UNIVERSITÉ CÔTE D'AZUR

BoostUrCAreer call for PhD projects

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Title: **Electromechanical Modelling of the Right Ventricle: the Forgotten Chamber**

Acronym of the PhD Project: **RV-Model**

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Electromechanical modelling of the heart has been an active research area in the last decades. Several mathematical models of cardiac electrophysiology and biomechanics have been proposed in the literature, as well as personalisation processes to fit such generic models to a specific patient data. However most of the research focus was on the left ventricle, while the right ventricle has been mostly ignored.

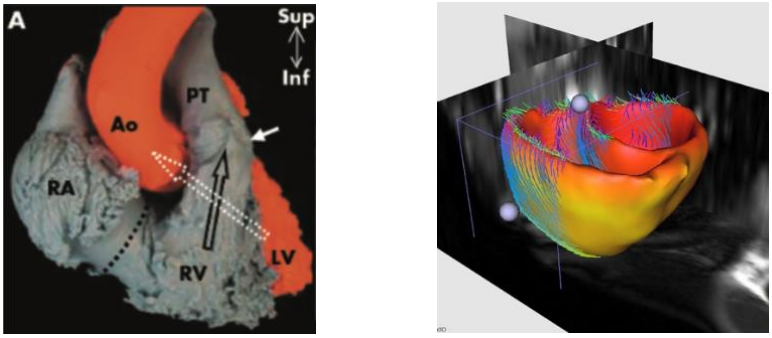

Figure 1: Right ventricular anatomy and electromechanical model of the heart [1]

However, right ventricular (RV) function evaluation is of utmost importance in heart failure, congenital heart disease, pulmonary arterial hypertension, pulmonary embolism, and most of respiratory diseases. Indeed, volume and pressure overload can affect the RV contractility and lead to RV remodelling in terms of shape and function. RV remodelling affects the patient's prognosis, especially in congenital heart disease patients and pulmonary hypertension but also in a widely spread disease: heart failure.

In patients with left ventricular dysfunction, the most important prognostic parameter is the occurrence of RV dysfunction. Thus, it is of critical importance to understand and recognize early RV dysfunction, to identify high risk patients. Knowledge about the left ventricular adaptation to afterload stress is already available, however, the RV is very different from the left ventricle, even from an embryologic point of view. Differences begin early during the foetal stage and right heart failure differs from left heart failure, even in terms of response to therapy (beta-blockers for example might not be as beneficial in patients with right heart failure as it is in left ventricular systolic dysfunction). While only little is known about RV response to afterload changes, it is a crucial problem as it occurs frequently. An important contributing factor is the activation delay of the RV, which occurs frequently, especially in case of bundle branch block. In imaging studies, electrical dyssynchrony has been associated with mechanical dyssynchrony. As when dyssynchrony occurs, the RV fails; studying the electromechanical activation of the RV is therefore important to understand the mechanisms behind the impairment of RV function.

The research proposed in this project is therefore original as it will develop new models for an insufficiently explored although important cardiac chamber. Over the last 20 years, Inria has developed state-of-the-art mathematical models of the myocardium, as well as methods to

personalise such models to clinical data for diagnosis and therapy planning. However these models have only been evaluated and used for the left ventricle [1]. Nice University Hospital has developed an expertise in the clinical evaluation of the right ventricle, with state-of-the-art tools for detailed analysis of the RV shape and function and numerous clinical publications. Collaborative work with Inria enabled to develop original methods for shape and deformation analysis [2]. The combination of these two research areas opens up possibilities for a better understanding of the RV function and for the design of better tools for clinical data analysis.

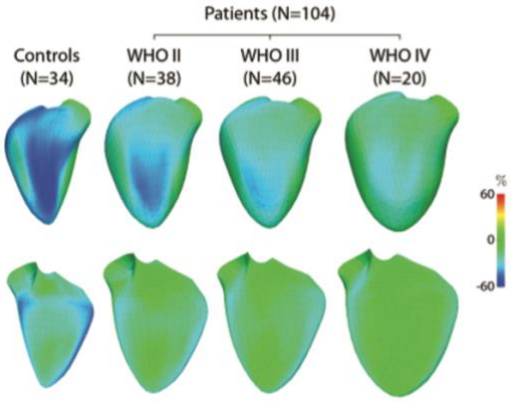

Figure 2: Shape and deformation analysis in pulmonary hypertension [2]

Specific research objectives: to build a detailed electromechanical computer model of the RV which can be personalised to clinical data in order to provide mechanistic insights in RV function and therapy guidance.

This project is in collaboration with UPF in Barcelona, which developed a detailed model of the RV fibrous structure, which impact on simulations started to be explored [3], and with Philips in Paris, which has an important know-how on ultrasound image processing and simulation using electromechanical models for tool validation [4].

Gender aspect: Cardiovascular diseases (CVD) is the main cause of death in men in all but 12 countries of Europe and is the main cause of death in women in all but two countries. There are specific risk factors to take into account in order to improve management of CVD in women (hypertensive disorders of pregnancy, gestational diabetes, breast cancer treatment...). These have been largely understudied until now. The student will be sensitised these differences in CVDs for his analysis.

References

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