Relationship between Electrical Instability and Pumping Performance during Ventricular Fibrillation: Computation Study

Da Un Jeong, Ki Moo Lim*

Department of IT Convergence Engineering, Kumoh National Institute of Technology, 61, Daehak-ro, Gumi, Gyeongbuk, 39253, Republic of Korea (South)

Many researchers have investigated dominant frequency, surface phase singularity and filament behavior observed in ventricular fibrillation (VF) for understanding VF mechanisms. However, they didn't predict quantitative severity of VF at the viewpoint of cardiac mechanics. Therefore, in this study, we compared quantified data of electrical instability and ventricular pumping performance.

Dominant frequency is defined as the frequency with maximum power through FFT analysis. Phase singularity is the point where the phase is undefined, and sum of the phase around singularity point is 2π or -2π. Filament is defined as the curve connecting to phase singularities existing on the surface and inside of ventricular model. In order to quantitatively predict the severity of VF, we compared dominant frequency, phase singularity, and filament in wild type (WT) and S140G mutation conditions.

Previously we have found that S140G mutation induced VF easily and lessened contractility in re-entrant condition. Stroke volume under S140G mutation was reduced by 34% from that under WT condition. Then, dominant frequency in WT was 3.7 Hz and had 0.9 Hz of bandwidth, while 4.8 Hz and 1.2 Hz of bandwidth in S140G mutation. The probability of alternans was higher in S140G mutation compared to WT. In this study, phase singularity in S140G mutation (44772) was observed more than in WT (34342). The number of filaments was 1380 in S140G mutation compared to WT (87). In addition, the frequency of birth and death of filaments was higher in S140G mutation condition. As a result, the higher frequency of electrical excitation and the more phase singularity are, the lower cardiac output was made. Filament is related to the pumping performance in VF. In conclusion, dominant frequency, phase singularity and filament can be an index of cardiac contractility in VF as well as a measure of the complexity of vortex patterns.