Hemodynamic consequences of ventricular tachycardia*

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The contraction of the heart during a heartbeat is the consequence of the synchronized reaction of the myocardium to the propagation of a non-linear electrophysiology wave. Such scenario, however, can be altered in pathological conditions, such as when ventricular tachycardia or ventricular fibrillation manifest. These phenomena are related to the non physiological impulse propagation within the tissue, namely spiral and scroll waves, which are often triggered by the presence of defects introduced by myocardial infarction. In particular, the scar region is known to act as a support for the generation of scroll waves owing to the high conductivity difference between healthy and pathological tissue. While the dynamics and formation of arrhytmogenic patterns is widely studied in literature [1, 2], their consequences on the cardiac hemodynamics are rarely taken into account. In this work, we aim at investigating what are the effects of ventricular tachycardia on the more relevant bio-markers, in particular, determine what pathological electrophysiology patterns have the most significant impact on the physiological blood flow dynamics in the left heart and try to understand the optimal treatment. To this aim, the tissue activation data of a patient affected by an arrhythmogenic ventricular scar mapped through the CARTO® 3 system, has been used in order to fine tune the heterogeneities of the substrate for the electrophysiology model in order to trigger reentries in the myocardium. The electrophysiology is then solved trough a monodomain model coupled with suitable cellular models encompassing the hetoregeneity of the myocardium owing to the presence of healthy tissue, peri-infarct region and scar tissue. The corresponding hemodynamics is then solved by integrating the Navier-Stokes equations, which are discretized using a staggered finite differences complemented with immersed boundary techinques [3]. The resulting multi-physics system can be then exploited as a predictive tool to reproduce ventricular arrhythmias and try to understand what is the optimal intervention in order to restore the physiological cardiac function.

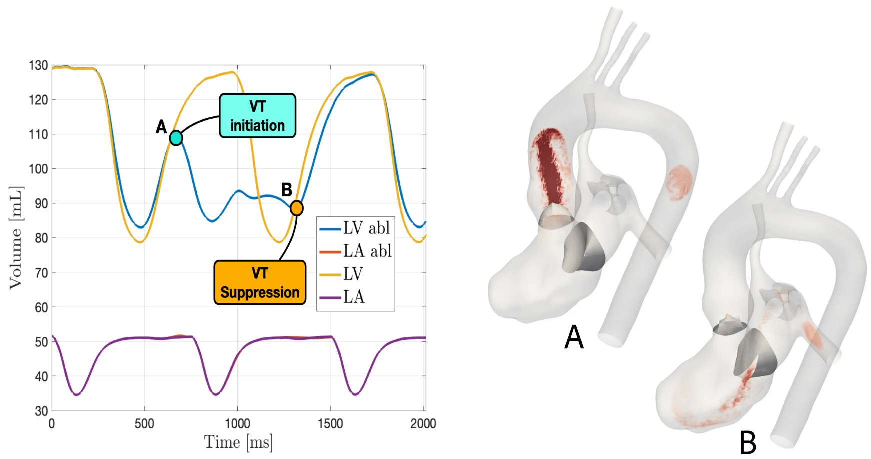

Figure 1: Time evolution of the left ventricle volume (blue line) in the post-intervention setting, which has been realized numerically to suppress the ventricular tachicardia. As a reference it is also reported the corresponding volume profile for a healthy case (yellow) and the left atrial volume (red/purple lines, which are superimposed in the two cases).

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