Anatomical modeling of electrical and mechanical function of the heart.
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Cardiac arrhythmias and sudden cardiac death is the leading cause of death accounting for about 1 death in 10 in industrialized countries. Although cardiac arrhythmias have been studied for well over a century, their underlying mechanisms remain largely unknown. One of the main problems in studies of cardiac arrhythmias is that they occur at the level of the whole organ only, while in most of the cases only single cell experiments can be performed. Due to these limitations alternative approaches such as mathematical modeling are of great interest. From mathematical point of view excitation of the heart is described by a system of non-linear parabolic PDEs of the reaction diffusion type with anisotropic diffusion operator. Cardiac arrhythmias correspond to the solutions of these equations in form of 2D or 3D vortices characterized by their filaments.

In my talk I will present a basic introduction to cardiac modeling and mechanisms of cardiac arrhythmias and briefly report on main directions of our research, such as development of virtual human heart model, and study organization of ventricular fibrillation due to dynamical instabilities in cardiac tissue. I will also report on modeling mechano-electric feedback in the heart using reaction-diffusion mechanics systems and ventricular fibrillation mechanisms due to deformation of cardiac tissue.

I will present our recent studies on arrhythmias due to early after depolarizations (EADs). EADs occur in many forms of genetic defects such as the long QT syndrome or under the action of pharmacological agents as a result of cardiotoxicity. I will also present our studies on the arrhythmias which occur due to fibrosis of cardiac tissue. We discuss importance of heterogeneity for the onset of the arrhythmias and recently found effect of attraction of sources of arrhythmia to the regions with a high degree of fibrosis. Finally we discuss possibilities of application of our approaches to clinic.