UNIVERSITÀ
DI TRENTO
Dipartimento di
Matematica

DOTTORATO

CYCLE 34th
ORAL DEFENCE OF THE PHD THESIS

Monday 25 July 2022 – at 10:00 am
Seminar Room “-1”

The event will take place online through the ZOOM platform.
To get the access codes please contact the secretary office

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PhD Student in Mathematics

Computational modelling of global haemodynamics and its interaction with cerebrospinal fluid and brain dynamics with application to essential hypertension

Abstract: It is becoming increasingly accepted that bodily fluid systems and their interactive dynamics play a major role in human-body physiology and pathology. Mathematical modelling of these systems represents a useful tool to better understand the complex physiological mechanisms of different diseases. In this field, we will present a multiscale model of the global, arterio-venous circulation in the entire human body which represents an enhanced version of the original Müller-Toro mathematical model.
After that, we will focus on two major medical applications: firstly, the potential link between the venous circulation and several neurological pathologies, secondly arterial hypertension.
We will address the coupling between the circulation and a refined description of the cerebrospinal fluid (CSF) dynamics in the craniospinal cavity. Two versions of the CSF model will be presented; both versions account for deformations and interaction between the cerebral vasculature, brain parenchyma and CSF compartments during the cardiac cycle. We will computationally show that intracranial pressure is the result of a dynamic interaction between the CSF production, the arterial pulsation, the venous reabsorption of CSF and the ability of the spinal subarachnoid space in accommodating the displaced CSF from the cranial spaces. This interaction is reflected in the intracranial pressure waveform with its physiological landmark peaks, both in healthy and pathological conditions.
The last part of the talk will deal with a computational study on arterial hypertension in the context of a global model. We will discuss on the importance of controlling the total amount of blood volume in the circulatory system and how it is distributed between different vascular districts by means of vascular compliance and unstressed volumes. Then, we will focus on changing model parameters to mimic the adaptation of the cardiovascular system to hypertension. Adaptation does not only affect large systemic arteries and the heart but also the microcirculation, the pulmonary circulation and the venous system. Using a global closed-loop model allows us to establish the interplay between different blood compartments and their role in the progression of the disease. We will observe that the hypertensive state is mainly determined by the combined effects of increased arterial resistance and reduced venous compliance; the last one plays an essential role in preserving cardiac output and stroke volume in case of left ventricular hypertrophy, as well as in blood volume distribution in the hypertensive subject.

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