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Mechanical Properties of Cranial Cavity and Brain Tissue with DMA Testing

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Editorial

Mechanical engineering plays an important role in healthcare through using engineering techniques to help understand the human body and in the development of new healthcare technologies, and then can be used to understand the human body and to repair and replace diseased or damaged tissues. The most common cause of death in neurosurgical patients is the raised Intracranial Pressure (ICP) and therefore it is essential that accurate monitoring of this pressure is undertaken clinically. ICP is the pressure inside the skull and therefore is the tissue of the brain and Cerebrospinal Fluid (CSF). Increased ICP can arise for a variety of reasons such as trauma to the head and brain tumours. Prolonged intracranial hypertension, a common pathway in the presentation of traumatic head injury, can lead to brain damage or even death. The current state of the art techniques for measuring ICP are all invasive, which means that devices must be inserted into patients, such as ventricular, extradural, subarachnoid, epidural and lumbar CSF monitoring methods [1]. These methods have many disadvantages including being invasive, having low-accuracy and cross-infection. Although many efforts have recently been made to improve the mini-traumatic or non-invasive methods used, currently there are no non-invasive methods available. A novel non-invasive technique for measuring the pressure was developed using the engineering techniques based on the deformed cranium as the ICP fluctuates [2]. Dr. Upledger discovered that the inherent rhythmic motion of cranial bones was caused by the fluctuation of CSF [3]. Accordingly, the cranium can move and be deformed as the ICP fluctuates. So the ICP can be monitored by measuring the deformation of skull bone. The function of human skull is mainly protecting the brain–the most important organ in the human body. Considering the particularity of biological models with its complex structure, material properties, the authentic modelling of human cranial cavity can be set up based on the CT data images of human skull. Components of the human skull have viscoelastic materials, non-linear materials, and hyper-elastic materials. Therefore, we'll explore how the material properties of human bone and dura mater influence the deformation of human skull. Our primary aim was to quantify the relationship between the deformation of cranial cavity and ICP and investigate the structure of human head as the brain-FSI (Fluid-Solid Interaction)-skull remodelling. The relationship between ICP and deformation of cranial cavity and among the microstructural skeleton, tissue fluid and deformation properties of cancellous skull bone in the primary anatomic directions need to be quantified by the finite-element method to examine the effect of real-time changes in ICP. And the material properties of skull bone and brain need to be investigated to demonstrate the viscoelasticity of cranial tissues. These relationships and data were used to provide a novel, real-time and precise means of monitoring ICP and could further help to setup the mechanisms underlying the therapeutic effects of neuromodulation in neurological and neuropsychiatric conditions using modelling and functional imaging techniques. Meeting this aim optimizes current therapies in existing patient populations with intracranial interventions, implements new approaches and techniques, explores new targets, and defines new disease populations; thus delivering clinical and financial benefits. In addition, the remodelling and material properties of cranial cavity and brain will be the great challenge in understanding the mechanisms of carnial injury in the infant population as well.

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