Numerical Analysis of Coupled Mechanical and Hydraulic Effects Induced by a Blood Pressure Meter

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Blood pressure is an essential measure when it comes to the health. All around the world, a high number of people are suffering from hypertension or low tension, and knowing that these diseases can lead to death, it is from great interest to know the blood pressure with accuracy. For instance, an increase of 5mmHg will double the risks of cardiovascular diseases, it is therefore essential not to underestimate the blood pressure. But it is also important not to overestimate it, cause that would lead to useless treatments, which are costly and sometimes risky if the patient is in good health.

The actual methods for the measurement of the arterial pressure, by induction of a pressure through an armband; with a control device called sphygmomanometer; introduce some significant errors. Those are caused by the impossible exact adequacy of the band's dimensions (either the length or the circumference) and the arm's ones.

The goal reached at the Institute of Civil Engineering of Liège is to study and simulate the discharge of the blood in the arteria during blood pressure measurement, but also in more general cases. If this can be done, the response of the fluid to the external pressure of the band could be obtained, and finally appropriate corrective factors between the true pressure and the read one could be determined. From this perspective, researchs are carried out with the aim of giving these subjects an engineering view… The arteria can be modelled as a particular deformable pipe, when the blood is actually a fluid with specific properties. Thus the researches cover two complementary and interconnected domains, so be it the solid mechanics and the hemodynamics.

With the solid mechanics, one can obtain analytic relations between the external strains (not only the armband's pressure, but also the blood pressure) and the deformations, using either linear or non-linear theories. In this manner, the way the arteria changes its shape may be determined. Given the obtained deformations for the arteria, it remains to study the discharge of the blood in this particular deformable pipe, what has been done with specific original models, but also with the modelling system WOLF, which is a finite volume flow simulation model developed within the Laboratory of Applied Hydrodynamics and Hydraulic Constructions (HACH) of the University of Liège. Behind these theoretical studies, bigger challenges arise. It effectively appears that while the medical understanding of the phenomenon is real, the knowledge of many factors is quite poor. Thus many things, like e.g. the boundary conditions or the mechanical parameters (depending on the choosen material model) of the muscle, have to be determined using experiments. In this way, the authors have conducted a number of parallel researches about anatomical and physiological data, with the final purpose of completing and calibrating the models, but also to finally validate their accuracy.

From a medical and a humanistic point of view, a practical perspective would be to integrate such models to control devices, if possible with low monetary costs. Everyone could then have a reliable measure and also an adequate treatment if needed.