Contribution ID: **33** Type: **Oral**

Advances on the modelling of blood flows and pressures in humans through a new multiscale mathematical model

Wednesday, 11 September 2019 12:10 (20 minutes)

Many biophysical factors affect human circulation, so that a satisfactory understanding of its behavior is challenging [1]. Moreover, congenital vascular disease is the leading cause of pediatric death, and it is proven that physiological parameters such as cardiac output, cerebral blood flow, and arterial stiffness are related to age [2]. For these reasons, the assessment of cardiovascular structure and function is recognized as a main topic in the history of scientific research [3]. We developed a mathematical model to simulate cerebral and extracerebral flows and pressures in humans. The model is composed of an anatomically informed 1-D arterial network [4] [5], and two 0-D networks of the cerebral circulation and brain drainage, respectively [6] [7]. It takes into account the pulse-wave transmission properties of the 78 main arteries and the main hydraulic and autoregulation mechanisms ensuring blood supply and drainage to the brain. Proper pressure outputs from the arterial 1-D model are used as input to the 0-D models, together with the contribution to venous pressure due to breathing that simulates the drainage effect of the thoracic pump. The model is able to evaluate the effects of reduced/elevated carbon dioxide in the blood (hypo/hypercapnia) [8], and to compare adult and pediatric circulation through a straightforward calibration of the parameters. Proper MRI and ultrasound datasets were used to extract information about blood rheology (e.g. blood velocity and flow), and vessel status (hydraulic resistance and capacitance, inner pressure and cross section area). The model has the potential to predict important clinical parameters before and after physiological and pathological changes with focus on head and neck circulation, such as posture changes, vessel occlusions, venous thrombosis, and congenital diseases.

[1] Fung. Biomechanics. Circulation, edited by Springer-Verlag (New York, USA, 1997)
[2] C. Wu, J. Am. Heart Assoc. 5(1), e002657 (2016)
[3] K.P. George, Eur. J. Appl. Physiol. 118(6), 1079 (2018)
[4] M. Majka, Math. Biosci. 286, 16 (2017)
[5] M. Majka, Phys. Rev. E. 95(3-1), 032414 (2017)
[6] G. Gadda, Am. J. Physiol. Heart Circ. Physiol. 308(3), H217 (2015)
[7] G. Gadda, AJNR Am. J. Neuroradiol. 37(11), 2100 (2016)
[8] G. Gadda, Eur. J. Appl. Physiol. 118(11), 2443 (2018).

Summary

Topic

1. Applications and interdisciplinary subjects

Primary authors: GADDA, Giacomo (Istituto Nazionale di Fisica Nucleare, Sezione di Ferrara); Ms MOHAMMADYARI, Parvin (Department of Physics and Earth Sciences, University of Ferrara); Prof. GAMBACCINI, Mauro (Istituto Nazionale di Fisica Nucleare, Sezione di Ferrara - Department of Physics and Earth Sciences, University of Ferrara); Prof. TAIBI, Angelo (Istituto Nazionale di Fisica Nucleare, Sezione di Ferrara - Department of Physics and Earth Sciences, University of Ferrara)

Presenter: GADDA, Giacomo (Istituto Nazionale di Fisica Nucleare, Sezione di Ferrara)

Session Classification: Morning Session 2