



In silico modeling in cardiovascular medicine: from fundamental research to entrepreneurship and back

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Cardiovascular diseases represent one of the leading causes of mortality in industrialized countries. In this context, surgery has undergone major technological developments over the past 20 years with the development of endovascular interventions and the systematic use of 3D/4D imaging in X-ray tomography and now in MRI.

Nevertheless, the technical difficulties encountered during surgical interventions remain very significant. The consequences in the event of complications (thrombosis, perforation) can be very serious (hemorrhage, renal failure with dialysis, intestinal necrosis, liver failure) and put the patient's life at risk, which unfortunately happens in approximately 10 to 20% of cases.

In order to eradicate these complications, we have developed **realistic, personalized and predictive digital simulation tools** that make it possible to anticipate these risks upstream of the intervention and thus avoid them by making the intervention safe. These tools have been industrially transferred to the start-up Predisurge and they now allow in clinical routine a selection of endovascular tools, tool/tissue interaction phases and the activation of simulation results to return relevant information to the user.

We are developing in parallel tools to simulate the result of long-term surgical actions by modeling tissues at the cellular level and mechano-chemo-biology. We are developing numerical simulations of the mechanisms by which tissues are damaged (under the action of aging) and how these mechanisms can lead to their rupture, numerical simulation of the microstructural mechanisms at the origin of the resistance of arteries subjected to various types of stress, numerical simulation of the growth and remodeling scenario of each patient's aneurysm, from 4D MRI data.

All this, once integrated into augmented reality platforms, will **allow the surgeon to be able to evaluate in real time the possible impact of his decisions** so that each patient can be treated with zero risk of complications.