Experimental Study Of The Influence Of Mechanical And Hemodynamic Parameters On Abdominal Aortic Aneurysmal Growth

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Objective: Abdominal aortic aneurysms (AAA) growth and rupture result from complex interactions between hemodynamics, wall mechanics and biochemical phenomena. Biological knowledge of the arterial network is more advanced than knowledge of its mechanical behavior (fluid, wall, interactions). Moreover, therapeutic approach is based on a statistical rather than individualized risk approach.

This work aims to use a mock circulatory loop integrating AAA phantoms to increase knowledge about AAA pathophysiology from a strictly mechanical point of view. All data (frequency, flow, pressure, viscosity…) are to be integrated within a platform coupled with a digital twin.

Methods: We have designed a bio-relevant circulatory loop (Fig. 1) comprising a pulsatile speed-controlled centrifugal pump, an aortic valve and an aortic arch phantom modulating the flow profile at the phantom inlet. It also includes downstream windkessel models and an extravascular immersion tank. Two types of phantoms are integrated (molded or 3D-printed). Ongoing tests are evaluating their mechanical characteristics, which seek to mimic those of the arterial wall and its complex microstructure (anisotropy and non-linear viscoelasticity) using compliant materials, 3D-printing, multilayer molding and inclusion processes.

Fluids are Newtonian (water-glycerol mixture) or can model the rheo-thinning behavior of blood when adding xanthan gum.

Our loop is equipped with flow-meters, pressure sensors, echo-Doppler and particle imaging. The phantoms can be characterized (tensile tests, inflation tests, photography or scanning) at different times.

Results: This work seeks to create an AAA model likely to grow after cyclic loading. In particular, we will evaluate the predictive character of growth of a new physio-marker of fluid-structure instability, as well as the role of mechanical fatigue. Measurements are currently in progress.

Conclusions: This project will enable us to experimentally identify purely mechanical factors influencing the structure of the arterial wall and hence its shape. It will also provide more data for numerical simulation.

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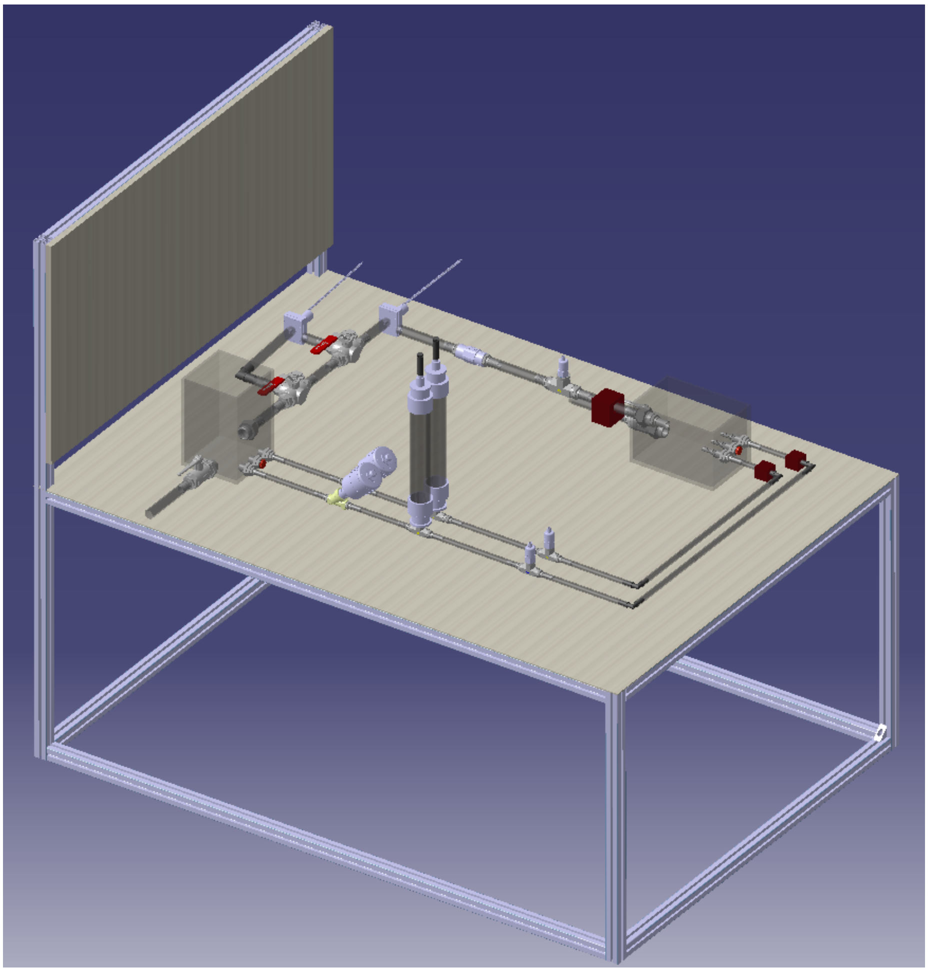

Fig. 1. 3D design of the circulatory loop.