In silico study of gaseous air pollutants effects on human atrial tissue

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Background: Exposure to gaseous air pollutants like carbon monoxide (CO), nitric oxide (NO) and sulfur dioxide (SO_2) promotes the occurrence of cardiac diseases. Studies have shown that CO and SO_2 block the calcium channel (I_{CaL}) of myocytes. SO_2 also increases the sodium channel (I_{Na}), the transient outward (I_{to}) and inward rectifying (I_{K1}) potassium currents. NO blocks I_{Na} and increases I_{CaL}.

Aim: To assess the effects of the gaseous pollutants at different concentrations on human atrial tissue, using computational simulation.

Methods: Based on experimental data, we developed concentration-dependent equations to simulate the gaseous pollutants effects on the ionic currents. They were incorporated in the Courtemanche model of human atrial cell and in a 2D tissue model. A train of 10 stimuli was applied. The APD_{90} was measured. S1-S2 cross-field protocol was applied to initiate a rotor. CO and SO_2 concentrations from 0 to 1000 uM and NO concentration from 0 to 500 nM were implemented. Six concentration combinations were simulated (cases 1 to 6).

Results: Our results in a human atrial cell model are in agreement with results from non-human in vitro and in vivo studies. The gaseous air pollutants cause the APD shortening and loss of plateau phase of the action potential in a fraction that increases as the concentration increases. When the highest concentrations was applied, the I_{CaL} peak decreased by 95%, the I_{Na}, I_{to} and I_{K1} peaks increased by 43%, 96% and 61%, respectively, and the APD_{90} decreased by 81%. In the 2D model was possible to generate rotors from case 4, from 600 μm of CO, 100 μm of SO_2 and 100 nM of NO. The rotors showed high stability.

Conclusion: Our results show pro-arrhythmic effects of gaseous air pollutants on expressed through APD shortening and a rotor generation, during normal electrophysiological conditions.