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Solving heterogeneities in defibrillation for a vascular remodeling of the heart

Arianna Pahlavan
Jericho High School Senior, USA

Acute cardiac arrhythmias are the main cause of death in industrialized countries; despite clinical importance, the mechanisms behind the onset and dynamics of cardiac arrhythmias are still poorly understood. The purpose of this work is twofold: (1) determine how smaller blood vessel radii affect the moving wave-front velocity, virtual electrode (VE) formation, and transmembrane potential induced by a shock (2) to elucidate a minimum radius correlative to shock strengths of interest. The model described here resolved tissue dynamics with a second-order solution to Poisson's equation uniformly to boundaries. Through examining the role of small blood vessels, a minimum radius was identified at which a current will propagate, a range of 100-400μm. The velocity of the moving wave-front remained constant and no VEs form in the blood vessel region for all blood vessels below the size of the minimum radius. An alteration of fiber orientation, perpendicular to parallel, caused a twofold reduction in minimum radius. Blood vessels of radii 400μm do not affect the propagation of a 6V, 3V, 1.5V, 0.75V, and 0.33V induced shock strengths. Thus, 400μm blood vessels can be excluded from the first ever vascular mathematical model of the human heart at a feasible cost. An accurate anatomical model is needed to computationally verify the results of low energy anti-fibrillation pacing (LEAP) for the implication of painless defibrillation therapy in hospitals. The implementation of low energy automated defibrillators will save the US $1.1 trillion annually and universalize the CPR protocol for the minimization of anoxic encephalopathy. Future investigations may involve nanoparticles monitoring the cardiac ion channel currents and activating a painless electric shock where re-entry begins to occur, a potential solution to sudden cardiac arrhythmia death.

Biography

Arianna Pahlavan is working with Professor Glimm at Stony Brook University. She was able to elucidate anatomical cardiac geometries for the first-ever efficacious vascular remodel of the human heart-a step necessary for the implication of painless defibrillation therapy in hospitals. She spent much of her time debugging tens of thousands of lines of code, in which her solutions were often met with more debugging challenges. She savored the challenging and almost addictive cycle. These accomplishments helped her to further define her career ambitions, and both came directly as rewards for her hard work and academic enthusiasm.

ariannapahlavan@yahoo.com

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