Elimination of Spiral Waves in Two Different Models: Electrical Defibrillation Revisited

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Background: Ventricular fibrillation is theoretically simulated by chaotic spiral waves. This kind of spiral wave is eliminated clinically by direct current (DC) defibrillation shock. However, experimental subthreshold, multisite pacing organizes such fibrillatory waves and improves the defibrillation efficacy. Methods: To investigate possible defibrillation by fixed-frequency alternative current (AC) and to compare the defibrillation efficacy of AC with that of DC, two different cardiac models (Aliev-Panfilov model and Luo-Rudy model) were adopted, because these two models were in sharp contrast in considering whole heart excitability and individual kinetics of many cardiac ion channels. Appropriate periodic boundary conditions were provided. Results: In Aliev-Panfilov model, alternans instability was observed by decreasing control parameter representing excitability. DC shock showed nominal defibrillation threshold (DFT) of 0.20 (dimensionless), whereas AC showed DFT of 0.036. In Luo-Rudy model, alternans instability was observed by reducing system size. The same was true in that DFT in DC shock is far greater than that in AC application. Moreover, AC defibrillation is most effective when external AC frequency is set close to the resonance condition. Conclusions: AC defibrillation is feasible in two different numerical simulations with very low DFT. Considering time-periodic change of DFT in AC defibrillation, a part of the low DFT in AC is accounted for by resonance phenomenon. Keywords: defibrillation, chaos, simulation