Rheology

Rheology is the study of the flow of matter, primarily in a liquid state, but also as "soft solids" or solids under conditions in which they respond with plastic flow rather than deforming elastically in response to an applied force. It is a branch of physics which deals with the deformation and flow of materials, both solids and liquids.

Alterations in brain rheology are increasingly recognized as a diagnostic marker for various neurological conditions. Magnetic resonance elastography now allows us to assess brain rheology repeatably, reproducibly, and non-invasively in vivo. Recent elastography studies suggest that brain stiffness decreases one percent per year during normal aging, and is significantly reduced in Alzheimer's disease and multiple sclerosis. While existing studies successfully compare brain stiffnesses across different populations, they fail to provide insight into changes within the same brain. Here we characterize rheological alterations in one and the same brain under extreme metabolic changes: alive and dead. Strikingly, the storage and loss moduli of the cerebrum increased by 26% and 60% within only three minutes post mortem and continued to increase by 40% and 103% within 45 minutes. Immediate post mortem stiffening displayed pronounced regional variations; it was largest in the corpus callosum and smallest in the brainstem. We postulate that post mortem stiffening is a manifestation of alterations in polarization, oxidation, perfusion, and metabolism immediately after death. Our results suggest that the stiffness of our brain-unlike any other organ-is a dynamic property that is highly sensitive to the metabolic environment. Our findings emphasize the importance of characterizing brain tissue in vivo and question the relevance of ex vivo brain tissue testing as a whole. Knowing the true stiffness of the living brain has important consequences in diagnosing neurological conditions, planning neurosurgical procedures, and modeling the brain's response to high impact loading ¹⁾.

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Weickenmeier J, Kurt M, Ozkaya E, de Rooij R, Ovaert TC, Ehman RL, Butts Pauly K, Kuhl E. Brain stiffens post mortem. J Mech Behav Biomed Mater. 2018 Apr 22;84:88-98. doi: 10.1016/j.jmbbm.2018.04.009. [Epub ahead of print] PubMed PMID: 29754046.

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Last update: 2024/06/07 02:58