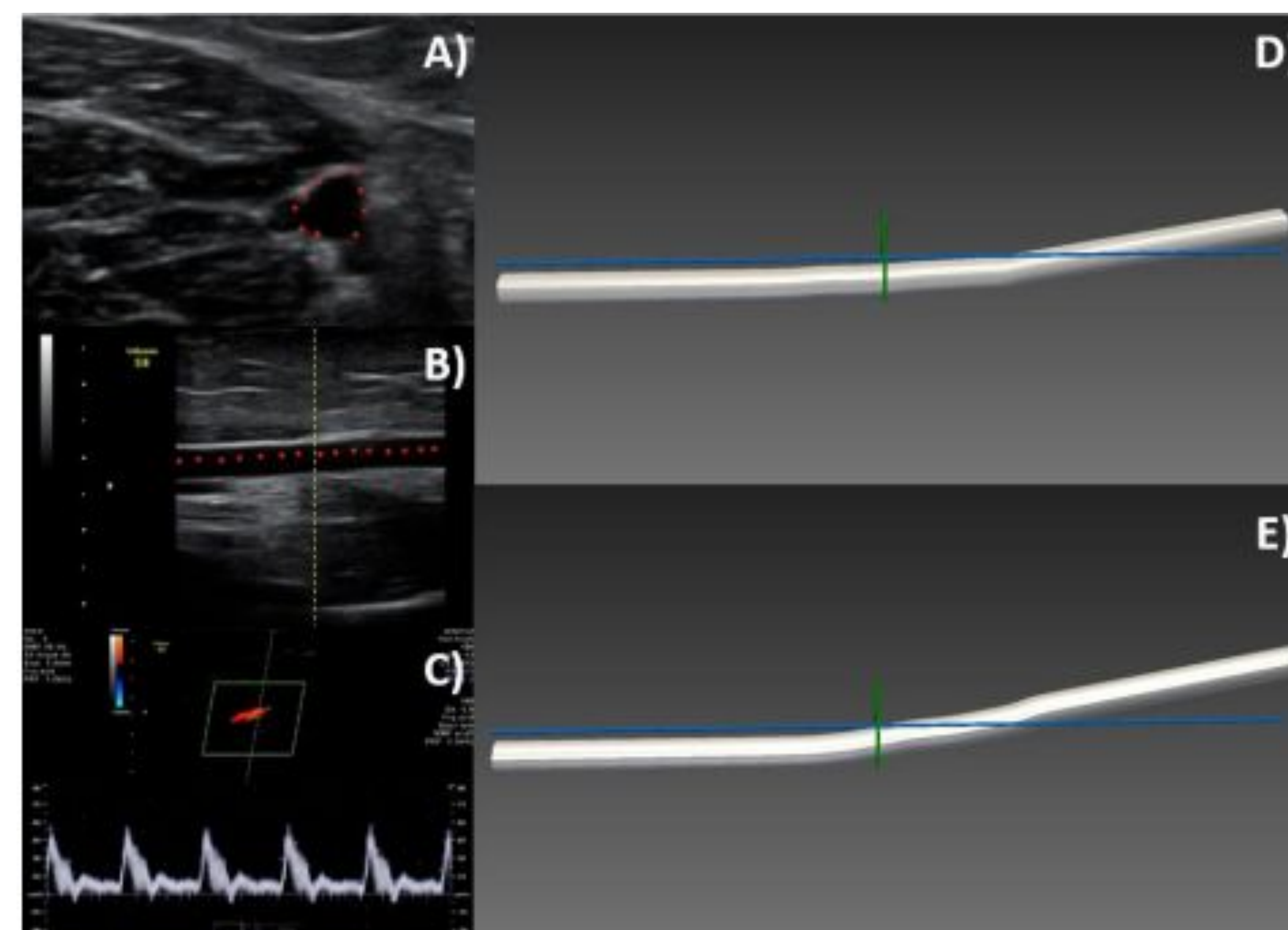


Figure 1: BA WSS evaluation pipeline. A) BA contour, B) BA length, C) velocity profile from doppler, D) pre and E) post-occlusion BA models.

- 2-D Ultrasound (US) scans and doppler scans of the brachial artery of patients of NT, HT and PE patients were processed using a custom MATLAB script to generate 3-D models
- These models accounted for the non-circular cross-sections and non-linear structures of the brachial artery pre and post occlusion using a sphygmomanometer
- Flow curves were then quantified for each model using the doppler scans.
- The models and flow curves thus obtained were imported into SimVascular to simulate blood flow in the modelled artery.
- Time averaged WSS (TWASS), peak systolic WSS, oscillatory shear index (OSI) and TWASS/OSI were obtained.

Results

- Around 115 models were created. Flow curves pre and post occlusion were created for each model.
- Further simulations and calculations are underway to calculate WSS derived parameters.
- These simulations will be used to further investigate the effects of underlying hypertension, including differences between HT, NT and PE Patients.

Conclusions

- This method could prove to be more accessible as it eliminates the need for invasive and expensive diagnostic tools.
- Allows for faster processing of images to provide more patient specific models.
- This enables for a more accurate diagnosis of PE as opposed to the currently available methods.

Future Work

- Process more models
- Optimization and automation of the described process

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