BIOENGINEERING AND MEDICAL-SURGICAL SCIENCES

Cardiovascular Engineering Tools

Funded By
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Context of the research activity
Research of novel in silico approaches leading to (1) a better understanding of physiological systems, and to (2) the development of new and affordable tools for cardiovascular diseases. In parallel, the developed tools will support (1) the optimization and exploration of multiple designs of blood recirculating devices, (2) an effective clinical diagnostics and decision support, and (3) a deeper comprehension of the biomechanical phenomena determining treatment outcomes, which are all key points for more sustainable health systems in international research programs.

Objectives
About 17.9 million people die from heart disease each year—that is 1 in every three deaths. Furthermore, the economic burden of heart diseases in Europe today appears to exceed 210 billion euros per year, with clearly increasing trends for the coming decades, according to the European Society of Cardiology Realities 2019. As a result, physicians will have more limited time per patient to make life-threatening decisions with little data, leading to poor patient outcomes and an economic burden to the healthcare system. Therefore, it is vital to bring patient-specific early cardiovascular diagnostics, detection, and planning technology to provide the proper treatment to patients, help healthcare professionals save time, and allow the healthcare system to save costs.

In this framework, in silico methods based on patient-specific models can provide a comprehensive understanding of the mechanisms at the basis of the onset and progression of cardiovascular diseases, as well as of the relation between cardiovascular devices design and the post-procedural outcomes. A key advantage of the use of a computational approach lies in the possibility to account for the interaction between blood fluid dynamics and vascular wall as well as transport of biochemicals. The research of novel in silico approaches, coupled to a better understanding of physiological systems, could lead to the development of new and affordable tools for cardiovascular diseases, thus allowing for (1) the optimization and exploration of multiple designs of blood recirculating devices, (2) an effective clinical diagnostics and decision support, and (3) a deeper comprehension of the biomechanical phenomena determining treatment outcomes, which are all key points for more sustainable health systems in international research.
The objectives of the research activity within the Doctoral program are manifold and interlaced:

- To develop quantitative diagnostic, predictive and intervention-optimization tools for cardiovascular diseases to support personalized interventions and clinical decision making, allowing patient-specific prediction of the outcome of therapeutic interventions;
- To uncover biomechanics-based mechanisms impacting the onset/progression of cardiovascular disease and the post-procedural outcome of cardiovascular devices;
- To design, evaluate and optimize cardiovascular devices through the study of their effects on the physiologic function;
- To lead multidisciplinary collaborative efforts to translate engineering-based findings and developments into clinical practice.

These objectives can be achieved through the tight integration of medical imaging, computational solid mechanics, computational fluid dynamics, and Artificial Intelligence. Building up an integrated framework for personalized cardiovascular in silico medicine compatible with clinical times will advance computational biomechanics offering a powerful means to augment clinical measurements and medical imaging to create non-invasive diagnostic, predictive and optimization tools.

**Skills and competencies for the development of the activity**

- Cardiovascular solid and fluid mechanics;
- Transport phenomena;
- Image processing;
- Computational solid and fluid mechanics;
- Computer programming;
- Machine learning