BIOCHEMICAL MECHANISMS INVOLVED IN CARDIAC DYSRHYTMIAS

Ducantoni Daniela[1], Timercan Tatiana[2]
[1] *Nicolae Testemitanu* State University of Medicine and Pharmacy, Chisinau, Republic of Moldova
[2]Chair of Biochemistry and Clinical Biochemistry, *Nicolae Testemitanu* State University of Medicine and Pharmacy, Chisinau, Republic of Moldova

Introduction: Cardiac dysrhythmias are disorders of impulse generation and conduction in the myocardium caused by molecular alterations in cardiomyocytes. Cardiac electrical activity depends on the maintenance of the resting membrane potential and the cardiac action potential through the function of sodium (Na^+), L-type calcium (Ca^{2+}) and potassium (K^+) channels, as well as membrane ion pumps. Disturbances of calcium homeostasis and cellular energy metabolism represent major biochemical mechanisms underlying myocardial electrical instability. The aim of the research was to elucidate the biochemical and molecular mechanisms involved in the development of cardiac dysrhythmias in order to correlate them with arrhythmia types and antiarrhythmic therapy.
Materials and Methods: 20 scientific articles from PubMed and NCBI databases, published between 2017-2024, were analyzed.
Results: Electrical stability of cardiomyocytes depends on the maintenance of ionic gradients by the Na^+/K^+-ATPase and the sarcoplasmic reticulum Ca^{2+}-ATPase (SERCA2a). During myocardial ischemia, ATP depletion reduces the activity of these pumps, leading to intracellular Na^+ accumulation and reverse-mode activation of the Na^+/Ca^{2+} exchanger resulting in Ca^{2+} overload. Pathological phosphorylation of the ryanodine receptor (RyR2) and altered phospholamban regulation impair calcium reuptake into the sarcoplasmic reticulum, producing spontaneous Ca^{2+} release events and delayed afterdepolarizations. Prolongation of the action potential due to hERG channel dysfunction leads to early afterdepolarizations and torsades de pointes–type arrhythmias. Mitochondrial oxidative stress increases reactive oxygen species production, modifies ion channel function, and decreases ATP synthesis, thereby promoting atrial fibrillation and ventricular tachyarrhythmias.
Conclusions: Cardiac dysrhythmias arise from the interaction between impaired energy metabolism, disruption of Ca^{2+} homeostasis, and ion channel dysfunction. Understanding these mechanisms provides a biochemical basis for antiarrhythmic therapy aimed at electrical stabilization of the cardiomyocyte.
Keywords: cardiac dysrhythmias, calcium homeostasis, SERCA2a, ion channels, oxidative stress, cardiomyocytes