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BLOOD FLOW MODELING AND APPLICATION TO NON-INVASIVE DETERMINATION OF ARTERIAL STIFFNESS

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Cardiovascular diseases are currently a leading cause of mortality in developed countries, due to the constant increase in risk factors in the population. Several prospective and retrospective studies have shown that arterial stiffness is an important predictor of these diseases. Unfortunately, these parameters are difficult to measure experimentally and exhibit large variability across subjects. We propose an approach which permits to determine numerically the arterial stiffness distribution of an arterial network using a one-dimensional model of the temporal variation of section and blood flow in the arteries [1]. The proposed approach solves the inverse problem associated to the reduced model to determine the stiffness of each artery, using non-invasive measurements by echotracking. The validation of this approach is made on experimental networks similar to the one presented on Figure 1.

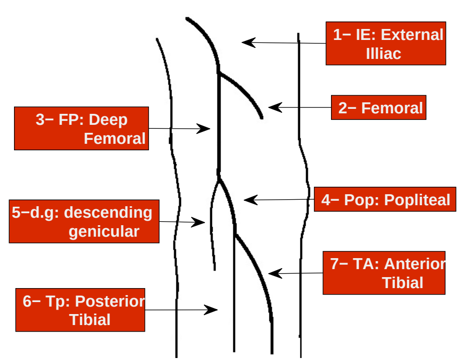

Figure 1: Arterial network of the lower left limb

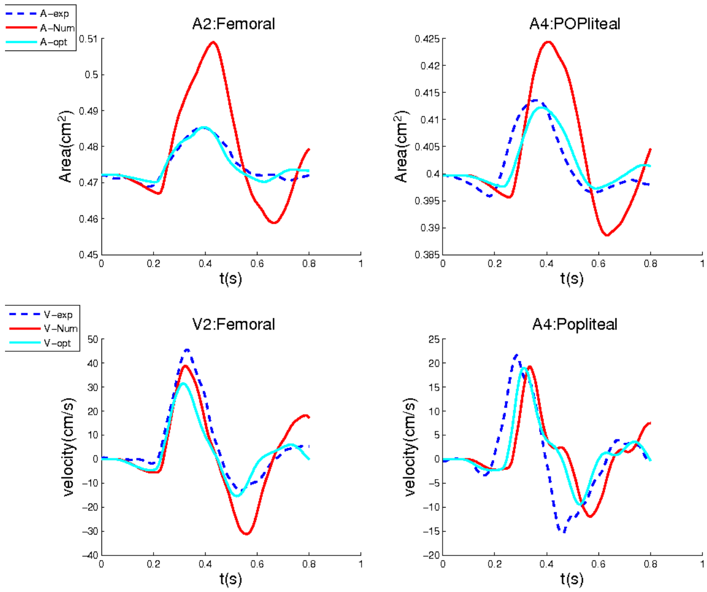

Figure 2: Numerical results before and after optimization compared with the experimental data (A: arterial section, V: mean velocity, Num/Opt: before/after optimization, exp: experimental).

Figure 2 shows a comparison between the experimental and the numerical section and mean velocity for the femoral and popliteal arteries, before and after the optimization process. On this example, the arterial stiffness of each of the seven arteries is only determined with the knowledge of the experimental section and velocity of four of them (iliac, femoral, popliteal and posterior tibial). As it can be seen, the optimization process is found to be a crucial step in order to recover a good accuracy with experimental measurements. Other results will be presented in order to show the robustness of this approach with less experimental measurements and its patient specificity.

Conclusion

A seven arteries network of the lower limb has been reliably reconstructed through a one dimensional fluid/structure blood flow model. After an optimization process, this model reproduces with a very good accuracy and at a low cost, the experimental velocity and section profiles in each artery and estimates one of the essential parameters characterizing cardiovascular diseases that are the arterial stiffnesses. In the near future, the goal is to provide to the practitioner a tool allowing a precocious and reliable diagnosis of cardiovascular risk for any patient based on a non-invasive exam.

REFERENCES

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