World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:15, No:09, 2021

A Benchtop Experiment to Study Changes in Tracer Distribution in the Subarachnoid Space

Authors : Smruti Mahapatra, Dipankar Biswas, Richard Um, Michael Meggyesy, Riccardo Serra, Noah Gorelick, Steven Marra, Amir Manbachi, Mark G. Luciano

Abstract : Intracranial pressure (ICP) is profoundly regulated by the effects of cardiac pulsation and the volume of the incoming blood. Furthermore, these effects on ICP are incremented by the presence of a rigid skull that does not allow for changes in total volume during the cardiac cycle. These factors play a pivotal role in cerebrospinal fluid (CSF) dynamics and distribution, with consequences that are not well understood to this date and that may have a deep effect on the Central Nervous System (CNS) functioning. We designed this study with two specific aims: (a) To study how pulsatility influences local CSF flow, and (b) To study how modulating intracranial pressure affects drug distribution throughout the SAS globally. In order to achieve these aims, we built an elaborate in-vitro model of the SAS closely mimicking the dimensions and flow rates of physiological systems. To modulate intracranial pressure, we used an intracranially implanted, cardiac-gated, volume-oscillating balloon (CADENCE device). Commercially available dye was used to visualize changes in CSF flow. We first implemented two control cases, seeing how the tracer behaves in the presence of pulsations from the brain phantom and the balloon individually. After establishing the controls, we tested 2 cases, having the brain and the balloon pulsate together in sync and out of sync. We then analyzed the distribution area using image processing software. The in-sync case produced a significant increase, 5x times, in the tracer distribution area relative to the out-of-sync case. Assuming that the tracer fluid would mimic blood flow movement, a drug introduced in the SAS with such a system in place would enhance drug distribution and increase the bioavailability of therapeutic drugs to a wider spectrum of brain tissue.

Keywords : blood-brain barrier, cardiac-gated, cerebrospinal fluid, drug delivery, neurosurgery
Conference Title : ICBET 2021 : International Conference on Biomedical Electronics Technology
Conference Location : Lisbon, Portugal
Conference Dates : September 20-21, 2021