Abstract Submitted
for the MAR11 Meeting of
The American Physical Society

Feedback control for stabilizing chaotic spiral waves during cardiac ventricular fibrillation[1] ILIJA UZELAC, JOHN WIKSWO, Vanderbilt University, RICHARD GRAY, Food and Drug Administration — The cardiac arrhythmias that lead to ventricular fibrillation (VF) arise from electrical spiral waves (SW) rotating within the heart with a characteristic period τ. A single drifting SW can degenerate into a chaotic system of multiple SWs and VF. Hence early SW detection and termination is crucial to prevent VF. Time-delayed feedback control (TDFC) is well known approach for stabilizing unstable periodic orbits embedded in chaotic attractors. We hypothesize that cardiac SWs can be stabilized by TDFC with a time-delay of τ. Implementing this approach will require precise, closed-loop control of the charge delivered to the heart during the defibrillation process. To do this, we have developed a 2 kW arbitrary-waveform voltage-to-current converter (V2CC) with a 1 kHz bandwidth that can deliver up to 5 A at 400 V for 500 ms, and a photodiode system for recording in real time an optical electrocardiogram, OECG(t). The feedback signal driving the V2CC will be the time-difference (OECG(t) - OECG(t-T), where we hypothesize that T is τ, the period of the SW. This may dramatically decrease defibrillation voltages by using a defibrillation waveform customized to the VF event, unlike commercial capacitor defibrillators.

[1]Supported in part by NIH R01 HL58241-11 through ARRA 2009

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Date submitted: 19 Nov 2010 Electronic form version 1.4