Doctoral School of Information and Biomedical Technologies Polish Academy of Sciences

Subject

Cardiovascular system diagnostics: mathematical modeling of pulse-wave propagation in the arterial tree

Supervisors, contact, place of research

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Project Description

Each heartbeat generates a pulse (pressure) wave that propagates in the arterial tree. Several parameters (biomarkers) derived from the pulse aortic waveform are currently used in the clinic to assess the state of cardiovascular system. The aim of the proposed PhD project is to dissect the information contained in the pressure waveform using a mathematical model of pulse wave propagation in order to propose new, more accurate biomarkers. The model should consider elasticity of vessels and describe the changes of the blood flow and pressure throughout the entire arterial tree as a function of time. We assume that the model will be expressed as a multiple systems of partial and ordinary differential equations coupled at the branching points of the arterial tree. The model will be calibrated with clinical data from pulse wave measurements at different points of the arterial system and other hemodynamic parameters. The Laboratory of Mathematical Modeling of Physiological Processes is equipped with a device for non-invasive assessment of arterial stiffness and central pressure containing an applanation tonometer (SphygmoCor, AtCor Medical) and an impedance cardiograph (PhysioFlow). Those devices allow for assessment of many parameters such as: pulse wave velocity, aortic pressure, augmented pressure, augmentation index, subendocardial viability ratio, ejection time, stroke volume, cardiac output, systemic vascular resistance, etc. The use of mathematical modeling for the analysis of parameters describing the cardiovascular system will provide detailed information on the propagation of the pulse wave and factors that affect its characteristics. The analysis of clinical data of groups of patients with various diseases will hopefully allow for better diagnosis and optimization of therapy.

An example of the application of mathematical wave modeling to the analysis of medical data can be found in [1,2].

Bibliography

1. J. Poleszczuk, M. Dębowska, W. Dąbrowski, et al. Patient-specific pulse wave propagation model identifies cardiovascular risk characteristics in hemodialysis patients. PLoS Computational Biology, 2018.
2. J. Poleszczuk, M. Dębowska, W. Dąbrowski, et al. Subject-specific pulse wave propagation modeling: Towards enhancement of cardiovascular assessment methods. PLoS One, 2018.

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