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A ONE-DIMENSIONAL MODEL OF WAVE PROPAGATION WITHIN THE CO-AXIAL VISCOUS FLUID FILLED SPINAL CAVITY.

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Abstract. One–Dimensional models have been used to simulate pulse waves propagation in the spinal cavity and the interactions between CSF, blood and the spinal cord. Some adopted compliant coaxial configurations but neglected the fluid's viscosity [1, 2] while others took into account CSF viscosity but simplified the cavity as one equivalent distensible tube [3]. Previous studies in the inviscid coaxial configuration have shown that the confinement reduces the wave propagation speed of the compliant part by a factor equal to the square root of the area parameter, i.e. the ratio of the tubes cross-sectional areas, when the dura is considered rigid. Here we use one-dimensional modeling of the spinal compartment in the coaxial configuration while considering CSF and blood as viscous fluids and the spinal cord as a poroelastic media. Different boundary conditions and their impact on the wave propagation are addressed. Concomitant to the area parameter, the viscous shear stresses developed at the different walls are involved in the dynamics of the system. They impact the coupled wave velocity and therefore the coupled distensibility as well as the wave attenuation due to the interaction between the contents of the spinal cavity. The addition of the viscous nature of the fluids induces a viscous attenuation whose effect depends also on the area parameter and the Womersley number. Although our modeling is non linear and the coupled system of equations is solved numerically we also consider the linear case and obtain a pressure damped wave equation similar to the so called telegrapher's equation. The pressure damping coefficient expression shows analytically how the area ratio and the shear stresses developed at the different walls are coupled.

The talk will present simplified configurations, to highlight the main physical phenomenons involved, and a more realistic configuration using the data of the Visible Human Man given in [4]. This spinal model will be integrated to the global mathematical model of the cerebral circulation in Man [5] to investigate the cranial spinal coupling and the autoregulation. This research is a part of a multi lab project called ROMBA (Retroactive Optimal Modelling of Brain Autoregulation) which aims to simulate autoregulation in the coupled cranial and spinal system, using modern fluid retroactive control optimal approach.

1. Berkouk K, Carpenter P W, Lucey A D (2003). Pressure wave propagation in fluid-filled co-axial elastic tubes Part one: Basic Theory. J Biomech Eng 125: 852-856.
2. Cirovic S, Kim M (2012) A one- dimensional model of the spinal cerebrospinal-fluid compartment. J Biomech Eng 134 (2):021005.
3. Martin B A, Reymond P, Novy J, Balédent O, Stergiopulos N (2012). A coupled hydrodynamic model of the cardiovascular and cerebrospinal fluid system. Am J Physiol Heart Circ Physiol 302: H1492-1509.
4. Loth F, Yardimci M, Alperin N (2001) Hydrodynamic modeling of cerebrospinal motion within the spinal cavity. J. Biomech. Eng. 123: 71-79.
5. Zagzoule M, Marc-Vergnes JP (1986). A global mathematical model of the circulation in man. J. of Biomechanics, 19 (12), 1015-1022.