OPTIMIZATION OF VASOPRESSOR DOSE IN SEVERE TRAUMATIC BRAIN INJURIES USING PULSE-WAVE PROPAGATION MODELING

Each year in European Union around 1.5 million people suffer from traumatic brain injury with about 55 thousand traumatic brain injury accounted deaths. Traumatic brain injury is the leading cause of mortality and morbidity among young individuals in high- and middle-income countries, with its global incidence rising due to the increasing vehicle traffic. In years 2009-2012 in Poland there were approximately 195 thousand hospitalizations related to traumatic brain injury, from which about 13% (about 25 thousand patients) required surgical intervention. Out of those patients that were treated surgically about 21% died (5344 people).

Precise control of systemic blood pressure in severe traumatic brain injury is of utmost importance. Current guidelines suggest maintaining mean pressure levels above certain thresholds, because too low blood pressure can result in a limited blood flow to the brain ultimately leading to cerebral ischemia. The control of blood pressure is especially important in traumatic brain injury patients, because they have already jeopardized blood flow to the brain due to the trauma-related increase in the intracranial pressure.

The most common method applied by the clinicians to keep systemic pressure levels above certain levels is to administer vasopressor agents, such as norepinephrine (noradrenalin). The increased concentration of vasopressors in blood results normally, among others, in increased heart rate and narrowing of small blood vessels (also in the brain), ultimately leading to increased systemic blood pressure. Vasopressors overdose can have, however, severe side effects such as hypertension resulting in cerebrovascular hemorrhage or cardiac ischemia. In the intensive care units clinicians try to avoid those side effects through continuous monitoring of patient's cardiovascular function and manual adjustments of the vasopressor dose. In a typical scenario, when the patient's blood pressure drops below the prescribed threshold, attending clinician increases the dose of vasopressor by a certain amount and observes the response. Vasopressor dose needs to be subsequently decreased and the procedure reiterated in the case of undesirably large increase in the blood pressure or other adverse events. Most importantly, patients' response to drug dose is not instantaneous. Therefore, the above described procedure obviously requires a lot of time and attention from medical staff and it is conceivable that during the drug adjustment period not optimal state of the patient is obtained, what can contribute to increased mortality rates.

The project will propose and evaluate new methods for optimizing vasopressors usage in patients with severe traumatic brain injuries. In particular, we hypothesize that the in-depth analysis of the pressure pulse wave shape at various locations of cardiovascular system augmented with already collected clinical data will allow to decipher what will be the patient-specific response to a given dose of the vasopressor. We will utilize a novel approach based on the mathematical pulse wave propagation modeling that will be used for computer simulations investigating influence of various doses of the drug. The model will allow to quantitatively and qualitatively describe the most important aspects of the influence of the vasopressor on the cardiovascular system. We plan also to gather clinical data in a group of patients with severe traumatic brain injuries that are treated at the intensive care unit. This will allow us to collect information necessary to validate the proposed model. We expect that the project results could be used in the future for better management of traumatic brain injury patients leading to increased survival rates.