Atrioventricular Delay Optimization in Cardiac Resynchronization Therapy Assessed by a Computer Model

Kevin Tse Ve Koon*, Christophe Thebault, Virginie Le Rolle, Erwan Donal and Alfredo Ignacio Hernández

LTSI, Université de Rennes 1, Rennes, France

Clinical studies have shown that patient response to Cardiac Resynchronization Therapy (CRT) is highly dependent on the pacing configuration namely the atrioventricular (AVD) and interventricular (VVD) delays; the former being the most sensitive parameter. Current research in this field is oriented towards individualization of AVD and VVD, in order to maximize patient response. Different echocardiographic indicators have been proposed to optimize CRT delivery. Maximizing left ventricular filling is widely regarded as the optimization target to achieve, with respect to AVD selection. This feature can be obtained through the pulsed-wave Doppler (PWD) recording of the mitral inflow. A lumped-parameter model of the cardiovascular system made of three interacting modules (an electrical heart model, an elastance-based mechanical heart model and a circulatory system), previously proposed by our team was used to analyze the mitral flow during AVD optimization. A sensitivity analysis of different model parameters is first carried out, showing that left ventricular diastolic compliance, electro-mechanical delay and elastance function forms are the most important model features affecting mitral flow. Patients undergoing CRT at the Pontchaillou University Hospital were included in a device optimization protocol. For different AVDs, the audio signal corresponding to the PWD of the mitral flow was acquired for at least three cardiac cycles and processed by short-term FFT. A contour-tracing algorithm was applied to the average recorded mitral flow to obtain its profile. Finally, parameter identification of the proposed model was performed to minimize a relative mean squared error (rmse) calculated between the observed and the simulated mitral flows (for all AVD). Data from three patients provided rmse values of 0.049, 0.13 and 0.18. This model is capable of reproducing the main mitral flow profiles observed clinically and may be useful in performing AVD optimization in a postoperative context.