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RHEOLOGY OF THE PORCINE BRAIN UNDER EXTREME METABOLIC CHANGES

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Recent magnetic resonance elastography studies have shown a change in the rheological behavior of brain tissue for various neurological conditions. Strikingly, brain tissue appears to soften one percent per year during normal aging and softens significantly faster in brains affected by Alzheimer's disease and multiple sclerosis. Despite its widespread use, magnetic resonance elastography has not yet been compared to ex-vivo measurements on the same testing samples for validation.

In this talk, we present our measurement setup [1, 2] and an in-vivo, in-situ, and ex-vivo comparison of the rheological alterations of the same porcine brain under extreme metabolic changes: alive and dead [2]. We found that storage and loss moduli of the cerebrum increase by 26% and 60% within only three minutes post mortem and continue to increase by 40% and 103% within 45 minutes post mortem. Gray and white matter, thalamus, cerebellum, and the brainstem showed the same immediate sensitivity to the breakdown of metabolic activity upon death but exhibited lower stiffening effects. The comparison of our elastograms with the micro-indentation tests on the same brain revealed noticeable differences between in-vivo and ex-vivo stiffness values and showed much better agreement with 45 minutes post mortem data.

The collapse of ionic homeostasis in the brain leads to severe changes in polarization, oxidation, and perfusion, and instantly triggers extensive compensatory mechanisms in neuronal and astroglial cells to delay neuronal damage. Our results suggest that the stiffness of our brain is a dynamic property that is highly sensitive to the local metabolic environment. Our results emphasize the importance of characterizing brain tissue in-vivo and call for a biophysical interpretation of in-vivo and ex-vivo differences. Knowing the true stiffness of the living brain has important consequences in diagnosing neurological conditions and modeling the brain's response to high impact loading.

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